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POPs Action in China

UNIDO

Strategies to Reduce Unintentional Production of POPs in China: BAT, BEP and Incremental Costs for Selected Sectors of Industry (Contract No. 2004/217)

The Contractor's Reports

(Sectors Reports)

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LIST OF SECTORS REPORTS

1. The POPs Emission Reducing Plan of Medical Waste Incineration Sector-Final Report
2. Report on Capability of Implementation of POPs Convention in China Paper Industry
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Sino-Italian BAT-BEP Program to Control and Reduce Emission of Unintentional Persistent Organic Pollutants

The POPs Emission Reducing Plan of Medical Waste Incineration Sector -Final Report

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The POPs Emission Reducing Plan of Medical Waste Incineration Sector-Final Report

-English abstract

Huzhou Shijiqing Solid Waste Disposal Center came into existence in September 2001, and the fixed asset is about two million Euros. 85 staff including management and technology works in this plant. The incineration system with capacity 10t/d was installed in November 2004. The main technology is "rotary kiln- pyrolysis-flowing bed".

Rotary kiln is the first chamber and drying part in the whole process. The temperature inside the rotary kiln is 500～800℃.When the medical waste is feed into the rotary kiln, and will be move forward with the movement of rotary kiln. Medical waste will be pyrolyzed in 500～600℃. The pyrolysis gas goes into the upside of the flowing bed to be incinerated, and the residual solid waste will be transported into the bottom of the flowing bed.

The temperature in the flowing bed is 850～1100℃. The delaying time of medical waste in the flowing bed is 40～60 minutes. The Heat Reducing Rate of residue is below 2%. Limestone was added into the flowing bed to reduce the production of HCl.

The emission gas will be cooled down to 500℃ when passing the pre-heater of air, at the same time the air was heated. The gas will be cooled down to 200℃ when passing the rapid cooling equipment.

The whole gas treatment system was composed of rapid cooling system, washing tower and bag filter.

To keep the incineration system running for 24h, and reduce the frequency of start and stop operation, is the important step to reduce the dioxin

emission.

The Jinan Hanyang Solid Waste Disposal Company was set up in May 2003, and the medical waste produced in Jinan city was send to here to be incinerated. The main equipment is erect rotary pyrolysis incinerator produced by Shenzhen Hanshi Company (mode LXRF), and the disposal capacity is 24t/d.

The main disposal procedure is: firstly, the medical waste is incinerated in erect rotary pyrolysis incinerator; then the gas is incinerated in the second chamber; then the high temperature gas was rapidly cooled when passing the boiler and washing gas tower; then the gas pass the bag filter and active carbon absorption tower.

The temperature in the first chamber is 1100℃, and that in the second is 1200℃. The delaying time of gas in the second chamber is longer than 2 second, and the oxygen concentration is 11%. The gas will be rapidly cooled from 600 ℃ to 200℃ in 3-4 seconds when passing the boiler. The combination of washing gas tower and bag filter is efficient to reduce the dust and dioxin.

The actual disposal quantity of medical waste is about 10t/d. So; it is far more the designed capacity of 24t/d. The running time is about 8-12 hours every day and the stopping time is more than 4 hours. It is proved that, a lot of dioxin is produced in the starting and stopping stage of incinerator. So, to keep the incineration system running for 24h, and reduce the frequency of start and stop operation, is the important step to reduce the dioxin emission.

Hazardous wastes incineration in China has come through two phases, single-chamber incinerator phase and multi-chamber incinerator phase. Fixed bed oxygen-control incinerator and liquid injection incinerator has been applied. Mechanic-grate incinerator and rotary kiln incinerator are been popularizing. Other incinerators and relevant technologies are still in experimental practice.

The production of hazardous wastes incinerator in China has a history of over 20 years. First, minitype incinerators were produced, and its disposal quantity was from several tens to over 100 kilograms per hour. Gas was disposed simply. In recent years, because of the emphasis on environmental protection from government and the need of medical wastes disposal, many universities, research academies and environmental enterprises have developed medical wastes disposal technologies and equipments. Several environmental enterprises have certain production capacity on the above equipments. Now, there are more than 20 normal enterprises producing minitype medical wastes incinerator. Enterprises producing large and medium scale medical wastes incinerator are few.

There are many incineration modes and incinerator types of medical wastes incinerator. According to incineration modes, there are excessive oxygen incineration mode, thermal decomposition gasification mode, etc. According to incinerator type, there are rotary kiln incinerators, reciprocating grate incinerators, chain incinerators, stand-up rotary incinerators, etc. Gas purification system is set up generally, but feeder system and monitoring system are simple.

Aiming at unique technology of medical wastes incineration system, referring to main techniques of dioxin release reduction, and considering support capacity of economic and technology, the following scenarios adopted in incineration enterprises in China are suggested.

1) Raw material control

Break up medical wastes before entering incinerator in order to reduce granule size and increase contact areas with air and make it combust equably.

2) Combustion control

Establish effective management measures. It is important for dioxin production to manage incineration enterprises effectively. To run incinerator full load and to operate according to "3T" principle strictly are important measures.

The design capacity of demonstration enterprise (Huzhou medical wastes incineration system) is 10t/d. But the maximum disposal quantity is 7t/d now because of several reasons. So incineration system couldn't run continuously for inadequate of combustion quantity. Now, Huzhou medical wastes incineration system run for about 16h/d, and stop running for over 4h. Frequent startup and turnoff cause not only difficulty of operation but also increase of maintenance costs. More important is that, during the startup and turnoff, large quantity of dioxin may be produced because of instability of incineration status and no accomplishment of designed incineration condition, which widely exist in medical wastes incineration systems in China. Thus, it is main approaches to increase continuous running time of incineration system and reduce startup and turnoff times

3) After-combustion control

After combust wastes adequately, which need to be solved is that remained dioxin precursors may be synthesized again and produced dioxin couldn't be easily collected. Temperature decrease is effective on synthesization of dioxin precursors and increase of collection rates. Controlling gas temperature from 250 to 400 ℃ in gas cooling chamber, reducing granule retention time mostly and controlling fly ash catalyzed activity, can reduce dioxin production quantity. Ammonia is added into gas in order to restrain dioxin forming in surface of fly ash. Ammonia can control production of NO_x and dioxin because it can deoxidize NO_x to N_2.

Dioxin is mainly collected by baggy dust catcher. Entrance temperature of baggy dust catcher is less than 150℃, but catalyzed reaction temperature of dioxin forming is 300℃, so dioxin precursors couldn't be synthesized to dioxin in baggy dust catcher. Baggy dust catcher is different with electrical dust catcher. When baggy dust catcher works, granule will be formed in the surface of filter fabric. Dioxin in the gas will be absorbed and removed by this filter fabric and discharge to residue disposal system. Thus, it is important to maintain the security of baggy dust catcher and operate it efficiently.

4) Terminal control

It is divided into dioxin absorbed by active carbon and dioxin decomposition or catalyzed deoxidization.

Active carbon is a sorbent which has medium of active carbon and coke. It can absorb not only dioxin but also NO_x, SO_2, heavy metal and other chemicals because it has large surface areas and strong absorption capacity. The technics can be divided into two stages, absorption and desorption. When gas enter absorption tower where temperature is 120-180℃, dioxin can be absorbed. Appending active carbon absorption tower in gas disposal system can reduce dioxin production. Catalyzer which can catalyze and deoxidize NO_x can also decompose dioxin. On the circumstances of 200-350℃ and no ammonia, selective catalyzer, which takes TiO_2 as basic material, can reduce dioxin concentrations in gas to less than 0.1ng/m^3.

Adopting certain reduction measure is based on monitoring results. Thus, dioxin monitoring scenario should include sampling and analyzing condition in different working status and position in order to find key factors of dioxin reduction.

Sino-Italian BAT-BEP Program to Control and Reduce Emission of Unintentional Persistent Organic Pollutants

Report on Capability of Implementation of POPs Convention in China Paper Industry

Sun Xuecheng

April, 2007

Content

Ⅰ. General

The consumption level of paper and board, to some extent, can reflect the modernization level and civilization degree of a country. It's a common rule that all the economy advanced countries have highly developed paper industry, which is one of the country's pillar industries. During last two decades, the paper industry in newly emerged developing countries has got great achievements. In China, paper industry as fundamental raw material industry plays very important role on the national's presswork and publication, advertisement, product packaging and national defense industry; thus related to the national economy and the people's livelihood. In 2005, the national paper and board output is 56 million t, apparent consumption is 59.3 million t, its total output and consumption is the second in the world, nevertheless the paper and board consumption per capita is only 45kg, which is much lower than the level of over 300kg in developed countries. There is great development potential for Chinese paper industry.

(1) Raw materials

In 2005, the total pulp consumption in China is 52million t, including 22% wood pulp, 24%non wood pulp and 54% secondary fiber pulp. The imported wood pulp is 7.59million t, imported waste paper is 17.03million t. Non wood fiber mainly consists of wheat straw, rice straw, reed, cotton stalk, bamboo etc.

Table 1 Structure of major fiber raw material consumptions in Chinese paper industry

	Year:1995		2000		2005	
	1,000t	%	1,000t	%	1,000t	%
Pulp consumption	22,590	100	27,900	100	52,000	100
(1) wood pulp	2,830	12.5	5,350	19.1	11,300	21.7
In which-domestic wood pulp	2,010	9.2	2,000	7.1	3,710	7.1
(2) non wood pulp	11,360	50.3	11,150	40	12,600	24.2
(3) recycle pulp	8,400	37.2	11400	40.9	28,100	54.0
In which, imported recycle pulp	730	3.2	2970	10.6	13,620	26.2

(2) Raw material handling

In China, raw material handling process typically adopts dry process or combination of dry and wet process. As for wood handling, dry process is generally applied to suit for either batch or continuous cooking. As for non-wood raw material(wheat straw or reed) handling, combination of dry and wet process is usually followed by the continuous cooking; while wet process is followed by the batch cooking. After sedimentation, discharged water from washing is recirculated in the system. For the recovered fiber plant, the only task in the raw material handling system is to sort the waste paper for trash removal. Pulper for ink detachment is usually one part of pulping process.

(3) Pulping

The process of chemical or/and semi-chemical pulping in China mainly includes alkaline(sulfate, ammonium sulfite), sodium sulfite and blasting pulping etc. Pulping process varies a lot in the different mills, ranging from advanced single chemical pulp line with capacity of 1million tones per year, which features depth delignification and medium consistency technology, high consistency black liquid evaporation technology and super high pressure, high temperature alkali recovery boiler; to conventional spherical digesters or vertical digesters for batch pulping. For pulping of non wood fiber such as wheat and reed, generally horizontal pipe continuous cooking and cold blow technology is used for large production scale.

Recent development of high precision and high efficiency large-sized refiner enables the biggest throughput of a single machine up to 750t/d, high quality BCTMP has been widely used in the production of high grade paper and paperboard. In order to simplify production process and reduce refining energy, alkali peroxide mechanical pulp (APMP) process came into existence in late 80's. In 1990's, a new pulp grade called gentle pretreatment and refiner chemical treatment alkali peroxide mechanical pulp (P-RC APMP) has been introduced. With the diversification of chip pretreatment chemistry, the production of chemical mechanical pulp become more and more flexible, qualified pulp can be produced according to different wood species and product quality requirement.

With shortage of wood raw material and high requirement on environmental protection, in the last decade recycle of waste paper has been paid great attention by paper industry. Waste paper pulping technology, especially high efficient cleaning and de-ink pulping technology has reached a very high level. Since large disperser was developed, the single line capacity of DIP plant is over 1000t/d, the optimum white water treatment and recirculation system makes it possible to reduce the fresh consumption per ton bleached DIP to around $5m^3/t$. Introduction of advanced technology has greatly improved the quality of secondary pulp. There is a development trend of substituting chemical pulp and unbleached sulfate pulp with secondary fiber in the production of high grade newsprint, LWC, SC paper, packaging paper and others. The largest and most advanced secondary fiber production line is located in China.

(4) Bleaching

Bleaching process varies a lot with different pup grade, target brightness of product, enterprise scope and also technical level. Normally for large scale enterprises with advanced process and equipment, chlorine free bleaching process, slightly element chlorine free process or completely chlorine free bleaching process is used. In Hainan Province of China, there is a 1 million t/y bleached hardwood sulfate production line, which has oxygen delignification equipment in 2 stages and element chlorine free bleaching in 4 stages. The commonly used bleaching process in China is conventional 3-stage bleaching process which combines chlorine bleaching, alkali treatment and hypochlorite(C-E-H) together. This process is extensively used for bleaching of straw pulp, bagasse pulp, bamboo pulp, wood pulp and reed pulp. Limited by investment cost, the small and medium sized pulp and paper mills usually use 1 stage or 2 stages hypochlorite bleaching. Since chlorine dioxide is superior to chlorine gas regarding to bleaching performance, some enterprises have rebuilt their conventional 3-stages bleaching process, to replace partial chlorine with chlorine dioxide, in order to improve bleaching efficiency. Hydrogen peroxide is used in both mechanical pulp bleaching and conventional CEH bleaching.

(5) Paper making

It's assumed that paper and board production in China in 2006 is over 60million t, consumption of paper and board is over 65million t. The major products include newsprint, uncoated printing and writing paper, coated paper, livelihood paper, packaging paper, white board (inc. coated white board), container board, corrugated base paper, specialty paper and board. The production and consumption of major products of Chinese paper industry in 2005 is shown in the following table.

Table 2 Production and consumption of major paper products in Chinese paper industry (Year -2005) unit: 10,000t

Paper/board grade	production			consumption		
	2004	***2005***	***Y-O-Y %***	***2004***	***2005***	***Y-O-Y %***
total	*4950*	*5600*	*13.13*	*5439*	*5930*	*9.03*
1.newsprint	300	319	*6.33*	310	331	*6.77*
2.uncoated printing and writing paper	1020	1070	*4.90*	1045	1079	*3.25*
In which: book paper	550	570	*3.64*	575	579	*0.70*
Writing paper	280	300	*7.14*	280	300	*7.14*
3.coated paper	300	365	*21.67*	358	359	*0.28*
In which: coated art paper	250	300	*20.00*	274	289	*5.47*
4.livelihood paper	384	436	*13.54*	361	409	*13.30*
5.packaging paper	470	510	*8.51*	474	516	*8.86*
6.white board	670	790	*17.91*	772	863	*11.79*
In which: coated white board	630	755	*19.84*	731	827	*13.13*
7.tank board	830	980	*18.07*	978	1115	*14.01*
8.corrugated base paper	810	950	*17.28*	921	1035	*12.38*
In which: high strength corrugated base paper	270	410	*51.85*	381	495	*29.92*
9.specialty paper and board	85	90	*5.88*	114	114	*0.00*
10.others	81	90	*11.11*	106	109	*2.83*

(6) Environmental protection

According to the statistics of National Environmental Protection Bureau, water consumption of pulp and paper making industry and paper product processing industry is 6880million t, including 3730million t fresh water and 3150million t reused water, the recycling rate of water is 45.8%, fresh water usage per 10,000yuan production value (present price) is 188.3tons. In 2004 Chinese paper industry has discharged totally 3190million t waste water, accounting for 16.1% of the total industry waste water in the country. Discharge amount of qualified waste water of paper industry is 2860million t, accounting for 89.7% of total waste water discharged by the industry, which is 3.8% higher than previous year. Chemical oxygen demand (COD) in discharged waste water is 1.49million t, which is 33.0% of the total COD discharge amount in Chinese industry, 380,000tons lower than 1.526million t of the previous year; reduced by 2.5%. Discharge intensity of COD per 10,000Yuan production value is 0.075t, which is 0.019t/10,000Yuan lower than last year's 0.094t/10,000Yuan.

(7) Economic index of the industry

The accomplishment of major production economy index and overall economy profit of the pulp and paper industry showed positive trend in recent years. Some major economy index such as overall industry production output, sales revenue, total profit payments and tax turnover and total profit margin in *2004～2005* are indicated in the following table:

Table 3 Total industry output（price in the same year）and sales revenue:

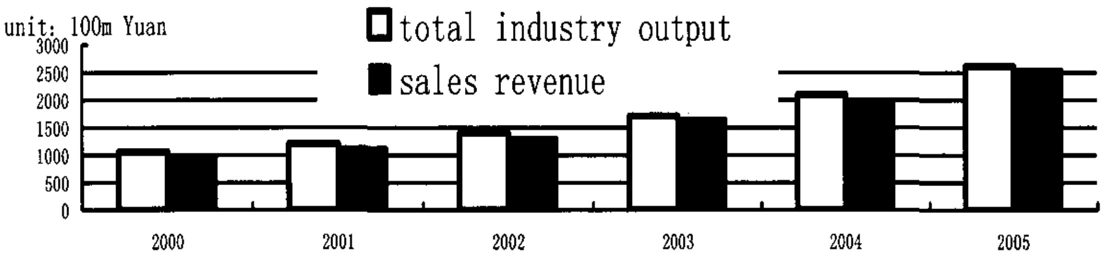
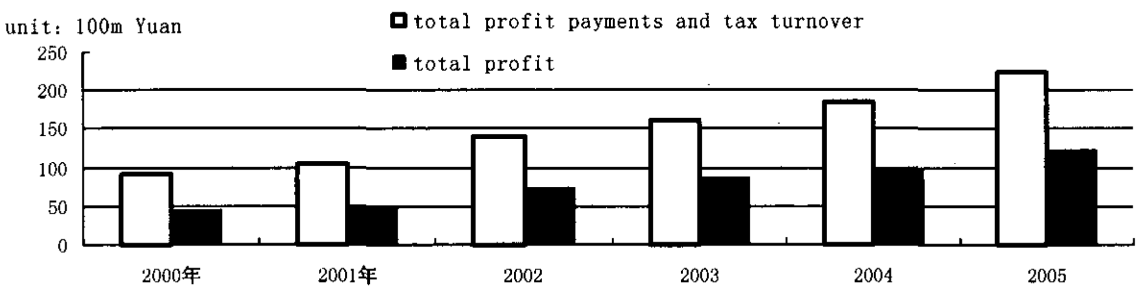


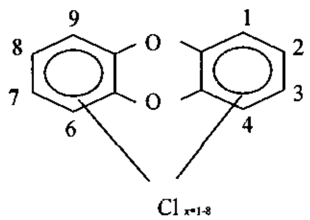
Table 4 Total profit payments and tax turnover and total profit:



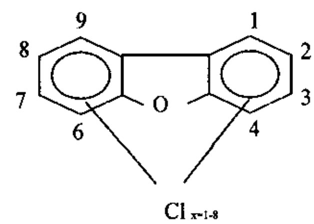
II

Fundamentals of Dioxins generated in paper industry and its channels of transferring into environment

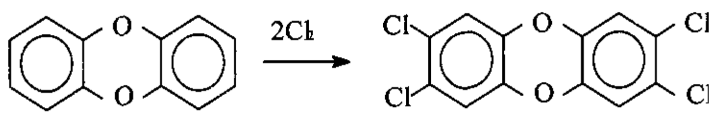
Along with rapid development of paper industry, unintentional production of POPs during pulp and paper making process become a severe threat to ecological environment. POPs product generated in pulp and paper industry mainly refers to dioxins alike persistent organic pollutants. The origins of dioxins alike persistent organic pollutants in pulp and paper industry include raw material for pulping, chlorine bleaching, waste paper pulping and papermaking, defoaming agent, alkali recovery and biomass incineration. The following figures present the molecular structure of two types of representative organic chlorine (dioxins) and generation fundamental of dioxins during pulp bleaching.



PCDD



PCDF



DBD 2、3、7、8 —— TCDD

Figure1 Molecular structure of dioxins (PCDD) and furan (PCDF) and generation fundamental of dioxins during chlorine bleaching of pulp.

Results of overseas research reveal that, POPs products generated in pulp and papermaking process are emissionted to the environment in ways of atmosphere, water body, final product and waste residues.

(1) Emission to air

POPs products Emission to the air are generated in alkali recovery and biomass boiler process of pulp and paper mill only. The test results on caustic and soda pulping mill using wood raw material indicate that, average flow of flue gas released from chemical recovery boiler is 6000～9000m^3/t pulp, every cubic meter of flue gas generates about 0.41ng I-TEQ(range 0.036～1.4 ng I-TEQ) （CEPA-FPAC1999） .Tests on wood pulping mill in coastal area of Canada which contains salty soil in their raw materials showed that, emission of POPs from chemical recovery boiler and biomass boiler is greatly increased. For black liquid boiler and biomass boiler using non wood fiber, the related data is still unavailable yet.

In caustic pulping mills using wood raw material, it's necessary to have caustic recovery boiler for combustion of thickened black liquid. The commonly used cleaning equipments for flue gas are cyclones, wet de-dusting equipment or static precipitators. The tested average POPs emission to atmosphere is 0.07ug TEQ/t black liquid （US-EPA2000） .

According to a report by American State Environment Protection Bureau in 1998 （US-EPA）, For the pulp and paper mills which use biomass boilers equipped with static precipitator, they have sludge generated from combustion effluent treatment plant and wood dust and bark generated during wood preparation and production, the POPs amount Emissionted to atmosphere is 0.0004～0.118ug I-TEQ /t sludge or wood.

(2) Emission to water body

Pulp and paper-making industry requires high water consumption. For the enterprises adopting modern technologies, the discharging effluent of bleaching lines is 15—20 m^3/ton (pulp). In 1988, typical water consumption of American pulp and paper-making enterprises is about 60—64 m^3/ton pulp; while for Europe, it was about 15--100 m^3/ton pulp. The water consumption can be reduced by increasing the usage of internal water circulation inside paper mills. At present, in the countries where pulp and paper-making industry are highly developed, the typical discharge amount of effluent in pulp and paper enterprises can be controlled within the range of 20--40 m^3/t pulp.

A report of American Sate Environmental Protection Bureau points out that the POPs in the effluent discharged by pulping and paper-making enterprises into waters is between 3pgTEQ /L to 210pgTEQ /L, and it's weighted average value is 73pgTEQ /L(LUS-EPA1998). For the enterprises using traditional CEH bleaching for kraft pulp, the POPs discharged into effluent reaches 4.5ugTEQ /t (pulp). If the chlorine in the first phase of bleaching is replaced by chlorine dioxide, the POPs discharged into effluent can be rapidly reduced, and the amount of 2、3、7、8－TCDD and 2、3、7、8－TCDF will be below than detecting limit(0.3-0.9pg/L).

（3） Emi to final products

The products of pulp and paper-making enterprises can be polluted by dioxin and furan, and the pollution degree depends on the technologies used in bleaching process. While for the CEH bleached pulp and paper products which use wood as raw material, the content of dioxin and furan is proved to be on high end. The measuring result shows that the amount of POPs in livelihood paper (including tissue, sack paper, etc.) and other consumer paper grades is approximately 8ugTEQ/t.

For the ECF bleached pulp, the content of dioxin and furan may be increased because of the high hardness of the pulp fed into bleaching phases or the low purity of chlorine dioxide. The evaluated data from America shows that the content of POPs in bleached pulp ranges from 0.6ngTEQ/kg (pulp) to 200ngTEQ/kg (pulp). Table 3 shows the content of total organic chlorine in different kinds of bleaching process and its toxicity equivalents value. Table 4 is the dioxin content of CEH bleaching pulp and paper products in US.

Table 5 Total content of organic chlorine in different kinds of bleaching process and its toxicity equivalents value

kraft birch pulp	bleaching process	Active chlorine used/%		Total chlorine content of pulp mg/kg	TEQ(toxicity equivalents) pg/g dry pulp
		Cl_2	ClO_2		
1mill	C/DEDED	83	17	1950	0.93
2mill	C/DEDED	30	70	1700	0.76
3laboratory	D/CEE$_O$DED	20	80	1050	0.048
4laboratory	D/CEE$_O$DED	13	87	518	0.023
5laboratory	DEE$_O$DED	2	98	156	0.006

Table 6 Dioxin content of CEH bleaching pulp and paper products in America

sample	2,3,7,8-PCDD/ppt a	2,3,7,8-PCDF/ppt b	Toxicity equivalents TEQ/ppt c
tissue	4	33	7.3
paper plate	4	30	7
diaper	na	8	0.8
High grade office paper	13	250	38

food package paper	coated	8	60	14
	uncoated	14	60	20

Remark: the calculating method of toxicity equivalents: c=a+fb. a、b are shown in the table, f is the toxicity equivalents factor that PCDF amounts to PCDD, f=0.1.

The related foreign research indicates that for the pulp and paper products based on waste paper, there has certain amount of POPs, approximately 3ugTEQ/t-10ugTEQ/t. The main source is waste paper.

（4）Emission to sludge

The residues that the POPs (dioxin and furan) discharged into mainly refer to sludge of the effluent disposal plant. The detecting results indicate that for CEH bleaching pulp and paper enterprises, the amount of POPs in the sludge is about 93ngTEQ /kg（range：2ngTEQ /kg-370ngTEQ /kg）. While for those chlorine dioxide bleaching enterprises, the amount of POPs in the sludge is only about 10ngTEQ /kg. The deinking sludge, produced by the enterprises using waste paper as raw material, has a high amount of POPs, ranging from 24.9ngTEQ/kg to 44.37ngTEQ /kg.

Ⅲ. Development trend and intrinsic drive of product and technology

Under the pressure of market, resources, environment and profit, the consolidation activity of paper-making industry is continuously increasing. The merger and acquisition, combination and restructure of enterprises, together with the developing trend toward larger scale group companies, have all promoted the development of new technologies and equipment. Large pulp and paper-making group companies make great efforts to increase their production efficiency, reduce operation and investment cost, upgrade the comprehensive profitability and risk aversion ability not only by merging and combining other enterprises, but also by developing advanced process technologies and equipment.

The product structure of Chinese paper-making industry will be adjusted to concentrate on developing middle, top grade and famous brand products. The present proportion of middle and top grade paper and paper board product in China is 60%, which will be increased to 70% by 2010. With regard to technology development, the whole paper-making industry chain including equipment manufacturing trade are trying to enhance their competitive ability, meanwhile attaching more importance to recyclable economy, clean production, efficient use of recourses, reduction of environmental pollution and promoting sustainable development.

(1) Pulp production line

The developing trend of pulping industry in recent years are expansion of production scale, simplification of process system, lower energy consumption and pollution load, improved system closure.

1、chemical wood pulp

The capacity of a single pulp line reaches up to 1 million t per year; pulping process generally adopt depth delignification technology (including low Kappa cooking and oxygen delignification) and MC technology (including MC washing, MC screening, MC mixing, MC handling, etc.); alkaline recovery HC black liquid evaporation technology and super high pressure, high temperature alkaline recovery boiler; optimization of ECF and TCF, diversified and flexible bleaching chemistry and processes. For the advanced large-scale bleaching wood pulp mill, the water consumption can be reduced to 30 m^3 /t pulp, the alkaline recovery rate can be higher than 95%, the energy self-sufficient degree is more than 90%, the AOX content in ECF bleaching effluent is less than 0.5kg/t pulp. After 2-stages biological chemical treatment, low ClO_2 ECF bleaching or TCF bleaching can realize system closure or semi-closure of bleaching water loop, and the AOX content is reduced to 0.3 kg/t pulp.

2、chemical mechanical pulp

With the development of high accuracy/efficiency big refiners, the capacity of a single refiner has reached 750t/d, and high quality BCTMP has been widely used to produce various kinds of high grade paper and paper board. In order to simplify the production process and reduce refining energy consumption, the APMP process was used in the late 1980s, while in 1990s, there developed the P-RC APMP process. With the diversity of chemicals used for chip pretreatment, the production of P-RC APMP has been very flexible and the mills can produce qualified pulp according to different raw material and quality requirements.

3、recycle pulp

As the shortage of wood fiber raw material and the high requirements on environmental protection, paper industry has attached great importance to recover waste paper in recent 10 years. The development of waste paper pulping technologies, especially of the high efficient clarifying and deinking technologies, has reached a certain high degree; with the development of big dispersing equipment, the capacity of a single deinking waste paper pulping line has exceeded 1000t/d; the perfect white water recovery system has the possibility to bring down the fresh water consumption to $5m^3/t$ during the production of bleached DIP. The adoption of advanced technologies has greatly improved the quality of waste paper pulp. It's the development trend to use recovered fiber pulp instead of mechanical pulp and natural color kraft pulp for production of high grade newsprint, LWC, SC paper, packaging paper, as well as other paper and board

4、Biological technology

Many studies about the application of biotechnology on pulping processes were carried out at home and abroad. If the pulp is preconditioned by xylan enzymes before bleaching, the dosage of chlorine-contained bleaching agents can be reduced by 10%-15%; chip pretreatment with white rot fungus before pulping by traditional chemical or mechanical methods can reduce the bleaching energy consumption by 40%. Enzymes can also improve the deinking effect of waste paper. Industrial biotechnology is promoting a new industrial revolution. Its application in pulping and paper-making industry may bring along developing potential for lower cost, better quality and more cleanness production.

5、Pulp mills in the future

With the energy shortage and the increasing pressure from social environment, people's notion is changing, and the wish of developing recycled economy is getting stronger. Not only will the paper mill produce pulp and paper, but also it will produce energy and chemical engineer products. Pulping industry shouldn't be an environmental polluter but be an environmental protector. USA is now implementing the"2020 Agenda Technical Platform" in its forest, wood and paper-making industry. In which the first platform is to carry out the development of forestry biological treatment technologies, including "extracting useful substances before pulping" and "creating new values from residues and pulping effluent", and the latter ones involved the research on farming and forestry wastes and gasification of black liquid. According to the technical platform, the future paper mills will be forest products biological extraction mills; the hemicelluloses will be extracted before chip cooking to produce alcohol and acetic acid; gasification of residue wood and pulping waste liquid will produce combustible gas for power and steam generation, and the surplus electricity may be supplied to paper mills or sold outside. The combustible gas can also be used to produce liquid fuel or chemical products.

(2) Paper-making line

1、Technical innovation of modern paper machines

(1) Wide web width, high speed, high efficiency. The application of high and new technologies on graphic paper machines and paper board machines, such as dilution head box, gap former, shoe press, single tier dryer section, soft nip calendaring and super-calendaring, film coating, blade coating, non-touching coating, etc; the application of technologies on tissue paper machines, such as multilayered head box, crescent former, hot air impingement drying, etc;.the application of information and computer technologies such as DCS, QCS, MCS, MMS, MCC, etc; all the above applications greatly increased the speed and efficiency of paper machines and improved the qualities of final products. Current equipment level: newsprint machines: wire width—11.1m, speed—2000m/min, fully closed operation from sheet formation to dryer section, automatic threading and roll change; coated paper machines: speed—2500m/min; tissue paper machines: web width—7.8m, speed—2200m/min; paper board machine: wire width--8.8m, speed—900m/min. Paper machines and paper board machines are developing to the direction of wide web width, high speed and efficiency. It's predicted that the speed of the paper machine will increase to 3000m/min 10 years later.

(2) Off-line equipments are replaced by on-line ones. Adopting on-line coating and super-calendaring instead of off-line processes make the paper machine to be more compact and the operation more convenient and flexible. Moreover, it can improve the effective operation rate and the rate of finished products and lessen the investment cost. For instance: when producing LWC, off-line super-calendaring needs 2 super calendars, while only one on-line super-calendaring is enough, the investment and operation costs are just 50% and 72% of off-line costs respectively.

(3) Water and energy saving. The water consumption per ton paper/board on paper machine can be reduced to 10-20m^3/t, the comprehensive energy consumption is 600-700kg (standard

coal)/t. While for sanitary base paper, the water consumption is reduced to 7-10m^3/t, the comprehensive energy consumption is 850-900 kg (standard coal)/t.

2. Paper machines in the future

The paper machine technology is always developing, how will be the new generation paper machine look like after 10 or 20 years, this is a concernful topic in paper industry in recent few years. Taking the newsprint paper machine as an example, the current web width is more than 11m and speed is 2000 m/min. Some specialists have the opinion that unless the structure material of PM is changed the web width cannot reach 13m, otherwise the structure would be too large and price would be too high. As a result, the paper machine will tend to be faster but not wider; and machine speed is expected to reach 3000 m/min after 10 years. The pilot paper machine could reach this speed. On a pilot coated machine which adopts the latest open spay coating technology; the speed of 3150m/min has been reached. There would be no much improvement with hydraulic headbox, gap former, straight through double shoe press and wire section. Sizing, coating, calendaring, winding, etc. could also meet the challenge. The key point is to study further on dryer section.

IV. Emission factor of dioxins in paper industry in POPs tool kit and actual discharge amount in demonstration production lines

The demonstration production line in Shandong Huatai Paper use wheat straw as raw material, and continuously cooking after dry and wet stock preparation and CEH 3-stages bleaching process. The project carries out BAT/BEP program (including before chlorine bleaching), uses biology enzyme for pre-bleaching and adds hydrogen peroxide in alkali treatment for reinforcement. The following table displays the data of demonstration production line in Huatai paper group before and after carrying out the BAT/BEP program and the data in the same toolkit.

	CONCENTR 1 ROUND pg TEQ/g (L)	CONCENTR. 2 ROUND pg TEQ/g (L)	INPUT/OUTPUT PER YEAR 1 ROUND mgTEQ/year	HUATAY INPUT/OUTPUT PER YEAR 2 ROUND mgTEQ/year
WASTE PAPER (BEFORE DE–INKING)	1.2	--	432	--
WASTE PAPER (AFTER DE–INKING)	0.70	--	252	--
STRAW	0.25	--	18	--
WHITE MUD	0.18	--	1.5	--
ALKALI ASH	0.69	--	1.17	--
PULP (BEFORE BLEACHING)	0.31	--	8.0	--
C PHASE PULP	0.45	2.9	10.8	128.2
E PHASE PULP	0.33	0.73	7.9	31.0
H PHASE PULP	0.53	--	12.7	--
C PHASE WATER	1.9	0.72	1.1	0.76
E PHASE WATER	2.2	1.6	1.3	1.63
PAPER (WASTE PAPER)	0.6	--	94.5	--
PAPER (FROM GRASS)	1.2	1.2 Art paper	43.2	43.2 Art paper
SLUDGE	2.8	5.7	16.8	38.76
EFFLUENT	--	0.67	--	10.25

HUATAY		EMISSION FACTOR 2 ROUND μ g TEQ/AdT product pulp or paper	CHLORINE BLEACHING Toolkit μ g TEQ/AdT product pulp or paper	ECF-TCF Toolkit μ g TEQ/AdT product pulp or paper
WHITE MUD	0.06 μ g /AdT bleached pulp	—	—	--
ALKALI ASH	0.046 μ g /AdT bleached pulp	—	--	NA
PULP (BEFORE BLEACHING)	0.33 μ g /AdT bleached pulp	—	—	--
C PHASE PULP	0.47 μ g /AdT bleached pulp	3.14 μ g /AdT bleached pulp	8-30	0.5
E PHASE PULP	0.33 μ g /AdT bleached pulp	0.73 μ g /AdT bleached pulp	8-30	0.5
H PHASE PULP	0.53 μ g /AdT bleached pulp	—	8-30	0.5
C PHASE WATER	0.046 μ g /AdT bleached pulp	0.017 μ g /AdT bleached pulp	4,5	0,06 after WT
E PHASE WATER	0.053 μ g /AdT bleached pulp	0.038 μ g /AdT bleached pulp	4,5	0,06 after WT
PAPER (WASTE PAPER)	0.63 μ g /AdT paper	—	8-30	3-10
PAPER (FROM STRAW)	1.20 μ g /AdT paper	1.20 μ g /AdT paper	8-30	0.5
SLUDGE	0.31 μ g /AdT bleached pulp	0.63 μ g /AdT bleached pulp	4,5 (100 μ g/ton)	0.2 (10 μ g/ton)
EFFLUENT	--	0.17 μ g /AdT bleached pulp	4.5	0,06

HUATAY		EMISSION FACTOR 2 ROUND μ g TEQ/AdT product pulp or paper	CHLORINE BLEACHING Toolkit μ g TEQ/AdT product pulp or paper	ECF-TCF Toolkit μ g TEQ/AdT product pulp or paper
WHITE MUD	0.06 μ g /AdT bleached pulp	—	—	--
ALKALI ASH	0.046 μ g /AdT bleached pulp	—	--	NA
PULP (BEFORE BLEACHING)	0.33 μ g /AdT bleached pulp	—	—	--
C PHASE PULP	0.47 μ g /AdT bleached pulp	3.14 μ g /AdT bleached pulp	8-30	0.5
E PHASE PULP	0.33 μ g /AdT bleached pulp	0.73 μ g /AdT bleached pulp	8-30	0.5
H PHASE PULP	0.53 μ g /AdT bleached pulp	—	8-30	0.5
C PHASE WATER	0.046 μ g /AdT bleached pulp	0.017 μ g /AdT bleached pulp	4,5	0,06 after WT
E PHASE WATER	0.053 μ g /AdT bleached pulp	0.038 μ g /AdT bleached pulp	4,5	0,06 after WT
PAPER (WASTE PAPER)	0.63 μ g /AdT paper	—	8-30	3-10
PAPER (FROM STRAW)	1.20 μ g /AdT paper	1.20 μ g /AdT paper	8-30	0.5
SLUDGE	0.31 μ g /AdT bleached pulp	0.63 μ g /AdT bleached pulp	4,5 (100 μ g/ton)	0.2 (10 μ g/ton)
EFFLUENT	--	0.17 μ g /AdT bleached pulp	4.5	0,06

EMISSION FACTOR µg TEQ/AdT product paper	CONC. YUEYANG pg TEQ/g (L)	INPUT/OUTPUT PER YEAR 1 ROUND mgTEQ/year	YUAN JIANG Paper mill	CONC. YUANJIANG pg TEQ/g	INPUT/OUTPUT PER YEAR 1 ROUND mgTEQ/year
REED	0.36	43.2			Preliminary Based on
REED PULP BEFORE BLEACHING	0.13	7.1	Do PULP BEFORE BLEACHING	0.43	40.94
C PHASE REED PULP	3.8	206.7	D1 PULP AFTER_	0.67	56.95
E PHASE REED PULP	2.8	152.3	Do WATER	0.43	0.82
H PHASE REED PULP	2.9	157.8	D1 WATER	0.45	0.103
WOOD PULP BEFORE BLEACHING	0.2	12.2			
C PHASE WOOD PULP	4.4	269.3	PAPER FROM REED	0.65	61.88
E PHASE WOOD	2.4	146.9			
H PHASE WOOD	2.4	146.9			
ALKALI ASH	0.24	1.63	EFFLUENT	0.48	4.08
SLUDGE	8.2	69.7	SLUDGE	1.5	4.59

The demonstration production line in Hunan Tiger Forest & Paper Group, which uses reed as its raw material, utilizes dry process for raw material preparation, batch cooking and CEH three-stage bleaching. The executed BAT/BEP was dry & wet process of raw material preparation, continuous cooking, oxygen delignification and chlorine-free bleaching process (D_0---E_O--- D_1).The comparison of data before and after execution of BAT/BEP is shown in the following table, as well as compared with the data in toolkit.

After the excution of BAT/BEP (the traditional CEH 3-stage bleaching was replaced by oxygen delignification and chlorine-free bleaching) in bleaching reed pulp line of Tiger F&P Group, the emission of PCDD/F was reduced and investmental benefit and environmental benefit was achieved. The reduced amount of PCDD/PCDF per BDT bleached pulp is 3.12µg TEQ.

CAPITAL COST Installation expenditure				
Items	Baseline scenario In Yueyang	Baseline scenario In Yuanjiang	Main difference	Lifetime and period required to install
	Annual chemical reed pulp 54400 ton	Annual chemical reed pulp 85000 ton		
Washing stage for raw material	-----	Total cost 2,300,000 27 yuan/ton	In Yueyang no washing stage, in Yuanjiang closed washing stage	
cooking	Total cost 9,600,000 176 yuan/ton	15,300,000 180 yuan/ton	In Yueyang not continuous, in Yuanjiang continuous cooking	
Bleaching in Yueyang (not including stage P which was operated later)	Total cost 16,600,000 (305yuan/ton) + 11,043,200 (203 yuan/ton= = 27,643,200 508 yuan/ton			
C phase	5,300,000			10years
E Phase	4,600,000			10years
H phase	4,600,000			10years
P phase	1,200,000			10years
Water supply cost	100,000			10years
Chlorine supply	200,000			10years
Sodium Hydroxide	150,000			10years
Hypochlorite supply	500,000			10years
hydrogen peroxide supply	200,000			10years
Chlorine tank	200,000			10years
Sodium Hydroxide tank	200,000			10years

Hypochlorite tank	200,000			10years
hydrogen peroxide tank	200,000			10years
Heating of E stage	50,000			10years
Chemical preparation	500,000			10years
Contingency allowance	11,043,200 203 yuan/ton			
Bleaching in Yuanjiang		Total cost 49,500,000 (582yuan/ton) + 32,980,000 388 yuan/ton) = 82,480,000 =970 yuan/ton)		
O (oxygen delignification) phase		2,800,000		
D_0 (chlorine dioxide) phase		4,600,000		
E (sodium hydroxide) phase		2,800,000		
D_1 (chlorine dioxide) phase		5,200,000		
Oxygen tank		3,800,000		
sodium hydroxide tank		300,000		
chlorine dioxide tank		300,000		
Sodium Hydroxide supply		600,000		
chlorine dioxide production equipment		28,000,000	The equipment is imported and the cost is very high if compared with others	
Sodium Hydroxide tank		300,000		
chemicals preparation		800,000		
Contingency	---	32,980,000		

allowance		388 yuan/ton		
BOILER	28,000,000	45,000,000	Not necessary for evaluation of costs	
Pollution control (main and auxiliary equipment)				
Water treatment plant	28,000,000 total	35,000,000 total	Not necessary for evaluation of costs	
Investment Cost for waste water treatment from bleaching lines	8,000,000/ 54400= 147 Yuan/tons	6,000,000/ 85000= 70.5 Yuan/tons		
TOTAL CAPITAL COST	35,643,200 655 yuan/ton With wastewater without P bleaching	55,500,000 1040.5 yuan/ton With wastewater		
	831 Including washing and cooking	1247.5 Including washing and cooking		

		YANJIANG	EMISSION FACTOR μg TEQ/AdT product pulp	CHLORINE BLEACHING μg TEQ/AdT product pulp	ECF TCF μg TEQ/
REED	0.79	Process data based on Yuevang	Could be lower	TOOLKIT	
REED PULP BEFORE B.	0.13				
C PHASE REED PULP	3.8	Do PULP	0.43	8-30	0.5
E PHASE REED PULP	2.8				
H PHASE REED PULP	2.9	D1 PULP AFTER BLEACHING	0.67	8-30	0.5
WOOD PULP BEFORE Bleaching.	0.15			8-30	0.5
C PHASE WOOD PULP	4.4			8-30	0.5
E PHASE WOOD PULP	2.4			8-30	0.5
H PHASE WOOD PULP	2.4			8-30	0.5
ALKALI ASH	0.014	EFFLUENT	0.033	4.5	0.06
		Do WATER	0.01	4,5	0,06
		D1 WATER	0.001	4,5	0,06
		PAPER REED	0.65	8-30	0.5
SLUDGE	0.60	SLUDGE	0.038	4,5	0.2

ANNUAL OPERATING COST	Baseline scenario In Yueyang	Baseline scenario In Yuanjiang	Action
Annual chemical reed pulp	54400ton	85000ton	
Washing stage for raw material	4,188,800 yuan (only screening) 77 yuan/ton	9,520,000 yuan 112 Yuan/ton	In Yueyang no washing stage, in Yuanjiang closed washing stage
Cooking Total cost	35,088,000 Yuan 645 Yuan/ton	57,205, 000 Yuan 673 Yuan/ton	In Yueyang not continuous, in Yuanjiang continuous cooking
Alkali and other chemical material costs (yuan /ton pulp)	430	441	
Electricity in cooking (yuan /ton pulp)	42	60	
Steam consumption in cooking (yuan /ton pulp)	120	115	
Water costs in cooking (yuan /ton pulp)	10	8	
Other costs in cooking (yuan /ton pulp)	43	49	
Energy costs for bleaching process			
Electricity (unit price and overall cost)	Unit price: 0.36 yuan/kw.h Annual total price: 1,530,000 78.5kwh/ton pulp	Unit price: 0.525 yuan/kwh Annual total price: 5,530,000 124kwh/ton pulp	0.36yuan/kw.h(85,000ton) Annual total price: 3,800,000
Steam consumption	Unit price: 29.66yuan/GJ Annual total price: 4,840,000yuan 3.0 GJ/ton pulp	Unit price:24yuan/GJ Annual total price: 5,440,000yuan 2.7 GJ/ton pulp	Unit price:29.66yuan/GJ Annual total price: 6,800,000
Bleaching in Yueyang			

Water supply cost	**Unit price:0.497yuan/ton 64 ton water/1ton pulp**		
	1,730,000 yuan		
Chlorine supply	**5,880,000 yuan**		
	6% chlorine, 1,800yuan/ton		
sodium hydroxide supply	**2,720,000 yuan 2．5%alkaline 2000 yuan/ton**		
hydrogen peroxide supply	**4,300,000 yuan (6.0yuan/kg) 1.8%**		**Not to be included in the costs, because it was operated after the first analytical campaign**
Bleaching in Yuanjiang			
Water supply cost		**Unit price:0.37yuan/ton 25ton water/1 ton pulp**	**Unit price: 0.497yuan/ton 25 ton water/1ton pulp**
		780,000yuan	**1,060,000yuan**
Oxygen supply		**1,020,000 (600yuan/ton, 2。0%oxygen treatment)**	
sodium hydroxide supply		**5,600,000(bleaching 18kg/ton pulp, oxygen treatment 15kg/ton pulp, 2000yuan/ton)**	
Cost of effluent treatment in bleaching(yuan/ton pulp)	**46.4 yuan/ton 2,524,160 yuan**	**18 yuan/ton 1,530,000 yuan**	**(0.8 yuan/ton effluent, including water cost depreciation)**
Total operating cost (bleaching stage) (not stage P)	**16,700,000 +2,524,160= 19,224,160**	**28,570,000 +1,530,000**	
Total bleaching operating cost per ton (same standard) (not stage P)	**307**	**335**	

(not effluent treatment)			
Total operating cost per ton (same standard) (bleaching+washing and cooking)) (not stage P)	307 +77+645 =1029	335 +112+673 =1120	

BENEFITS	Baseline scenario In Yueyang	Baseline scenario In Yuanjiang	Notes
Annual chemical reed pulp	54400 tons	85000 tons	
Pulp cost (including routine maintenance, regular maintenance, facility depreciation)	2278 yuan/ton 123,923,200	2371 yuan/ton 201,535,000	
Paper cost (yuan/ton) Include also pulp cost production water treatment and other costs.	3940 yuan/ton 43520 tons 171,468,800 RMB	4156 yuan/ton 68000 tons 282,608,000 RMB	Paper 80% of the pulp
Paper net cost (paper –pulp)	1662		
Pulp/paper %	46.25	45.64	Calculated 80% bleached reed pulp per 1 ton paper
Paper price per ton	5100 yuan/ton 43520 tons 221,952,000	5500 yuan/ton 68000 tons 374,000,000	
Paper benefit per ton paper cost except pulp cost	1160 50,483,200	1344 91,392,000	490.1 595.4
Pulp benefit per ton	536.5	613.4	Focus on pulp benefit since paper benefit includes

			many different things like transport, package, etc.
Sale price difference (yuan/ton pulp)		**76.9**	
The amount of effluent treatment in bleaching	**58 tons**	**22.5 tons**	
Cost of effluent treatment in bleaching(yuan/ton pulp)	**46.4 yuan/ton 2,524,160 yuan**	**18 yuan/ton 1,530,000 yuan**	**(0.8 yuan/ton effluent, including water cost depreciation)**
Effluent treatment operating difference(yuan/ton pulp)	**-------**	**28.4**	
Sum of Benefit yuan/ton		**105.3**	

INCREMENTAL COST/EFFECTIVENESS EVALUATION

Since all costs are reported as RMB/Adt, the effectiveness will be calculated on the basis of the emission factors (reported as μg TEQ/AdT) of reduced PCDD/F, in order to have the cost expresses as RMB/mg of reduced PCDD/F

<u>First scenario</u>: **retrofit with ECF bleaching line in Yueyang maintaining the old treatment system for bleaching effluents**

	Capital cost (RMB/ton)	**Operating cost (RMB/ton)**	**Benefits (RMB/ton)**	**Emission rate (μg TEQ/AdT)**
Baseline (with chorine bleaching)	**508**	**307**	**490.1**	**4.1**
With ECF	**970**	**335**	**595.4**	**0.68**

bleaching				
	Incremental capital cost (RMB)	Incremental operating cost (RMB)	Incremental Benefits	Incremental effectiveness (μg TEQ/AdT)
Increments	970	28	105.3	3.42

Year	Incremental Cost stream (RMB/AdT)	Incremental Discounted cost stream (RMB/AdT)	Effectiveness mg TEQ/AdT
0	893	893	0.00342
1	- 77.3	-72	0.00342
2	- 77.3	-66	0.00342
3	- 77.3	-61	0.00342
4	- 77.3	-57	0.00342
5	- 77.3	-53	0.00342
6	- 77.3	-49	0.00342
7	- 77.3	-45	0.00342
8	- 77.3	-42	0.00342
9	- 77.3	-39	0.00342
Total Present value		410	
Incremental equivalent Annual cost $\Sigma^* \frac{d(1+d)^n}{(1+d)^n-1}$		76	
Incremental Cost/effectiveness ratio RMB/mg TEQ reduced		22,323	

<u>Second scenario</u>: Extended retrofit

	Capital cost (RMB)	Operating cost (RMBs/year)	Benefits	Emission rate (mg TEQ/year)
baseline		307+77+645=1029	490.1	4.1
With	970+27+4=1001	335+112+673=1120	595.4	0.68

modifications				
	Incremental capital cost (RMB)	Incremental operating cost (RMB/year)	Incremental Benefits	Incremental effectiveness (mg TEQ/year)
increments	1001	91	105.3	3.42

Year	Incremental Cost stream (RMB/AdT)	Incremental Discounted cost stream (RMB/AdT)	Effectiveness mg TEQ/AdT
0	987	987	0.00342
1	- 14	-13	0.00342
2	- 14	-12	0.00342
3	- 14	-11	0.00342
4	- 14	-11	0.00342
5	- 14	-10	0.00342
6	- 14	-9	0.00342
7	- 14	-8	0.00342
8	- 14	-8	0.00342
9	- 14	-7	0.00342
Total Present value		897	
Incremental equivalent Annual cost $\Sigma^* \frac{d\,(1+d)^n}{(1+d)^n-1}$		167	
Incremental Cost/effectiveness ratio RMB/mg TEQ reduced		48,880	

<u>Third scenario</u>: Comparing the difference of cost in building a new ECF plant instead an old plant with chorine bleaching

<u>First hypothesis: with washing and cooking</u>

	Capital cost (RMB/ton)	Operating cost (RMB/ton)	Benefits (RMB/ton)	Emission rate (µg TEQ/AdT)

Yueyang (bleaching + cooking + effluent tretment	**831**	**1029**	**490.1**	**4.1**
Yuanjiang (bleaching+ washing+cooking+ effluent treatment)	**1247.5**	**1120**	**595.4**	**0.68**
	Incremental capital cost (RMB)	**Incremental operating cost (RMB)**	**Incremental Benefits**	**Incremental effectiveness (µg TEQ/AdT)**
Increments	**416.5**	**91**	**105.3**	**3.42**

Year	**Incremental Cost stream (RMB/AdT)**	**Incremental Discounted Cost stream (RMB/AdT)**	**Effectivenes s mgTEQ/Ad T**
0	**402**	**402**	**0.00342**
1	**- 14**	**-13**	**0.00342**
2	**- 14**	**-12**	**0.00342**
3	**- 14**	**-11**	**0.00342**
4	**- 14**	**-11**	**0.00342**
5	**- 14**	**-10**	**0.00342**
6	**- 14**	**-9**	**0.00342**
7	**- 14**	**-8**	**0.00342**
8	**- 14**	**-8**	**0.00342**
9	**- 14**	**-7**	**0.00342**
Total Present value		**313**	
Incremental equivalent Annual cost Σ* d (1+d)n (1+d)n-1		**58**	
Incremental Cost/effectiveness ratio RMB/mg TEQ reduced		**17042**	

Second hypothesis: without washing and cooking

	Capital cost (RMB/ton)	**Operating cost (RMB/ton)**	**Benefits (RMB/ton)**	**Emission rate (µg TEQ/AdT)**

Yueyang (without cooking)	**655**	**307**	**490.1**	**4.1**
Yuanjiang (without washing+cooking	**1040.5**	**335**	**595.4**	**0.68**
	Incremental capital cost (RMB)	**Incremental operating cost (RMB)**	**Incremental Benefits**	**Incremental effectiveness (μg TEQ/AdT)**
Increments	**386**	**28**	**105.3**	**3.42**

Year	Incremental Cost stream (RMB/AdT)	Incremental Discounted cost stream (RMB/AdT)	Effectiveness mgTEQ/AdT
0	309	309	0.00342
1	- 77	-72	0.00342
2	- 77	-66	0.00342
3	- 77	-61	0.00342
4	- 77	-57	0.00342
5	- 77	-53	0.00342
6	- 77	-49	0.00342
7	- 77	-45	0.00342
8	- 77	-42	0.00342
9	- 77	-39	0.00342
Total Present value		-174	
Incremental equivalent Annual cost Σ* d (1+d)n (1+d)n-1		-32	
Incremental Cost/effectiveness ratio RMB/mg TEQ reduced		Not possible	

V. BAT/BEP to reduce UP-POPS

By comprehensively considering the release source of dioxin in different process of paper making, the best available technology for pulp and paper making mills which uses chlorine bleaching are as followed:

- To use more effective pulp washing method;
- Not to use wood or reed that polluted by polychloride;
- To reduce the usage of chlorine and add more chlorine dioxide ECF as substitution;
- To use depth delignification technology and reduce remaining lignin that enter into bleaching plant;
- To use oxygen treatment to remove remaining lignin after cooking;
- To use biology enzyme for pre-bleaching and reduce the usage of chlorine;
- To use hydrogen peroxide or ozone bleaching;
- To control the sludge treatment;
- To rationally control soda recovery burning process of wood or reed pulp;
- To dispose deinking sludge of waste paper effectively.

VI. General introduction of strategies to reduce and eliminate dioxins in Chinese paper making industry

(1) Raw material and generation of wastes

The raw materials for pulp and paper making include fiber (wood fiber, non-wood fiber and waste paper) and supplementary chemical materials (calcium carbonate, PAM, sodium sulfide, sodium hydroxide). Fiber raw material for paper making includes non-wood fiber, wood fiber and waste paper, etc. Non-wood fiber includes reed, bamboo, bagasse, cotton and linen, agrimony, rice and wheat straw and annual plant straw. Over 90% of pulping raw material (exclude waste paper) is wood fiber in the world paper making industry, but in China the ratio of wood is less than non-wood raw material such as straw. China is the biggest straw pulp production country in the world. The fiber raw materials for paper making in China include many kinds of woody plant and herbage. Wood material mainly includes loblolly pine, masson pine, poplar and birch, while herbage includes reed, Chinese silver grass, bamboo, bagasse, wheat straw, rice straw, Chinese alpine rush, hemp, cotton, etc. In recent years, the ratio of wood pulp increased, mainly due to imported chip and imported wood pulp (the imported wood pulp is 60% of the total). The wood pulp reached 22% in 2005. The proportion of waste paper pulp rose from 28.2% in 1990 to 54% in 2005 (imported 26%). The proportion of non-wood fiber went down year after year, from 57.2% in 1990 to 24% in 2005. However, its absolute amount is still increasing, and there will be no evident decrease in short period.

Waste water, residues, gas, noise, etc. are generated in pulp and paper making process. The exhaust gas in paper mill is mainly from fuel burning. The CO_2 created by reproducible biology fuel such as pulping black liquor, bark, etc. does not increase the greenhouse effect. But the most consumptive energy in national pulping and paper making industry at present is mineral fuels. The vehicles, electric power station and alkali recovery furnace release oxides that containing sulfur and nitrogen, which causes acidification of air and hazard the regional environment. Also the dust and fume are harmful to the nearby community.

Pulp and paper making effluent comes from process water, which carry over remaining chemicals and soluble fiber chemical components. Chemical bleached pulping will generate pulping black liquor (in alkali recovery system inorganic substances are recovered; organics are combusted to produce heat) and bleaching waste water containing organic chloride. The chemicals after mechanical pulping and waste paper pulping and the separated or detached fiber debris are drained out with waste process water. Most of the process water is recycled after treatment within the paper making plant. A small quantity of waste water containing organic and mineral is discharged. The waste water from pulp and paper making process will finally be sent to the effluent treatment plant, and be discharged after physical chemical treatment and biological chemical treatment. Solid wastes are generated in every stage of the whole pulp and paper making procedure. For example, sludge treatment out of the mill may causes pollution to environment. To apply cleaning production technology or improve the utilization of resources could obviously reduce environmental hazard from waste water, gas and solid.

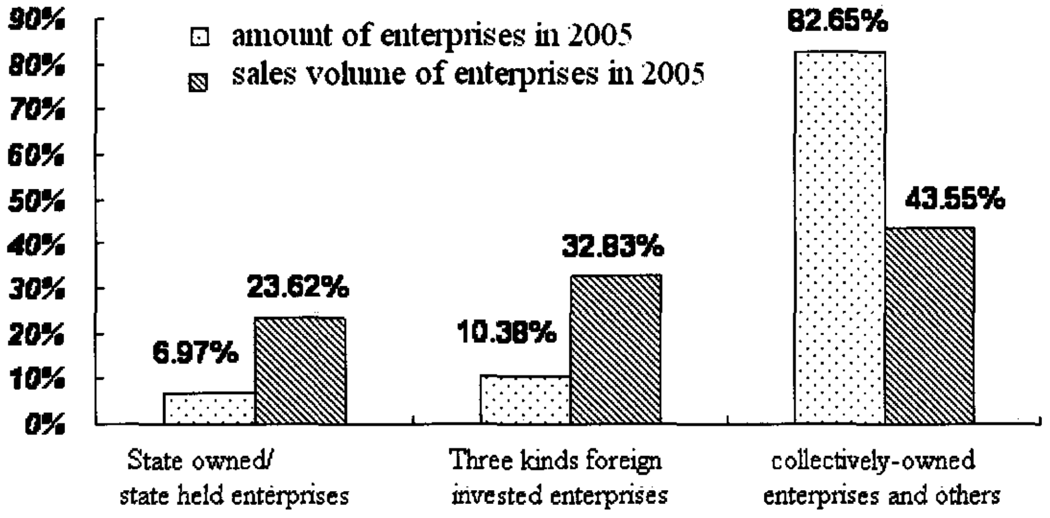
The organic chloride——dioxin exists as a by-product in pulp and paper making process, and its source closely relates to pulping raw material (including waste paper) , chemical engineering materials(bleaching agents, de-foaming agent), and the process and equipment for pulping, washing and screening.

(2) Description of enterprises

According to statistic analysis on medium/large scale paper making enterprises by National Statistical Bureau of China, there are 233 state-owned and state-held enterprises, accounting for 6.97%, reduced by 3.2% comparing to 10.17% last year; 347 foreign-invested enterprises or ventures (three kinds of enterprises including Sino-foreign joint ventures, cooperative businesses and exclusively foreign-owned enterprises in China) accounting for 10.38%, increased by 1.77% comparing to 8.61% last year; 2762 collectively-owned enterprises and others accounting for 82.65%, increased by 3.01% comparing to 46.56% last year. In total sales revenue of paper and board products, state-owned and state-held enterprises account for 24.22% which has reduced by 3.3% comparing to 27.52% last year; three kinds foreign-invested enterprises or ventures account for 29.75%, reduced by 3.46% comparing to 33.21% last year; collectively-owned enterprises and others account for 46.03%, increased by 6.76% comparing to 39.27% last year. In total profit payments and tax turnover of paper and board products,, state-owned and state-held enterprises account for 21.76% which has reduced by 2.45% comparing to 24.21% last year; three kinds foreign-invested enterprises or ventures account for 33.38%, reduced by 6.62% comparing to 40.00% last year; collectively-owned enterprises and others account for 44.87%, increased by 9.08% comparing to 35.79% last year.

The above data indicates that the economic type and structure of domestic paper making enterprises is still changing in 2005. Comparing to 2004, the total amount of paper enterprises went up to 3342 from 3009 with 333 new enterprises added in, but state-owned and state-held enterprises reduced by 73 enterprises to 233 enterprises.

Collectively-owned enterprises and others developed relatively faster, amount of these enterprises increased, and the major economic indicators such as sales income, total profit payments and tax turnover and tax profit climbed a lot than last year.



Data source:State Statistical Bureau
(staticstics on enterprises of certain scale)

(3) Industrial economy

According to the statistics of National Statistics Bureau, in 2005 the amount of paper enterprises of certain scope reached 3342, which is 333 more than 3009 in last year; the employees reached 762,600, which is 2,400 more than 760,200 in last year; the total capital value reached 322.8 billion, increased by 16.32% than last year; the total industrial output value (price in the same year) is 262.2 billion, increased by 24.68% than lat year; sales income is 254.6 billion, increased by 26.73%; production to marketing rate is 97.47%, 0.21% higher, total profit payments and tax turnover is 22.52 billion, up by 21.53%; in which total profit is 12.32 billion, grew by 23.69%; asset-liability rate is 61.84%, 0.19 % less than 62.03% last year; gross liabilities is 199.64 billion, rose by 15.98%. Among the 3342 paper enterprises in the statistics, there are 662 loss-making enterprises, amounting to 19.81%, increased by 0.63%. So from the above data, the paper industry in China keeps well rising tendency in 2005.

According to the statistics of National Statistics Bureau, in 2003 the production of top 30 key paper enterprises in China reached 1.12395 million ton, accounting for 26.1% in total production; in 2004 production of top 30 key paper enterprises reached 1.4595 million ton, accounting for 29.5%; in 2005 it reached 1.8429 million ton, accounting for 32.9%.

Main paper enterprises in china are listed in the following tables:

Top 30 key paper making enterprises of production in 2005

Number	Enterprise	production（10,000 ton）		
		2005	2004	y-o-y%
1	Dongguan, Jiulong Paper CO.,LTD	228.00	169.92	34.18
2	Shandong,Chenming Paper Group CO.,LTD	205.46	144.41	42.28
3	Jiangsu, Jindong Paper CO.,LTD	148.06	130.08	13.82
4	Liwen Paper CO.,LTD	119.08	87.00	36.87
5	Shandong, Sun Paper CO.,LTD	108.50	87.90	23.44
6	Ningbo, Zhonghua Paper CO.,LTD	100.73	53.77	87.33
7	Huatai Group CO.,LTD	83.67	76.82	8.92
8	Hunan Tiger Forest and Paper Group CO.,LTD	64.28	54.12	18.77
9	Shandong, Bohui Paper CO.,LTD	62.72	60.00	4.53
10	UPM, Changshu CO.,LTD	55.00	37.41	47.02
11	Anhui, Shanying Paper CO.,LTD	48.66	44.76	8.71
12	Guangzhou Paper Group CO.,LTD	47.45	45.29	4.77
13	Jinhuasheng Paper CO.,LTD (Suzhou industrial area)	43.59	36.57	19.20
14	Shandong(Linqing),Yinhe Paper Group CO.,LTD	41.00	38.00	7.89
15	Xinxiang, Xinya Paper Group CO.,LTD	41.00	33.00	24.24
16	Shandong, quanlin Paper CO.,LTD	38.55	34.15	12.88
17	Zhejiang, Jingxing Paper Group	38.14	26.80	42.31
18	Zhongshan united Hongxing Paper CO.,LTD	35.22	30.55	15.29
19	Henna, Yinge Industrial Investment Group	35.00	19.20	82.29
20	Shandong, huajin Group CO.,LTD	32.70	22.51	45.27
21	Fujian, Nanzhi CO.,LTD	30.50	29.32	4.02
22	Dongguan, Jinzhou Paper CO.,LTD	30.00	26.00	15.38
23	Ningxia, Meili Paper CO.,LTD	28.40	25.78	10.16
24	Wuxi, Rongcheng Paper CO.,LTD	27.41	27.73	-1.15
25	Fujian (Jinjiang) Youlanfa Paper CO.,LTD	26.00	22.00	18.18
26	Hebei, Yongixing Paper CO.,LTD	25.70	23.10	11.26
27	Shandong, Yongfa Paper CO.,LTD	25.08	16.50	52.00
28	Dongguan, Jianhui Paper CO.,LTD	25.00	10.00	150.00
29	Fujian, Qingshan Paper CO.,LTD	25.00	24.08	3.82
30	Zhuhai Special Economic Zone Hongta Renheng Paper CO.,LTD	23.00	22.73	1.19

Top 30 Papermaking Enterprises of Sales income in 2005

No.	Name	Sales Income (0,000 RMB)
1	Shandong Chenming Paper Group	1716831
2	Huatai Group	751289
3	Jindong Paper (Jiangsu)	688366
4	Shangdong Sun Paper	591668
5	Dongguan Jiulong Paper	539979
6	Shandong Bohui Paper	520280
7	Shandong Quanlin Paper	459500
8	Hunan Tiger F&P Group	420750
9	Li Wen Paper	392896
10	UPM(Changshu) Paper	308000
11	Ningbo Zhonghua Paper	283100
12	Jinhuasheng(Suzhou)Paper	241593
13	Shandong(Linqing)Yinhe Paper	234735
14	Guangzhou Paper Group	201000
15	Henan Yinge Industrial Investment Corporation	180000
16	Fujian Nan Paper	158660
17	Shandong Huajin Group	155051
18	Zhuhai Hongta Renheng Paper	152000
19	Shandong Yatai Senbo Pulp & Paper Co.	149366
20	Anhui Shanying Paper	148012
21	Zhejiang Jinxing Paper	136713
22	Shandong Taishan Mountain Paper	132766
23	Ningxia Meili Paper	128884
24	Jinhongye Paper(Suzhou)	127935
25	Xinxiang Xinya Paper	126000
26	Fujian Qingshan Paper	117772
27	Zhejiang Yongtai Paper	113946
28	Shandong Weifang Henglian Investment Corporation	102214
29	Zhongshan United Hongxing Paper	93313
30	Mingfeng Group	91227

(4) Development tendency of paper market and industry

1. The developing tendency of papermaking industrial market in China

Since the establishment of People's Republic of China, the production and consumption of paper and board in China have kept continuous stable increase. The annual average growth rate of production and consumption were more than 9%, which was 5-6% higher than the growth rate of global papermaking industry in the same period. China has achieved outstanding performance in the progress of global papermaking industry: the consumption per capita increased to 45 kg from 0.7 kg. The growth speed is especially rapid after 1978, from 5 kg to 45 kg, the annual growth rate was 8.5%. However, compared with the American consumption of 300 kg per capita, there is still a wide gap between China and US.

According to an investigation report by Finnish Company JP, there is a relationship between GDP per capita and consumption of paper & board per capita. When GDP per capita of global papermaking industry is less than 2000 US dollar, the industrialization of society and the consumption development of paper & board are both low; when the GDP per capita is about 3000 to 13,000 US dollar, the consumption of paper & board increases linearly with the development of overall economy; when GDP per capita is over 15,000 dollars the consumption of paper & board starts to increase slowly.

According to the investigation on relevancy of Chinese papermaking industrial development and social development, this linear relationship is also true with the Chinese consumption of paper & board per capita and GDP per capita, in which, the correlation coefficient R^2 is 0.978 and the relative model is $Y=382.021+0.4816x$.

Based on the linear regression equation of consumption of paper & board and GDP per capita, the estimated consumption in 2020 will be more than 110million ton.

By the end of 2020, the development target is to make the Chinese national economy to be tripled as the value of 2000, the total economy value to be 35 trillion -36trillion; the GDP per capita to be 24,000 RMB (3,000 dollar); the average annual economic growth will be about 7%; the gross population will be about 1.5 billion and the urbanization rate will be above 50%. In this case, the development of national economy and the continuous increase of consumption will support and motivate the development of paper industry, and Chinese paper industry will remain in development course during this time. According to the comprehensive consideration of uncertain factors that affect the development of national economy and the development forecast of relative industry, it is preliminarily confirmed that: the annual average growth rate of Chinese paper & board consumption in 2000 – 2020 will be 6.02%, in which, the growth rate in 2000 – 2005 will be 10.65%; 7.5% in 2005 – 2010; 3.10% in 2010 – 2015 and 3.03% in 2015 – 2020. And based on the estimated growth rate, Chinese paper and board consumption will be 59.3 million ton in 2005; 85 million in 2010; 99 million in 2015 and 115 million in 2020.

The develop potential of paper market in future will include:

- to fulfill the domestic market demand
- to expand export volume
- to sort out laggard capacity for increasing market share

According to the estimated demand and supply of paper & board, during 2000 – 2020, the homemade paper products will dominate Chinese paper & board market with self sufficient rate of domestic products at above 85%.

The estimated self sufficient rate of domestic paper/board products

	2000	2005	2010	2015	2020
demand（0,000t）	3575	5930	8500	9900	11500
domestic supply（0,000t）	3050	5600	7600	8700	9800
net import （0,000t）	525	330	900	1200	1700
self sufficient rate of domestic paper/board product（%）	85.31	94.44	89.41	87.88	85.22

2. The developing tendency of Chinese paper industry

（1）A brand new competitive situation of market and subject of investment will be formed in Chinese paper industry.

Paper industry is an openly competitive industry. The internationalization of Chinese paper industry is accelerated obviously with internationalization of market, investment, technology & equipment. Chinese paper industry is faced with a brand new competitive situation of market and investment subject, in which 41% market is taken by imported paper and "three-kind foreign invested enterprises or ventures", which developed most rapidly, and the other 59% is shared by domestically-funded enterprise, as a result, China will be the focus point for the M&A of international paper industry. The shape of new Chinese paper industry will be affected by selecting multiple subjects of investment; utilizing domestic and overseas capital and forming up the orderly competitive market.

(2) Due to the fact that the structural contradiction of paper industry is still severe, the most radical and exigent task of the industry is to optimize structure and improve the comprehensive strength and competitiveness.

Generally speaking, Chinese paper industry is now in the conversion period from traditional industry to modernized industry. In the environment that the global economy is in harsh competition there are a lot of opportunities and challenges. As a result, the following measures must be taken: firstly, to optimize industrial structure to fit into the overall industrial development tendency; secondly, to accelerate the construction of integration project of "forest, timber, pulp & paper", optimize raw material structure and reuse more domestic waste paper to solve the contradiction of demand & supply; thirdly, to promote technical innovation for increasing the proportion of production capacity for medium & high level products, increasing brand product, optimizing the product mix and adapting the conversion of consumption structure from low level to high level; fourthly, to promote the asset reform, merge and acquisition to improve economical scale of the enterprises, optimize business structure for creating a group of international advanced companies and products and improving the integrative strength of Chinese paper industry and the competitiveness in domestic and overseas market.

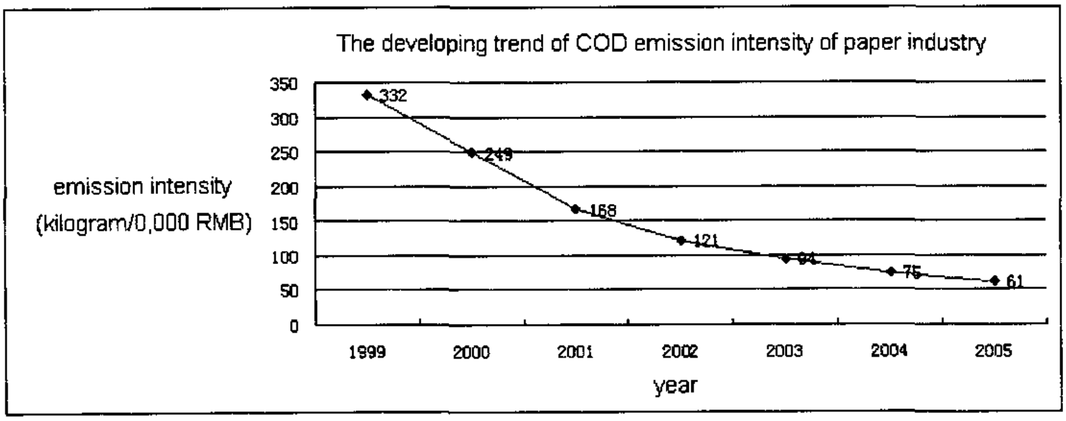
(3) It is imperative to solve the problem of resources shortage and environmental impact, reform the development mode, and execute the strategy of sustainable development.

Generally speaking, the traditional developing mode, which supported the rapid development of Chinese paper industry in the past 20 years, has caused great pressure in resources and environment and now facing great challenge. Therefore, based on the principle of scientific development and circulating economy, Chinese paper industry should change the developing concept, reform its developing mode and improve the developing quality. With the precondition of continuous development, the concept of "water saving, energy saving, consumption reducing, contamination reducing and benefit increasing" must be considered as the primary target; on the other hand, the resources must be used efficiently & circularly and the traditional paper industry should be changed to modernized industry under the implementation of cleaning production and technical innovation to improve the sustainable development of paper industry.

(5) Discussion on environmental protection of Chinese paper industry

The governing guideline of "comprehensive control and environmental protection mainly by paper mills" is taken by Chinese paper companies. With the effort of environmental control, adjustment of business structure, closedown of old mills with heavy pollution, establishment of modernized mills, introduction of overseas advanced technique & devices and increase of wood & recycled pulp's proportion in raw material structure, the governing effect of pollution was improved and the emission intensity of output value per ten thousand RMB was reduced year by year. As a result, the environmental pollution of paper industry was under control and the industry is developing to the beneficial cycle. As showed in the following table, the developing tendency of COD emission intensity of paper industry was reduced from 332 kg/10,000RMB (1999) to 62 kg/10,000RMB (2005) , reduced by 81.6%, which means the pollution prevention of Chinese paper industry has made a great progress. However, compared with other industries in national economy, the environmental pollution of paper industry is still higher in regard to its economic contribution. Therefore, the technology of cleaning production must be executed for harmonization of the development of industrial economy and environmental protection.

The developing tendency of COD emission intensity of paper industry unit: t/0,000 RMB



(6) Estimated total amount of dioxins discharged to environment

The Chinese consumption of paper and pulp in 2005 was 52 million t with 11.3 million t wood pulp, 12.6 million t non-wood pulp and 28.1 million t recycled pulp. The imported amount of paper and pulp in 2005 was 7.59 million t (with a major part of ECF wood pulp and a small part of TCF wood pulp) while the exported amount was 47,000 t. Exclude the recycled pulp and imported pulp, the Chinese output of wood and non-wood pulp in 2005 was 16.3 million t with 3.7 million t wood pulp and 12.6 million t non-wood pulps.

Chlorine bleaching processes has dominant position in pulping technology now in China, the ratio of chlorine-free bleaching of chlorine dioxide is increasing, but only a small amount of chlorine-free bleaching and mechanical pulp is used. Based on preliminary evaluation, among 16.30million ton pulp, TCF pulp is not very much; the production of ECF bleaching pulp is about 10% and the annual production is about 1.5million ton, the mechanical pulp is 2million ton; semi-chemical straw brown stock is about 4.8million ton; the annual production of kraft pulp which bleached by Cl_2 is 8million ton. The emission amount of dioxin in China is listed in following table:

The emission amount of dioxin

Item	Pulp Production/ (10000ton)	Water		Product		Residue	
		µg TEQ/ Adt	PCDD/Fs /g TEQ	µg TEQ/ Adt	PCDD/Fs /g TEQ	µg TEQ/ ADt	PCDD/Fs /g TEQ
Kraft pulp bleached by cl_2	800	4.5	36	8	64	4.5	36
TCF pulp	NA	1		3		1.5	
ECF pulp	140	0.06	0.084	0.5	0.7	0.2	0.28
Sulfite pulp (Cl2)	10	ND		1	0.102	ND	
Mechanical pulp	200	ND		1	2.0	ND	
Recycle paper （deinking）	800	ND		10	80		
Recycle paper （ no deinking）	1500	ND		3	45	ND	
Imported pulp	759			0.5	3.80		
Black liquor boiler	500	0.07(Air)	0.35(Air)				
Total			36.08		195.60		36.28
Total	267.97						

—In 2005, the total emission amount of PCDD/Fs is 268g TEQ in pulp and paper making procedure.

（7）Technical options to reduce dioxins emission in Chinese paper industry

Technologies for reducing /eliminating the dioxins which produced in the process of papermaking are multilayer and all round technologies, include：

1、More effective pulp washing;

2、To use papermaking raw material without polychlorinated treatment;

3、ECF e.g. chlorine dioxide bleaching instead of chlorine gas bleaching;

4、To adopt DDT (depth delignification technology), reducing remain lignin into the bleaching plant;

5、To adopt oxygen delignification technology to further remove the remaining lignin;

6、To use bioenzyme for pre-bleaching, reducing chlorine use;

7、To use H202/ozone for bleaching;

8、To control the sludge handling;

9、To optimize the combustion process in the alkaline recovery system;

10、To dispose the deinking sludge effectively.

According to the related requirement of industry policy, "Presently, pulping enterprises that use chlorine bleaching should reduce/eliminate the process, new enterprises should forbid the use of chlorine bleaching process.", the technologies are somewhat different for new enterprises and existing ones. For new enterprises using bleaching process, the technology choices mainly include: oxygen delignification technology (adopt oxygen technology to further remove the remaining lignin) combined with chlorine-free bleaching and hydrogen peroxide/ozone bleaching. For existing enterprises using chlorine bleaching, the possible solutions are: to decrease the amount of chlorine; use the technology of chlorine dioxide bleaching instead of chlorine gas; adopt DDT (depth delignification technology), reducing remaining lignin into the bleaching plant; use bioenzyme for pre-bleaching, reducing chlorine; control the sludge handling.

Either for new enterprises or the existing ones, importance should be attached to the following technical options, including use effective way for pulp washing; not use wood and reed that polluted by polychloride for pulping; optimize the combustion process in the alkaline recovery system; and effective disposal of deinking sludge.

(8) Budget estimation on incremental cost for reducing POPS emission

By far, 8 million ton's existing pulping facility using chlorine bleached process were rebuilt to chlorine-free bleaching process, to calculate based on 1001 Yuan/ton as rebuild cost, the total price is 8.008 billion Yuan.

Based on the calculation for the coming ten years, the total pulp production in 2015 will be 21.15 million ton, increasing capacity of 4.85 million ton pulp and 2.8 million bleaching pulp over 2005. By the comparison of investment per ton pulp, ECF production is 416.5Yuan more than chlorine bleaching, total incremental cost is 1.166 million yuan.

The summed price of above is 9.174 million yuan, equal to 1.18 million dollars.

(9) Possible barriers and sources of leverage during implementation

The project will try to identify and remove obstacles and to make full use of leverage in the fulfillment of project objectives. Possible sources of leverage include:

For enterprises using chlorine, the eliminating technology should be the necessary means and adopting the substituted bleaching technology without chlorine is the future developing direction and the obligation, duty to the enterprises. So propaganda about implementing the Convention and consultation and instruction to the substituted technology of bleaching by chlorine in paper industry throughout the country should be carried out. Moreover experimental work in developed provinces should be done. Preliminarily it is considered that carrying on the promotion work of reducing chlorine for bleaching and instructing the enterprise to rebuild the technology of substituting chlorine for bleaching in Shandong, Guangdong, Zhejiang, and Jiangsui province, then on the basis of experiences got in those provinces reducing and substituting chlorine in bleaching process is carried out all over the China.

Possible barriers include:

- Although Dioxin-liking POPs are formed in the course of pulp bleaching using chlorine, there are some advantages using chlorine or bleacher containing chlorine to bleach pulp, such as good selectivity, low cost and low equipment investment in the degradation of lignin, and so on. Now almost all pulping plants use bleacher containing chlorine (such as ClO2, hypochlorite) for bleaching in China. There is much resistance and obstacle in reducing or eliminating bleaching process with chlorine in China, so strict plan and mechanism of implementation plan are needed. At the aspect of capital mechanism, the state or local government should provide the necessary financial support to enterprises who are active to take reducing and eliminating measures to rebuild the bleaching process and encourage them to fulfill the obligation of implementing the Convention spontaneously and voluntarily.

- The implementing plan of the Convention cannot be carried out exactly without the safeguard of technology research. Now there are a few technology obstacles for implementing the Convention in China paper industry. A large proportion of raw materials for paper making in China are grass. As different materials are used between our country and other counties, there are much differences of pulping, bleaching process, water consumption of unit production, etc. Thus the overseas technologies of reducing or eliminating dioxin in the course of pulping with wood as raw materials can not applied in China paper industry directly. It is blind and unrealizable for citing oversea data simply

(10) Function mechanism of political measures on convention implementation

People's Republic of China ratified the Stockholm Convention in 2004 and is now making provisions for Convention implementation, which has laid a solid foundation for the sustainability of the project. The commitment of People's Republic of China to the implementation of the Convention and all its efforts for the development of a NIP provide initiatives to mainstream the objectives of the Convention into the nation's broader development policies and strategies, and opportunities to engage a wide range of stakeholders.

Various objectives of the full project are directed to remove barriers to the acceptance of BATs and BEPs so as to reduce or eliminate emissions of dioxin and furan in pulp and paper sector.

Chinese government will enact a law on papermaking industry which strictly limits the use of chlorine bleaching process in new project and state that the chlorine bleaching process will be eliminated gradually. All of those provide an important and powerful policy safeguard for China papermaking industry.

China is taking great efforts to boost the economic restructuring and change of economic growth pattern from extensive growth to intensive growth and put forward a sustainable development policy target such as saving energy and water. The BAT/BEP technologies for reducing emissions of POPS are all clean production technologies, they are not only beneficial for reducing the emission of POPS, but also beneficial for energy and water saving in the paper mills. The ECF process is one of the basic processes in papermaking system closed circulation. Sustainability will also be enhanced through the dissemination of information and public awareness materials and by the high degree of capacity building.

(11) Possible effects in GE plan frame

Implementation of the project will provide technical and political support for the next GE plan to be implemented successfully in China.

Implementation of the project has given a preliminary understanding for the current conditions and the amount of POPS of China paper industry, one of the most important achievement of the project was promoted the national government to set up the policy of "Forbidden the use of chlorine bleaching process in new project and gradually eliminate chlorine bleaching process in existing system" during drafting of "policies on Chinese paper making industry". The effectiveness of the policy provides significant and powerful policy guarantee for the convention implementation of China paper industry.

In the aspect of promoting the realization on the convention, through stimulation effect of demonstration enterprise who implements reducing emission of POPS; training the people of the same industry and propaganda about implementing the convention, a fine atmosphere for implementing the convention in Chinese paper industry has been formed and a good foundation for GE plan has been established.

Since the fiber materials are different between Chinese and foreign paper industry, the representative enterprises which use non-wood cellulose such as rice straw and reed were chosen as demonstration enterprises in implementation the emission reduction of POPS.

Waste paper DIP plant was also tested. Based on the related test data, incremental cost of unit pulp was calculated, and incremental investment cost for the whole industry was assumed, target of technical and capital support for Ge plan implementation was determined.

This project has the potential to bring in various effects in GE plan frame; the convention by paper industry is in line with the national requirement for sustainable development strategy, with the industrial requirement for technical advancement, industrial restructuring and the upgrade of industry development; and with the requirement for ensuring people's health and industry sustainable development. GE plan will implement successfully in Chinese paper industry and achieve good effect beyond expectation.

Sino-Italian BAT-BEP Program to Control and Reduce Emission of Unintentional Persistent Organic Pollutants

Analytical Report on Reducing Unintentionally Produced POPs in Iron and Steel Industry of China

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China Iron & Steel Association
1 June 2007

CONTENTS

I. General information on industrial development and reducing unintentionally produced POPs in iron and steel sector of China

With more and more rapid urbanization and industrialization in China, Steel structure engineer in construction, automobile and ship manufacture industry constantly promote the consumption of the steel material market. By the influence of requirement of China and international steel market, the yield of steel in 2005 in China reaches 355,790,000 tons, the raw iron 343,750,000 tons, and the steel products 377,710,000 tons.

China is becoming a steel great nation in the world, the yield of steel production is no longer the main problem, the emphasis for sustainable development of China iron and steel industry is resolving the problem of industrial structure, product structure, equipment structure and industrial distribution etc.; Alleviating the pressure of iron ore, coal, conveyance, electric power, water resources etc.; paying more attention to the environmental protection problem, promoting the construction of circulatory economy and economical manufacture of iron and steel industry, producing qualified and low capital costs product with lowest resources consumption, highest produce efficiency, superior quality control and minimum of environment burden closely "zero emissions".

The environment capacity has already started to limit the extending of China iron and steel enterprises, and the increasing of productivity .The target of our country is that the total amount of waste should be continuously descended, And strictly controlled or forbidden to setting up and expanding the high energy requirement factory such as steel and metallurgy industry etc. in the city or its suburb. The construction investment project of steel, electrolysis aluminum and cement should be managed seriously, and the management of investment ,field using, credit, judgment of environment and quality should be strengthened, quasi- market strictly.

The Persistent organic pollutants (POPs) are a group of toxic chemicals produced by mankind which can be existed for a long time in the environment and harmful to mankind's health and environment. For example, POPs accompanied with smoke and dust can be absorbed by plants after getting into the soil, and accumulated through food chain(net) of creature, then getting into the body of domestic animal and human.

Polychlorinated dibenzo-p-dioxins (PCDDs) and Polychlorinated dibenzofurans (PCDFs) are usually named dioxins. Dioxins is not the natural chemical material in environment, but be produced accompanying with mankind's production. The DTI by medical science (DTI: the quantity that can't influence human body's health taken in everyday) is no more than 4nng per. average one kilogram weight. Because the global and Persistent property the pollutants have, the international society pays extensive attention to it. On May 22, 2001,UNEP passed the 《Stockholm convention on Persistent organic pollutants(POPs)》at Stockholm in Sweden, the dioxins is included in the first 12 kinds of POPs lists which is controlled in the Convention. China is one of first batch signature countries.

As the developing country with quickly increasing economy, China is facing more complicated environment problem than developed countries. As the normal pollutants haven't been gotten a valid control, 12 kinds of POPs controlled by Stockholm Convention become the environment problem that our country should be resolved urgently. Because of China is still a developing country, the level of whole equipments in iron and steel industry is still not high, the degree of industry concentration is low, the amount of equipments is large but the distribution is wide, effective monitor and evaluation towards produce equipments containing POPs like dioxin, furans, and benzypyrene is lacked, and the relative emissions standard has not been studied and drawn up yet.

The dioxin can be formed by polymerization, substitute reaction and radical reaction etc. it also can be synthesized by a complicated reaction with hydrocarbon compound and inorganic chlorine in the condition of rich oxygen and catalyst. The main condition of formation is :1)composition condition: The raw material has the hydrocarbon compound containing chlorine;2)temperature condition:200 ℃～600 ℃, and the range of 250 ℃～400 ℃ is the best temperature zone for the formation of dioxin; 3) catalysis condition: such as some metal oxides in the dust. In accordance with international research experience, the Iron ore sintering and the electric arc furnace steel-making process are the vital segments which produce the persistent organic pollutant of the dioxin in the working procedure.

China steel industry produced common sinter ore 51,748,000 tons, high basicity sinter ore

317,486,700 tons, iron ore pellet 59,114,300 tons, the steel yield of electric arc furnace process is about 42,000,000 tons in 2005.China implement action plan of 《Stockholm convention on persistent organic pollutants(POPs)》has fully estimated the dioxin emissions of China iron and steel industry, and paid great attention and studied the possible measures to reduce or eliminate releases. The data by estimation and analysis is as follows:

Table.1

Serial number	Emission sources and category	The quantity dioxin emissions per year (g TEQ/year)				
		air	water	production	residue	Total amount
2	Steel and other metals producing	1603.5	13.5		2554.8	4171.9
Among them	Iron ore sintering	1150	0		0.69	1150.7
	Coke producing	239.2	13.4		0	252.6
	Iron and steel making	123.5	0		628.1	751.6

For implementing the obligation in the Convention, the government of our country is actively developing the project of releases reduction of POPs. Italian environment and national *territory department (IMET) donates our country to develop the project of reduce and* eliminate releases of unintentional production POPs by Sino-Italian Cooperation office.

Under this background, Sino-Italian Cooperation project" mainly aims at the present condition of the dioxin emissions in the sintering and the electric furnace process to carry on the sampling and analysis on the spot in the iron and steel industry, and carries on experiments in the lab and industry experiment analysis according to the technique measure in the BAT/BEP recommended by Secretariat of Convention, researches these applicability of BAT/BEP, the capital costs increment of this application and possible influence on economic and society.

II.Analysis of POPs produced in the sintering process of China

Table.2 The pollution sources and main pollutants of sintering produce

No.	Produce facilities	Controlled process facilities	Main pollutants

	classification		
	Sinter, pellet	Sintering machine, shaft furnace, roasting machine with wrapping, Chain grate-Kiln	dust、SO2、NOx、CO、CO2、HCl、HF、 VOC、PAH、PCB、PCDD/F、Heavy metal etc.

In the sintering(roasting) process, the material takes place many physical and chemical reactions in the heating and combusting process. In addition to the smoke(powder) dust, there are various of harmful gases in the waste gas emissions from the head of sintering machine, shaft furnace, roasting machine and rotary kiln ,such as SO_2, NOx, CO_2, CO, HCl, HF, volatilizing organic compound(VOC), Polycyclic arene hydrocarbon(PAH), PCB (PCB), Polychlorinated dibenzo-p- dioxins, (PCDD), Polychlorinated dibenzofurans (PCDF) and heavy metals etc.

The percentage of sinters in the blast furnaces of Most of large and medium-sized steel enterprise is 75%-80%, pellets is 13%, including some soil pellets, among them, 8.5% is produced in China, 4.5% is imported; all of the 8% lump ores is almost imported, among them, about 7% is imported, and only 1% is domestic.

Table.3 The artificial iron lump ores yield of China in 2005

	China	Key enterprise
I Artificial rich iron mineral	42844.68	39527.41
1. Iron ore sintering	36923	34084.2
1)common	5174.83	3689.54
2) high basicity	31748.67	30394.66
2. iron ore pellet	5911.43	5433.45
1) For the blast furnace usage	5911.43	5433.45
2) for direct reduction usage		
II Artificial rich manganese mineral	26.98	2.03
1) manganese ore sintering	8.61	2.03

2) Rich manganese residue	18.37	0

Table.4 The condition of sintering equipments in China in 2005

Equipments designation and specification	Equipments amounts	Produce capacity of equipments at the end of year (thousand tons)
Sintering machine	369	379,440
200-495m^2	27	187,860
130-129m^2	52	
90-129m^2	63	69,610
36-89m^2	119	80,690
19-35m^2	104	40,340
Less than 18m^2	4	940

Table.5 The technique economy index of sintering machine of China steel key enterprises in 2004

Usage coefficient t/(m^2.h)	produce rate %	TFe %	ISO centrifugal machine strength, %	Solid fuel consumption kg/t	Process energy consumption kg mark coal /t
0.862	88.34	55.91	74.97	53	66.72

In recent years, China iron and steel industry has already designed and manufactured large modern sintering equipments independently; The raw material structure is further optimized; Advanced techniques have already been developed and applicated ,such as enhancing to mix and make grains, small pellets sintering, thick material bed, high basicity, full-automatic control etc.; and the technique of high-efficiency dedusting and recovery and utilization of remain heat of the low temperature waste gas has also been made certain progress.

Comparing with iron and steel industry of Japan and other countries, the average area of sintering machine of china is only 58 m^2, but that of Japan is 342 m^2,the utilization coefficient is lower 0.07 t /(m^2 .h) than Japan, The of produce rate is lower 3.9% ,and the sinters TFe, FeO is respectively lower 3.6%and higher 2.7%, the solid fuel consumption is higher 7.6 kg a mark coal/t; Most of sintering machines in Japan have devices to take off SOx, the minority have devices to take off NOx ,but China just started to install those devices; In accordance with incompletely statistics in 2005, there are about 420 sets of sintering machines in China, the large and medium-sized key enterprises which produced about 340,840,000 tons of sinters have 369 sets of sintering machines, only 79 sets of them are larger than 130 ㎡,their production capacity shares about the half of total production capacity. Moreover, 28,380,000 tons iron sinter mostly exist in some regional iron and steel plants, their equipments of sintering machines are more backward.

Table.6 The dust emissions limit value of partial sintering process in the United States

(unit: mg/ NM^3)

process	Existing pollution sources	New pollution sources
crush	18.3	11.5
The cooling zone of sintering machine	68.7	22.9
Loading and unloading of pellet product	18.3	11.5

At abroad, the bag dust catcher has already more and more applied to manage the waste gas of the head of sintering machine, as a result, the concentration of emissions decreases to less than 30 mg/m3, For example, the test value of sintering machine with bag dust catcher is less than 30 mg/m3 in England. The EU standard limit of dust emissions is 0.17～0.28 kg for each ton of sintering mineral; The British standard limit of dust emissions is 0.037～0.41 kg for each ton of sintering mineral; The American standard limit of dust emissions is 0.14 kg for each ton of sintering mineral.

Presuming the steel yield of china in 2010 is 500,000,000 tons, the iron yield will require about 480,000,000 tons, According to the percentage of sintering ore, lump ore and pellets of China usage, the requirement of sintering ore is anticipated to 612,000,000 tons.

Table.7

	Common sintering ore	High basicity sintering ore	iron ore pellets

yield(thousand tons)	51740.8	317480.67	59110.43
Percentage %	12	74	14

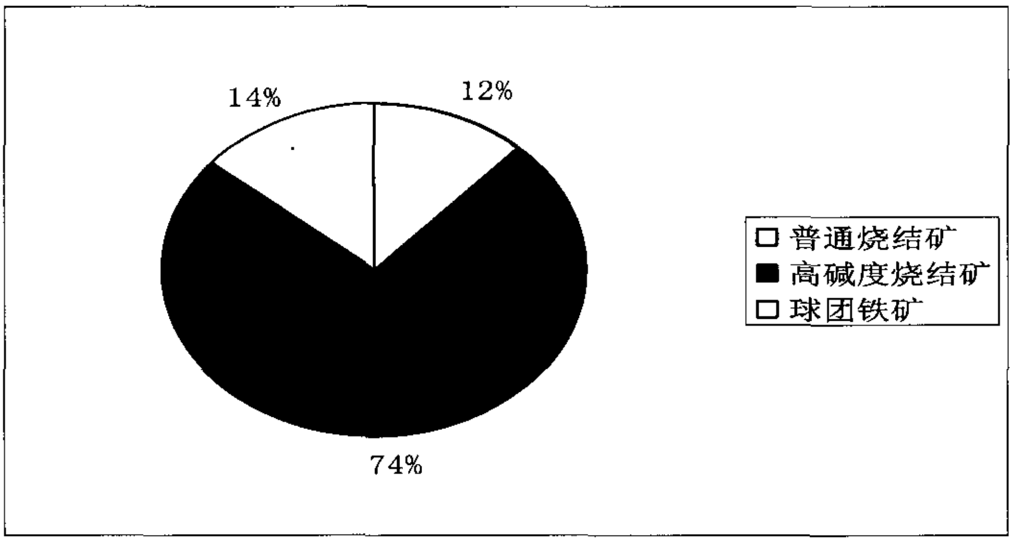

Chart.1 The percentage of all kinds of sintering ore of China

Improving the concentrate level of raw material to a great degree; Quickly raise the percentage of pellets feeded into the blast furnace;(by 2010, the request that the percentage of pellets is more than 20% should be realized from the ability); Quickly eliminating the small less than 75 M2 sintering machine and the pellets process equipments of small shaft kiln, and forming the new sintering production process and equipments with the corpus of more than 180M2sintering machine.

Table.8 the target of technique and economic index of sintering

Index disignation	The year of 2006～2010	The year of 2011～2020
Utilization coefficient t/(m².h)	1.4 ～ 1.6(Regard powder mineral as principle) 1.3 ～ 1.5(Regard concentrates as principle)	1.6～1.8(Regard powder mineral as principle) 1.5 ～ 1.7(Regard concentrates as principle)
produce rate，%	94	97～98
Sinter mineral TFe，%	59	60
Sinter mineral FeO，%	6～7	5～6
The strength of Sinter mineral,%	79	80

Solid fuel consumption ,kg mark coal /t	45	40

As China iron and steel industry decides the limit value of new source emissions in sintering plants is 30 mg/m3, the potential and possibility of the dioxin pollutants release reduction in the sintering process is quite large from now on.

III. The analysis of POPs produced in the electric arc furnace process

In the process of steel-making with electric furnace, all the course of adding of scrap steel and material blending, blowing the oxygen, producing the residue and the steel can produce smoke with dust. Besides the dust, the smoke has some pollutants such as CO and fluoride...etc.; The feed system of loose material can produce dust, the smelting process of refinement furnaces like LF, VD etc. have also produced the smoke with dust. Its characteristics of pollution is:1)The paroxysm of smoke is strong, the volume of smoke fluctuates largely, 2)The spot of smoke emissions in the steel-making with electric furnace is many, the collections difficulty of the smoke is great, 3)The temperature of smoke is up to 1200～1500℃, which increases the design complexity of dust removal system ; 4) The grain diameter of smoke and dust is small, in the oxidization period, the diameter of about 90% grains is less than 10 μm, the diameter of about 50% grains is less than 2 μm, That request high quality filter material for bag filters;5) The iron content of smoke is high, in the oxidization period, the iron content in some electric furnaces is up to about 80%, that has higher value of recovery and utility.

The development strategy with the center of casting continuously of China iron and steel technique, successfully aroused to optimize the smelting process and the whole steel produce, the yield of casting continuously production of China iron and steel industry is more than 300,000,000 tons in 2005, the percentage of casting continuously is near 97%, but comparing to countries with advanced steel produce, the progress of the smelting equipments becoming large-size is slower, which influenced the labor rate of production, the whole level of equipments, the reducing of material and energy consumption and the improvement of produce stability. The absolute amount managed outside furnace grows quickly, but comparing to countries with advanced steel produce, there is still difference on the ratio of molten iron pretreatment and molten steel refinement. The steel yield of electric furnace in the world is more 35% than that of 2003, in the countries and regions with abundant scrap steel resources and cheap electricity price, the steel-making with electric arc furnace develops quickly.

For example, the percentage of electric furnace steel to the total steel yield in 2002 and 2003 is respectively 50.7% and 48.9% in the United States. Because of the shortage of scrap steel resources and higher electricity price in China, the yield of electric furnace steel started to decrease from the mid of 90's, although the yield has increased year by year since going into the new century, the levels still remains less than 18%.The yield of electric furnace steel attains 39,060,000 tons in 2003, the second in the world, the ratio of electric furnace steel is 17.6%. In 2004, the yield of electric furnace steel is 41,670,000 tons, but the ratio of electric furnace steel declined to 15.17%, In 2005, the ratio of electric furnace steel is about 15%, that is far smaller than the increment of the converter steel yield.

Table.9 The yield and Percentage of EAF steel in China

year	the total yield of steel / thousand tons	The yield of electric furnace steel/thousand tons	The percentage of electric furnace steel/%
2000	128,490	20200.0	15.7
2001	151,630	24000.5	15.8
2002	182,250	30490.0	16.7
2003	222,340	39060.0	17.6
2004	272,800	41670.0	15.3
2005	355,790	42000	15

Table.10 The EAF production capacity of China in 2005

Electric furnace classification	1-10tons	10-50tons(exclude)	50-100tons(exclude)	More than 100tons
production capacity (thousand tons)	1,020	10,770	15,970	11,060
percentage %	3	28	41	28

Table.11

year	2000	2001	2002	2003	2004	2005
imported quantity of scrap steel (thousand tons)	5,100	9,790	7,850	9,290	10,220	14,600

In recent years, the total amount of scrap steel requirement in China has significantly increased, and the scrap steel resources has sharply dropped, which cause the sharp contradiction of the shortage of scrap steel market. At the same time, because of the great shortage of scrap steel resources, the quality and composition control in the classification, store and utilization of scrap steel is easily neglected. Generally, the classification condition of recycling the scrap steel in society is bad, and in the process of steel-making, only a few of special steel factories classify the scrap steel and the special steel recovery, but scrap are mixed in storage site, so the rate of elimination of scrap steel impurity and the valid composition utilization is decreased. The process of scrap steel has great gap from that of other countries, particularly the equipments and techniques of shredding process of scrap steel recovery, of deposed automobiles etc. which influence not only store and utilization, but also the molten steel quality, these factors also influence the control of dioxin.

The emissions to the air in the steel-making with electric arc furnace and continuous casting in EU(Germany) include inorganic compound (dust of oxidized iron and heavy metals) and organic compound, for example ,the important organic chloride such as chlorine benzene, PCB and PCDD/F. The main technique and control level is as follows:

(1)The collection of dust. By using of the direct waste gas pumping system and hooding system, or the high frequency and high voltage shield cover and hooding system...etc., collecting the primary or secondary emissions more effectively.

(2) Waste gas dedusting. For newly established factories, adopting the bag filters can make the amount of dust decrease to lower than 5 mg/m3, the existing factories is lower than 15 mg/m3.

(3) The minimum amount of Organic chloride emission (particularly PCDD/F and PCB). After the reasonable post-burning in the waste gas pipe system, in order not to start de novo synthesis and quickly turn off later on, infusing brown coal before getting into the bag filter or in the pipe. The amount of PCDD/F emission is 0.1～0.5 ngI-TEQ/Nm3.

The primary and secondary flue gas of electric furnace usually collect through the fourth port(DC furnace is the second port) taking out and absorbing +large sealed hood and hood on the roof together, the collected flue gas has been purified by adopting large high efficiency bag filters, the concentration of the flue gas emission usually can be decreased to lower than 20 mg/m3.the waste gas containing dust in the feeding system and the smoke in Ladle furnace...etc., usually adopt high efficiency bag filters to purify, some smoke merging into the electric furnace smoke and dust separation to purify. High efficiency bag filters have been adopted widely to purify in China, this technique is stabilized and mature, the purification efficiency is high.

According to the emission standard of foreign countries, the existing sources and new sources of American electric arc furnace(cast) is 11.45 mg/m^3 and 4.58 mg/m^3 respectively, the dust emissions limit of EU steel-making with electric furnace is 5～15 mg/m^3, exist sources of the British steel-making with electric furnace is 15 mg/m^3, the control level of German electric furnace smoke of existing sources is 15 mg/m^3, control level of new sources is 5 mg/m^3. existing sources of China is 35 mg/m^3, new sources is 20 mg/m^3.

Table.12 The electric furnace equipments of China (quote from iron and steel almanac in 2005)

Equipments designation and specification	amounts of equipments	Production capacity of equipments at the end of year (thousand tons)
electric furnace	159	38,820
More than 100tons	12	11,060
50-99tons	32	15,970
11-49tons	76	10,770
Less than 10tons	39	1,020

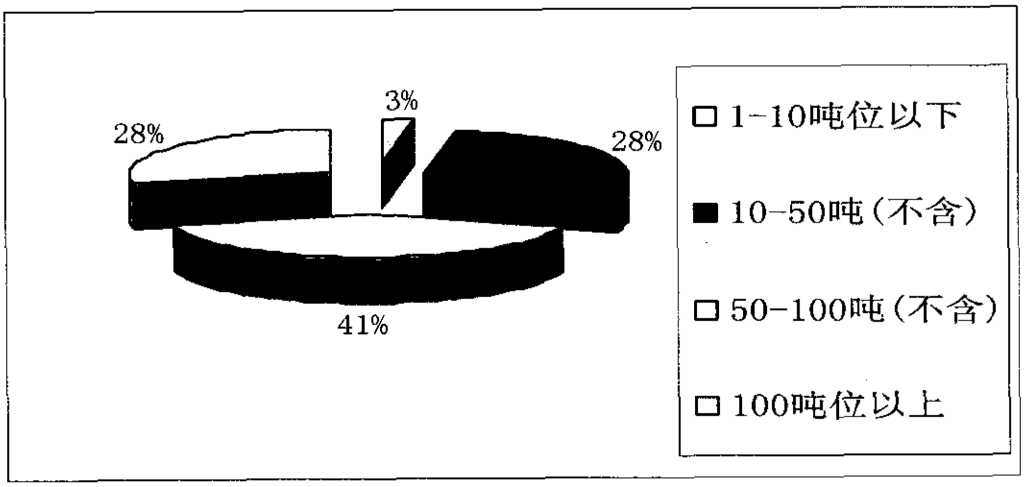

Chart.2 The percentage of the electric furnace equipments of China

The average productivity of electric furnace equipments of China is only 150,000 ton/year set, which is still in the lower level, the main reason is still that the furnace capacity is small, most of electric furnace is about 30 ton, but the capacity of most steel-making with electric furnace in foreign countries is 80~120 tons, and there has been a trend to increase to 150～200 tons in recent years. The too small furnace capacity can lead to a series of problems such as the lower level of automation and mechanization, the lower utilization of energy, the poor management of environment, the lower quality of metallurgy, the poor stability of production, and the lower per person productivity etc.

One great characteristic of steel- making with electric arc furnace in China is proportioning with a great quantities of molten iron, the production pace of electric furnace is significantly accelerated, For electric furnaces with molten iron percentage higher than 30%, the smelting electricity consumption is decreased to less than 300 kwh/t, the average content of harmful remaining chemical elements in the steel is decreased, the content of nitrogen in steel is also reduced, because the cost of molten iron produced by small blast furnaces in China is lower, the electric furnace steel plants obtained an obvious benefits. But the small blast furnaces installed before electric furnaces and related process before the iron, lost the advantage of short and compact process of steel-making with electric furnaces. However from reducing the dioxin pollution point of view, this is a beneficial factor.

Table.13 The scrap steel consumption of China（quote from China scrap steel association）

year	2000	2001	2002	2003	2004	2005
The yield of raw steel（thousand tons）	128,500	151,030	182,250	222,340	272,970	352,390
The scrap steel consumption（thousand tons）	29,200	34,000	39,200	48,200	54,300	63,300
The percentage of scrap steel（%）	22.7	22.5				

The prediction of scrap steel resources

(1)The scrap steel of society: During the "Eleven's Five Year Plan" period, the creation of scrap steel haven't reached the climax in China, According to the average increment of 3,810,000 tons every year in the "Ten's five year plan" period ,the scrap steel yield in 2007 is anticipated to reach about 44,000,000 tons.

(2)The self-produced scrap steel: In accordance with 6% of Chinese average creation rate of self-produced scrap steel in 2005, the yield of self-produced scrap steel in China is about 27,000,000 tons in 2007.

(3)The imported scrap steel: According to the above-mentioned parameters, the scrap steel requirement is 80,000,000 tons in 2007. the yield of self-produced scrap steel is 27,000,000 tons, the yield of scrap steel from society is 44,000,000 tons, if all of those are used for metallurgy industry, the resources gap is still 9,000,000 tons, Including the material used by foundry, machine manufacture, small hardware profession and small steel factories etc., the scrap steel resource gap is 12,000～15,000 thousand tons.

Scrap steel is also a kind of energy resource, Comparing to steel-making after iron-smelting by using the iron ore, steel-making by using scrap steel directly can save 60% energy, and 40% water, and the emission of waste gas, waste water and waste residue is greatly reduced, which is advantageous to clean production and lower waste discharge, But it also should be paid great attention the scrap steel classification , process(including crashing, shearing and packing), store and material blending technique. In order to utilize successively and separately, pretreatment of scrap steel (such as crushing and separating), recovery and utilization of scrap steel (including removing of copper, tin, zinc , preheating and smelting, disposing of the dust and waste gas etc.), should adopt discriminating and categorizing to recycle the reusable parts of the scrap steel (including another available metals and engineering plastics etc.). These measures are advantageous to reduce dioxin formation, and the investment is not large relatively , so they are applicable to the nations with relatively lower labor cost as China.

For example, the electric furnace steel plants can adopt some measures as follows to inhibit and reduce the dioxin formation and emission:

(1)Classify and pre-treat the scrap steel, before feeding into the electric furnace, reduce the usage of scrap steel with paint, coating, plastics, oil remains as much as possible, strictly control the total amount of the organic material and chlorine fed into the furnace;

(2)Don't adopt the method of preheating the scrap steel with higher organic matter and chloride and feeding them slowly and continuously, improve the smelting process according to the condition of scrap steel.

IV. The cooperation projection of POPs research of the steel sector

Table.14 Data of TISCO

<table>
<tr><th>Production facilities name</th><th>Sampling site</th><th>Work time of a year (day)</th><th>yield (thousand tons)</th><th>The waste gas creation quantity of a Year (Nm3)</th><th>The fly ash creation quantity of a year (tons)</th></tr>
<tr><td>100M^{2}sintering machine</td><td>The head of sintering machine ESP</td><td>300</td><td>950</td><td>2.0×10^9</td><td>1,200</td></tr>
<tr><td rowspan="2">50tons electric furnace</td><td>BF of EAF</td><td rowspan="2">320</td><td rowspan="2">390</td><td>1.0×10^9</td><td>6,400</td></tr>
<tr><td>EAF Smoke hood BF</td><td>2.3×10^9</td><td>3,200</td></tr>
</table>

Table.15

Production facilities disignation	Dioxin concentration in the flue gas (ngI-TEQ/Nm3)	Dioxin concentration in the fly ash (ngI-TEQ/g)	Dioxin emissions in the flue gas (g/year)	Dioxin emissions in the fly ash (g/year)	Dioxin emissions of unit product (µg / ton* year)
100 M^2 sintering machine	0.235	0.19	0.47	0.23	0.736
50tons electric furnace	0.132	0.0075	0.13	0.05	1.923

Table.16 Data of BaoSteel

Produce facilities disignation	Sampling site	Work time of a year (day)	yield(thousand tons)	The annual flue gas yield (Nm3)	The annual fly ash yield (tons)
$450m^2$ Sintering machine	The head of sintering machine ESCS	352.2	5,500	21.3×10^9	7,044
	ESP of end of sintering machine EP	352.2		7.61×10^9	29,938
100tons electric furnace	BF of EAF	323	550	6.59×10^9	8,250

Table.17

Produce facilities disignation	Dioxin concentration in the flue gas (ngI-TEQ/Nm3)	Dioxin concentration in the fly ash (ngI-TEQ/g)	Dioxin emissions in the flue gas (g/year)	Dioxin emissions in the fly ash (g/year)	Dioxin emissions of unit product (µg/ton*year)
$450m^2$ Sintering machine	2.29	1.409	48.781	9.925	11.256
	0.24	0.046	1.826	1.377	
100tons electric furnace	0.079	0.61	0.521	5.033	10.096

Table.18 (Jue.19, 2005)the dust removal efficiency of the main ventilation electrostatic precipitator of sintering machine(ESCS) in BaoSteel

project		Flue gas speed (m/s)		Flue gas temperature(°C)		The amount of flue gas(Nm^3/min)		The amount of dust(mg/Nm^3)	
		inlet	outlet	inlet	outlet	inlet	outlet	inlet	outlet
ESCS dust collector	N system	14.5	16.38	122	110	9,977	10,898	811.7	74.8
	S system	16.3	18.2	161	150	10,055	10,632	857.1	79

The increment cost analysis

The sintering process of the EU iron and steel industry adopted the best following techniques to eliminate the dust from flue gas:

- The advanced technique of electrostatic precipitator (ESP), electrostatic precipitator coupling with bag filter, eliminating dust in advance (such as ESP or cyclone) coupling with the wet high pressure scrubbing system. After adopting these techniques, the amount of dust emission is usually less than 50 mg/m3, If using the bag filters, the concentration of dust emission can be reduced to 10～20 mg/m3.

- Employing the technique of recycling flue gas. If the quality and productivity of sintering product are not influenced greatly, the technique of recycling partial flue gas from sintering machines and recycling flue gas locally can be applied.

- The technique of minimizing heavy metals release. The purpose of using the better efficient wet scrubbing system is for the sake of eliminating soluble heavy metal chloride, especially the elimination efficiency of lead chloride is more than 90% or using the bag filters filled with lime, remove the dust from the final step electrostatic precipitator, landfill safely after pour them out.

- The technique of the minimum solid waste release.

Recycle the by-products with the iron and carbon in the whole steel production process, The oil in those by-products is less than 0.1%.Recycling solid waste adopt the technique as follows: the technique of minimal yield of waste; recycling the waste selectivel and returning to sintering process; When the inner part can't carry on recycling, pay attention to develop exterior recycling ability ;If recycling can't be carry on in interior and exterior , the quantity of solid waste should be controlled.

In this Sino-Italian Cooperation project ,both BaoSteel and TISCO adopt the process measure of decreasing powder material and stopping the usage of five solid recycle material including mill scale(ZSC-S), blast furnace ash(ZBG-S), sintering ash(ZES-S) , sintering powder(the S1C-F) and iron slag (ZFG-S) etc. Which influence the ventilation of sintering. This directly caused the main raw materials of sintering to rise, But if stopping the usage of recycling material inside plants of blast furnace ash, eliminating dust of sintering ESCS, mill scale etc., how to handle and reuse these resources will certainly generate indirect cost.

After TISCO adopt the emission reduction measure in the sintering process, the cost increases by 19 yuan/ton*sinter ore. In 2006, the yield of one 100 m2 sintering machine is 950,000 tons, if adopting the emission reduction measure, the cost of process will increase 18,050,000 yuan per year ;the whole yield of sintering process is 3,850,200 tons per year, if adopting the release reduction measure, the cost will increase 73,153,800 yuan. From the aspect of circular economy and comprehensive utilization, the sintering process has totally digested kinds of comprehensive powder 651009 tons in 2006, if adopting the emission reduction measure, the above-mentioned comprehensive powder has to look for another disposal channel. According to the practical calculation of TISCO, the cost for each ton of steel increases about 37.65 yuan in the technique of low iron ratio comparing to that of high iron ratio.

In the process of 50 tons steel-making with electric furnaces, the quantity of molten iron blending is nearly 50%, but viewing from the monitor data, there is no rules to be followed, which should be further studied.

V. The studying and cooperating direction of Reducing Unintentional Production of POPs in China iron and Steel industry

The practical comments and suggestion for China iron and steel industry to implement the

BAT& BEP:

1. Through the support from international project and national finance, continue to carry on monitoring and evaluating the level of dioxin release generated by sintering and EAF

The technique of examining PCDFs and PCDDs mainly includes: the technique of sampling, the test technique of extremely low level content, the fast test technique with low cost and the safe test technique of environment. Supporting some professional dioxin test technique expert's teams and organizations who is familiar with the characteristics and monitor standard of some industrial process. Because the test target is trace, the process of removing other material out of dioxin (clearance process) will spend a lot of time, this is also one reason that the test will take long time.

Because of the special limit of the continuous steel production and the raw material species etc., the monitor data of this project is less, the representative of data is still not strong, but the high difficulty and high complexity of analyzing and sampling technique for dioxin trace, moreover the shortage of sampling experience of Chinese technicians on the spot of steel factory and the limit of special steel produce, make the sampling and testing data of the dioxin of this project is still inadequate, parts of data has some contradiction, logic and credibility is not strong. For example, in the test data of this cooperation project, the dioxin content in the flue gas release of the No.1 sintering machine ESCS and ESCS B with after passing through the electrostatic precipitator in BaoSteel is 1.28 and 3.30 ng-TEQ/m3 respectively; the dioxin content in the flue gas release of the machine ESCS before passing through the electrostatic precipitator is 2.88-5.71 ng-TEQ/m3. Under the normal situation(namely the baseline period) ,these analytical results are equal to that of the same kind of sintering plants without adopting the UP POPs emission reduction measures in Western Europe.

If based on those data, the total release amount by analyzing may result in big deviation. Hope the international cooperation project or national particular finance continue to support this project from now on ,in order to develop a series of monitor activity, further reveal the dioxin release rules and actual level of emission in China steel industry.

Therefore it is recommended that continue to carry on monitoring and evaluating the actual level of dioxin release produced by sintering and electric furnaces with the support of international project and national finance.

2. Considering to research and establish the standard of dioxin release for the steel enterprise set up recently adjacent to the important city and the environment sensitive district.

According to the research and fulfillment of dioxin problem, the metallurgy field has already put forward some measures which can prevent dioxin formation in the scrap steel process, Including the technique of controlling the amount of dioxin release in the smelting process of electric arc furnace, which can make the concentration of dioxin release to the atmosphere be reduced to 0.04-0.06 ng I-TEQ/M3., that concentration is lower than the standard of 0.1ng I-TEQ/M3 formulated by some developed countries .The China iron and steel industry should also have enough understanding and adopt necessary technique measure to effectively resolve the possible dioxin pollution problem in the steel production .

Referencing the experience of Europe, Japan formally promulgated the examining standard in 2000, after investigating in the year of 1997~1999, which promoted every section to adopt measure, and obtained obviously effect. Among them ,the three standards of electric furnace, sintering and recovery of zinc are in connection with examining the steel industry.

Table.19 The amount of dioxin release of Japan and steel industry (g-FEQ / a)

project	The year of 1997	The year of 1999	The year of 2000	The year of 2002	The year of 2003
Total of whole nation	7,910	3,040	2,460	891	390
Electric furnace	228.5	141.5	131.1	130	80.3
sintering	135.0	101.3	89.8	93.2	35.7
Recycling zinc	47.4	21.8	26.5	13.8	6.5

The iron and steel industry of Our country has possessed large technical equipments such as large-size 450 M^2 sintering machine, 7.36 M^2 coke battery, large-size 4350 M^3 blast furnace, 300 tons blow converter, extremely high power 150 tons electric furnace and large hot and cold continuous rolling mill etc. but steelmaking equipments in our country are far from realizing large-size , The problem that different technical equipments of the process coexist, the main reason of some enterprises with backward energies is that most of technical equipments are 4.2m coke ovens and less than 4.2m sintering machines, less than 300 M^3 blast furnace, less than 20t converter ,small less than 20t electric furnace, and the small line type, reply two heavy type good line and rod rolling mill with high energy consumption which will be eliminated soon after. These backward small equipments not only are high energy consumption, but also can't adopt the economy energy technique measure to recover the waste heat. At the end of "Ten's five year plan", there still have 1130 sets of less than 1000 M^3 blast furnaces in our country, which take up above 60% of the capacity of smelting iron, In addition, the quality of iron ore in our country is poor and the shortage of scrap steel resources etc., so the iron and steel industry should change the growth method practically from now on, improve the industry concentration, research and carry out the steelmaking industry process optimization, quickly eliminate the blast furnaces less than 200 M^2, converters ,electric furnaces less than 20 tons and the backward rolling machines. For the small sintering machines, small blast furnaces, small coke ovens and small electric furnaces etc., the possibility of installing all environmental protection facilities is small, On the other hand ,because the productivity of single set equipment is limited, the amount of equipments involving dioxin pollutant is very large, If all the equipments are carried on the dioxin monitor and the monitor data science and credibility is ensured , the monitor workload and difficulty will be very great, and the cost of monitor of unit product is very high , so it is more better to used more funds to the engineering measure and reformation to effectively reduce the dioxin production and emission.

During the period of "Eleven's five year plan", China iron and steel industry will continue to reduce the ratio of iron and steel, the ratio of iron and steel in 2010 will be descended from 0.92 of 2004 to 0.85;thus the use percentage of the sintering ore can be decreased and the large-size equipments will be achieved, so the possibility and maneuverability of valid monitor to the dioxin release may probably be realized .

The distribution of iron and steel industry should be more reasonable; Craft process and product structure should be more optimal; The steelmaking equipments should be more large-size, more efficient, more continuous , more automatic and more environmental protection. Therefore not only the iron and steel industry development policy should be grasped firmly from now on, the level of equipment of new project should be controlled strictly, but also considering to research and establish the standard of dioxin release for the steel enterprise set up recently adjacent to the important cities and the environment sensitive district at the same time.

3. Thoroughly carry on extending and application of technique development and international cooperation to reduce dioxin release

Through this Sino-Italian Cooperation project, the China iron and steel enterprises understood more technique about disposal of dioxin, furans and benzypyrene release: for example, handling the sintering flue gas by adsorption with active carbon and the air scrubbing device can reduce the concentration of dioxin release in the flue gas and other pollutants of the SO_2, NO_x etc; the efficient incineration technique which can inhibit the dioxin emission;

The British Corus UK has already studied a technique of reducing the dioxin formation and release in the sintering process of iron ore, the result by 94 experiments expressed that the concentration of emission from the main flue gas stack of five sintering plants of England are 0.28～4.4 ng I-TEQ/ M^3, the total average is 1.19 ng I-TEQ/ M^3, which is slightly higher than the release limit of 1 ng I-TEQ/M^3 formulated by the British environment bureau for new plant. The main measure is reducing chlorine and precursors of the raw material; before sintering, adding a little amount of urea particle to the mixture or spray ammonia water into the last four wind boxes, in order to inhibit the dioxin formation ;sintering flue gas should be quickly quenched to reduce dioxin formation , and making the dioxin condense onto the surface of the dust; installing active carbon adsorption tower behind the desulphurization device to eliminate the dioxin; using the wet electric precipitator to eliminate the dioxin in the flue gas.

Adopting suitable quenching technique (For example, the method with double flows to spray can make use of its huge surface of very small water drop to promote condensation and adsorption of dioxin),can ensure the flue gas temperature to descend below 250 ℃ as soon as possible, in order to inhibit dioxin formation.

Through the environmental protection technique exchanges with Japan iron and steel industry, we know that the technique of reducing and eliminating dioxin in Japan iron and steel industry are as follows:

①the technique measure of dioxin release reduction in the process of electric furnace.

After systematic researching the produce mechanism and variety of dioxin in the process of electric furnace (including scrap steel preheating and dust collector), the following knowledge is obtained:

a. If decreasing the amount of Cl in the scrap steel, the effect of inhibiting the dioxin formation is great,

b. Raising the temperature of electric furnace smoke first burning can increase greatly the decomposition efficiency of dioxin ;(the decomposition rate is 99.9% at 900 ℃)

c. Decreasing temperature of smoke at the outlet quickly cooled and spray pour tower to lower than 250 ℃ can inhibit the dioxin reproduction;

d. Controlling and lower the temperature of the flue gas getting into the bag filters to reduce the dioxin production.

The eliminate technique of mixed chemical elements. The mixed hard eliminating chemical elements is the key problem to influence the scrap steel recovery in the smelting process. The influence of Cu upon the steel quality is bigger, which is the important factor to bar scrap steel from recycling. the Cu in scrap steel mainly comes from the electric machine and wire of discarded automobile and the household electrical appliances. The copper content in scrap steel will still ascend from now on. Much of those mixed chemical elements depended on prolonging refinement and strengthening artificial classification to eliminate, the harmlessness research will be developed recently.

②The measure of dioxin release reduction in the sintering process of iron ore . After carrying on the measurement and related experiments concerning the dioxin change of two kinds of sintering machine with different disposal method (one only has the dry electric precipitator and one has wet electric precipitator with desulphurization and denitrogening device),The SDD research constituted of 7 large blast furnaces steel factories and 3 universities in Japan has already ascertained those following issues: a. the amount of Cl in the raw material is almost proportion with the amount of dioxin, the influence of the chlorine appearance is very small; b. The dioxin content is highest when the flue gas temperature is reaching the climax; c. Dioxin content in the raw material and in the electric precipitator is almost consistent, which explains that the dioxin in the raw material is almost decomposed; d. The influence of species of coal and coke blending and the Cu content in the raw material is greater. Therefore, including using the anthracite of little dioxin production and decreasing the raw material with high Cu and oil content, and eliminating chlorine, the measure of enhancing the process of eliminating dust to reduce the dioxin release outside ,because of much of dioxin attaching on dust. and the measure of letting the main flue gas through sintering layer to decompose the dioxin should be considered.

Moreover, it is known that BaDeng steel engineering company of Germany (BSE) and JiangYin XingCheng steel limited company of China have signed a technique cooperated contract about environmental protection and eliminating dust recently , BSE provided a set of BSE — HTQ high temperature rapid quench system of flue gas to improve the 100t direct current electric furnace dedusting system of JiangYin XingCheng steel limited company, which can reduce the dioxin and furans emission in the steel-making with EAF. The dioxin and furans emission is Polychlorinated dibenzo-p-dioxins(PCDDs) and Polychlorinated dibenzofurans (PCDFs)produced after the raw material containing chloride combustion. For the EAF steel factory, it means that scrap steel with PVC plastics, chlorinated oil, and solvent is the main sources of chloride which causes the dioxin and furans emission. The dioxin is the result of the low temperature burning (300～700℃) process in the EAF furnace. The BSE—HTQ high temperature rapid quench system can effectively obstruct the dioxin and furans formation. Ba Deng Gang factory of German BSW installed the HTQ system in 1990. This system make BSW dioxin emission lower than 0.1 ngTEs/Nm3. It is 12 years since the German BSW company adopted the HTQ technology, the value in the last 7 years was always 0.1 ng TE/Nm3 or smaller. Replacing the waste gas cooler, The HTQ technology can cool the electric furnace flue gas with water fog from above 800 ℃to 300 ℃ within several seconds, which has no time and condition for the dioxin production. Using the HTQ system can also eliminate the climax of the waste gas temperature by spraying water fog, so the operation technology of enhancing the oxygen usage to accelerate smelting is allowed to apply. As a result, the capability of the bag filters can be better utilized. The waste gas is cooled off by water evaporation, so it is not necessary to use the DEC waste gas cooler of low efficiency, and the pressure of system can also be decreased.

The technology of circular sintering method is that part of carrying heat air emission from sintering process return to the trolley behind the ignition to use circularly, which can not only recycle the remained heat of sintering smoke, but also reduce the amount of smoke dispose and emission, reduce the amount of smoke emission to 50%, improve environmental protection and save energy. Because the amount of smoke emission decreased, with the technique of smoke temperature control and the smoke adsorption and disposal, the dioxin pollution can be reduced greatly. The new flue gas circulatory system in the sintering process developed by Voestalpine Stahlt and the VoestAlpine industrial equipments manufactory (Siemens VAI) replaced the old sintering machines of Voestalpine Stahlt in the City of Austrian Linz, the new technique make the amount of the dust and the pollutant in the waste gas to the stack decrease greatly, and by making use of the remained heat of smoke and the secondary combustion of CO, the fuel consumption is also decreased.

Hope more international co-operations could be carried out, research and develop the technique of dioxin emission deeply.

SINO-ITALIAN COOPERATION PROJECT

Summary Report of Strategy to Reduce the Unintentional Production of Persistent Organic Pollutants in China

Contract No.: C/V/S/05/019

To: Convention Implementation Office (CIO) of State Environmental Protect Administration (SEPA)

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Contents

1. Background

Stockholm Convention has become effective in state to China since November 11, 2004. Choosing the key sectors and key sources of pollution enumerated in the Convention, developing a list methodologies, research on different types of POPs on the list, organizing the BAT/BEP model as soon as possible and accumulating valuable practical experience, are of great significance to the integrated and effective implementation of the POPs Convention, as well as to avoid the negative impact on China industry and social life in the implementing process.

According to the requirements for some demonstration sectors emitting the byproducts POPs listed in Annex C of Convention in National Implement Project (NIP), the Convention Implementation Office (CIO) of State Environmental Protection Administration (SEPA) should select key sectors and key enterprises, in order to research emission factors and emission inventories as well as the various impacts on the sectors implementing BAT/BEP technologies, including reduction efficiency of PCDD/PCDF emission, incremental costs brought by BAT/BEP the and state of the BAT/BEP application. The United Nations Development Program (UNDP) and United Nations Office for Project Services (UNOPS) act as role of the international implementing agencies and institutions of the project. The Ministry of the Environment and Territory of Italy (IMET) in cooperation provide funds for the unintentional POPs emission reduction through Sino-Italian environmental protect office.

During the choice phase of BAT/BEP demonstration sectors in 2004, the three sectors including steel, incineration and paper have been identified as the representative dioxins sources, and the strategies project for dioxins reduction should be implemented in this three sectors.

In January 17-18 of 2005,. the Convention Implementation Office (CIO) of State Environmental Protection Administration (SEPA) organized domestic and foreign experts to conduct an appraisal for the choice of demonstration enterprises. China Iron and Steel Industry Association (CISIA) and the environmental professionals committee of China Paper Association (CPA) agreed to implement the dioxins emission reduction demonstration projects in six certain enterprises.

In March 1-3 of 2005, the Convention Implementation Office (CIO) of State Environmental Protection Administration (SEPA) managed a conference – Information exchange on alternative enterprise for the Sino-Italian byproduct POPs emission reduction demonstration projects. After the conference, the domestic and foreign experts and sector experts visited the site of the alternative enterprises.

On June 1 of 2005, the Convention Implementation Office (CIO) of State Environmental Protection Administration (SEPA) organized a technical training for the demonstration enterprises. The domestic and foreign experts and sector experts gave lectures on the analytical methods, sampling requirements for UP - POPs. Chinese and Italian technical and industrial experts took the site visit together of the alternative enterprises, and ultimately the demonstration enterprises determined to implement the dionxins reduction strategy included: Steel sector: Shanghai Baosteel Group, Taiyuan TISCO Group; Incineration sectors: Jinan Hanyang, Huzhou Shijiqing; Paper Sectors: Hunan Yueyang Paper, Shandong Huatai Group.

In June of 2005, experts and officials from the China Iron and Steel Industry Association (CISIA), the Convention Implementation Office (CIO) of State Environmental Protection Administration (SEPA), the Ecological Research Center of the Chinese Academy of Sciences (CAS) and Italy delegation inspected the sintering and electrical furnace steelmaking process in Baosteel and Taisteel. After discussion, the sintering and electrical furnaces of Baosteel have been identified for dioxin sampling monitoring location as well as quantity and sequence of sampling and monitoring. In June 4 -7, Secretary-General Sun of China Paper Association (CPA) and foreign experts Mr. Luigi Pistone inspected the production line of Hunan Yueyang Paper, and the sampling monitoring points have been initially set.

From August to December of 2005, the National Environmental Analysis and Testing Center (NEATC) have carried out dioxin analysis for the demonstration enterprises mentioned above in accordance with monitoring plan developed by the Center of Environmental Protection Cooperation (CEPC), State Environmental Protection

Administration (SEPA). The relevant monitoring and test work has set into two stages: the normal production stage and the pilot stage for dionxins emission reduction.

In the first half of 2006, the experts have developed the corresponding BAT/BEP reforming plans depending on the specific conditions for the demonstration enterprises mentioned above. In June of 2006, after the reforming plans implemented in the demonstration enterprises, in order to evaluate POPs emissions efficiency effectively for these BAT/BEP technologies, some tracking monitoring and tests have been carried out in the certain special technology process closely linked with the generation of POPs in the production process of the demonstration enterprises. POPs emission levels and the practical significance of BAT/BEP implementation have been assessed through analysis of monitoring data.

In the second half of 2006, the major job was data collation, analysis and statistics, and the sector experts completed the summarized research report for the demonstration projects.

This report is based on the summary of the report submitted by the sector experts, focusing on the comprehensive summary of the demonstration project implementation process and results, and making recommendations to the POPs emissions reduction in the demonstration sectors.

2. Selection of demonstration sectors & enterprises

2.1 Selection of demonstration sectors

2.1.1 Selection principles

When this project began implementing, the selection of the demonstration sectors depended briefly upon the key sectors for byproducts POPs emission, which were emphasized by the Stockholm Convention. In general, emission seriousness and potential of the byproducts POPs listed in Annex C should be taken into account, as well as the special national conditions of China, in particular the role acted by these sectors in China's economic and social development. Furthermore, the possibility and enthusiasm of these demonstration sectors and enterprises for support this project is also important to think over. To be specifically, the selection of the demonstration sectors depended on the following principles:

(1) Contribution to the national economy and society development

In the selection of key sectors and key sources of pollution, the first should be considered was the contribution of these sectors to the national economy and social development. Implementation of the POPs Convention would certainly affect the development of these sectors, and even the social development. Therefore, these sectors might have been influenced, should take the initiative to implement the POPs Convention, as well as the BAT/BEP demonstration in order to accumulate experience, and deal with the potential impact actively caused.

(2) Emission level of byproduct POPs

Emissions of byproducts POPs listed in Annex C is the top priority of concerning. it was relevant not only to the implementation work, but much closely to the physical health of employees and people of the region. So the emission level of byproduct POPs was the key principle of testing and choosing the demonstration sectors. Taking into account that our country has not yet carried out the survey for the byproduct POPs list, there has no emission inventories of the various sectors. In view of this situation, for the selection of demonstration sectors, we could estimate emissions level through preliminary evaluation, with the emission factor which can be applied by the UNEP as well as the production amounts and production technology level of the key sectors.

(3) Existing environmental infrastructures

The BAT/BEP (Best Applied Technology/Best Environmental Practice) guidelines prepared by the UNEP experts emphasize that taking some basic environmental protection measures (such as feed sorting, removing dust by bags and electrostatic technology for gas treatment, etc.), will be effective in reducing byproduct POPs emissions. Therefore, the selection of key sectors and demonstration enterprise depended on whether or not having the basic environmental facilities, which was relevant to the efficiency of BAT/BEP demonstration projects for the certain enterprises, influencing the increasing cost, as well as the BAT/BEP follow-up application.

(4) Initiative of the key sectors and enterprises participation and the funds

The initiative of the key sectors and enterprises involved in the project will have a bearing on the implementation level of the BAT/BEP demonstration. This initiative was not just referring to participate in demonstration projects, and it also included the awareness degree of the sectors for the POPs Convention and environmental protection, as well as whether the sectors have developed some pertinence guideline system in order to see if it can implement the matching funds for demonstration project implementation.

2.1.2 Confirmation of the demonstration sectors

Depending on the selection principles mentioned above, the demonstration sectors which were confirmed to implement the POPs convention included: steel sector, incineration sector and paper sector.

(1) Steel sector

PCDD/PCDF generated from the steel sector provided a great deal of contribution to the total PCDD/PCDF emissions (for example, PCDD/PCDF emissions of German French steel sector was approximately 56% and 70% respectively in both of total emissions). The output of China's steel sector has been ranked first in the recent decade of the world. To be specifically, on account of the huge demand of the international steel market from China, in 2005, the steel output was 3.5579 million tons, the iron output was 3.4375 million tons and the rolled steel was 3.7771 million tons. Due to the PCDD/PCDF sources list of the POPs Convention, most of PCDD/PCDF generation stage in the steel sector is the sintering process. The sintering process is defined as the pretreatment section for the steel sector, which mixed and heated the fine iron ore, coke and coal, generating a state of semi-molten material, and then solidifying into the porous sintered substances to prepare for the follow-up of production. For steel sector of China, there have been about 80 per cent of the enterprises to use sintering process as a pretreatment section, and this technology has been applied in all the small and medium enterprises. In addition, despite China's lack of scrap steel resources, high electricity price, there was still a certain proportion of scrap steel recycling applying electric furnace steelmaking process in our steel sector, which has been maintaining at 15-18% in recent years. For example, in 2003 the steel output from electric furnace reached 39.06 million tons, ranking second in the world, which was 17.6% of the total steel output. And because of scrap steel containing paint, coatings, plastics, residual oil, and other organic chloride impurities, this production process was considered as important source of PCDD/PCDF. So the steel sector of China was a very important emission source of PCDD/PCDF.

In order to estimate the approximated PCDD/PCDF emissions per annual of steel sector of China, based on the output and the current integrated level of steel industry in 2003, the emission factor from UNEP can be the reference to calculate the PCDD/PCDF emissions, and the estimated results are showed as below:

Table 1. PCDD/PCDF emissions estimated per annual of steel sector of China

Medium	Gas	Water	Soil	Products	Residuals
Emission factor (μg TEQ/t)	10	ND	ND	NA	15
PCDD/PCDF emissions estimated (g TEQ/a)	2223.5				3335.25

Depending upon the estimated results, we can make sure that the PCDD/PCDF emissions of steel sector are a great deal of amount, so the BAT/BEP demonstration project has to be implemented in steel sector to reduce the PCDD/PCDF emissions.

(2). Incineration sector

Incineration sector could completely and quickly actualize volume reduction of industrial and municipal combustible waste, as well as eliminating pathogens and toxic organic compounds, and the heat generated was able to be recycled. So incineration sector has been the major solution to carry out the waste disposal now for the developed countries. But the PCDD/PCDF was easily formed in the flue gas from incinerators, for example, in the course of incinerating chlorine precursor (such as DDT, PCPs), and the temperature was kept in the range of 300-800 °C; and

PCDD/PCDF can also be generated in the cooling process of incineration flue gas encountering the following conditions: 200-500 °C temperature range and having sufficient staying time, the presence of chlorine, oxygen, and containing heavy metals and carbon dust as the catalyst. The main factors taking impacts on PCDD/PCDF generations and emissions include: composition of waste, design of the incinerators, the temperature of the region after the combustion, as well as the air pollution control equipments for the removal of pollutants in flue gas. These factors could lead to magnitude differences of PCDD/PCDF generated volume from per unit waste combustion. In China, the incineration technology was widely used for the medical waste, hazardous waste and municipal waste disposal. Especially in the period of "atypical pneumonia" in 2003, after the medical waste having been strictly controlled, incineration is recommended solution for waste disposal. However, at present, the portion of various types of waste through incineration technologies for disposal was quite low, for example in 1999, the medical waste incineration volumes in Shenzhen were 397 tons, only 10 percent of the total medical waste generated. Therefore, it could be assumed that incineration sector was one of the most important PCDD/PCDF emission sources in China on account of the huge waste generated volumes.

In order to estimate the approximated PCDD/PCDF emissions per annual of incineration sector of China, based on the all kinds of waste generation amounts and the portion of incineration as the ultimate disposal method, the emission factor from UNEP can be the reference to calculate the PCDD/PCDF emissions. For example, the urban population of China is about 300 million, and there are approximate 1000 tons medical waste generated by 1 million people, and only 10% of the medical waste can be treated by incineration, so the estimated results are showed as below:

Table 2. PCDD/PCDF emissions estimated per annual of medical waste incineration sector of China

Medium	Gas	Water	Soil	Products	Flying ash	Residuals
Emission factor (μg TEQ/t)	3,000	NA	NA	NA	800	20
PCDD/PCDF emissions estimated (g TEQ/a)	90				24	0.6

The hazardous waste generated per annual was about 10 million tons in China. Supposing only 5% could be treated by incineration, there were 500 thousand tons.

The emission factor from UNEP can be the reference to calculate the PCDD/PCDF emissions, and the estimated results are showed as below:

Table 3. PCDD/PCDF emissions estimated per annual of hazardous waste incineration sector of China

Medium	Gas	Water	Soil	Products	Flying ash	Residuals
Emission factor (μg TEQ/t)	5000	NA	NA	NA	1500	NA
PCDD/PCDF emissions estimated (g TEQ/a)	2500				750	

The municipal waste generated per annual was about 150 million tons in 2000 of China. Supposing only 10% could be treated by incineration, there were 15 million tons. The emission factor from UNEP can be the reference to calculate the PCDD/PCDF emissions, and the estimated results are showed as below:

Table 4. PCDD/PCDF emissions estimated per annual of municipal waste incineration sector of China

Medium	Gas	Water	Soil	Products	Flying ash	Residuals
Emission factor (μg TEQ/t)	350	NA	NA	NA	100	50
PCDD/PCDF emissions estimated (g TEQ/a)	5250				1500	750

Depending upon the estimated results of the three kinds of waste, we can make sure that the PCDD/PCDF emissions of incineration sector have a great deal of potential, so the BAT/BEP demonstration project has to be implemented in incineration sector to reduce the PCDD/PCDF emissions.

(3). Paper sector

Paper sector is the most important light sector in China. In 2000 the output of paper and paperboard was 30 million tons, in 2001 amounting to 32 million tons, in 2005 achieving 38-40 million tons. However, the existing technology and equipment of most paper enterprises were behindhand, and the high energy consumption and pollution were also rather serious. PCDD/PCDF was usually generated from the chlorine bleaching process (only 2,3,7,8-TCDD and 2,3,7,8-TCDF). To be specifically, most of the 2,3,7,8-TCDD and 2,3,7,8-TCDF were produced in the C-stage, where chlorine reacted with the precursor of TCDD (DBD) and the precursor of TCDF (DBF). The precursors of PCDD/PCDF existed in a certain mineral oils, which were the commonly used defoamer components in the pulp and paper sector. Furthermore, wood itself was the source of PCDD/PCDF source, such as the lignin of benzodioxin category for compressing wood. In addition, waste paper as raw material to paper mills was also the major source of PCDD/PCDF, and the proportion of waste paper as raw materials was more than 50 percent in China.

In order to estimate the approximated PCDD/PCDF emissions per annual of paper sector of China, based on the output of 38 million tons and the integrated level of paper industry in 2004, the emission factor from UNEP can be the reference to calculate the PCDD/PCDF emissions, and the estimated results are showed as below:

Table 5. PCDD/PCDF emissions estimated per annual of paper sector of China

Medium	Gas	Water	Soil	Products	Residuals
Emission factor (μg TEQ/t)	NA	NA	NA	8	NA
PCDD/PCDF emissions estimated (g TEQ/a)				304	

Depending upon the estimated results, we can make sure that the PCDD/PCDF emissions of paper sector are a great deal of amount, so the BAT/BEP demonstration project has to be implemented in paper sector to reduce the PCDD/PCDF emissions.

Through the analysis of the PCDD/PCDF emissions, the steel sector, incineration sector and paper sector have been confirmed to implement the BAT/BEP demonstration projects to reduce the PCDD/PCDF emissions.

2.2 Confirmation of demonstration enterprises

2.2.1 Selection principles

Based on the above selection for demonstration sectors, the investigated enterprise list need to be determined in order to further conduct the BAT/BEP project. The technological and economical ability of enterprise need be considered during the selection of demonstration enterprises, which can ensure the achievement of the demonstration project. In addition, the representative characteristic, possibility, and positivity of enterprises also need to be concentrated. The principles for the selection of enterprises are as follows:

(1) The environmental protection abilities of enterprises

The abilities include the previous capacity of the pollution control and the relevant technological support of enterprises. When UNEP organized experts to compile the guideline of BAT/BEP, they especially focused on the use of some basic methods of environmental protection to effectively reduce the production of unintentional POPs, such as the distribution of feed, bag filter, electrostatic precipitator. So the selected enterprises should be provided with some basic facilities of environmental protection, which would have important effects on the implement performance of BAT/BEP project, the concerned incremental cost, and the extended application.

(2) The economical capacity and participation enthusiasm

It is important for the enthusiasm of enterprises and sectors to participate in the BAT/BEP project and the fulfillment of the assistant fund, which determined the implement process of the project. The enthusiasm include not only the positivity of participating project but also the cognitive level of sectors for POPs convention and the concerned issue of environmental protection. So it could ensure that the sectors establish some technical criterions and prepare the obligatory fund to promote the implement of the demonstration project.

(3) The representative characteristic of technologies used by enterprises

Since the demonstration project is the first step of the implement of BAT/BEP, the aim of this project is the accumulation of the concerned data and experiences. So the technologies used by the selected enterprises should possess significant representative characteristic for a sector, which would be help to the wide implement of the BAT/BEP.

(4) The production level of unintentional POPs

POPs convention especially focused on the production amount of unintentional POPs. The amount is closely related with the performing process of POPs convention in China and the health of workers in the above sectors. So the concerned production amount of POPs should become the important selection principle to the sectors. Since the investigation work for unintentional POPs has never been carried out to various sectors in China, the preliminary production inventory of the unintentional POPs could be estimated on the basis of UNEP emission factor, and the yield and the situation of manufacture process of enterprises. So the emission amount of unintentional POPs should be considered during the selection of enterprises.

Based on the above principles, six enterprises were selected as the demonstration enterprises to carry out the BAT/BEP project. Shanghai Baosteel Corporation and Taiyuan Taisteel Corporation were selected as the represented enterprises in steel sector. Huzhou Century Clean Corporation and Jinan Hanyang Corporation were selected as the represented enterprises in incineration sector. Shandong Huatai Corporation and Hunan Tigering Paper Corporation were selected as the represented enterprises in paper making sector. The technological situations of six enterprises before the implement of BAT/BEP are introduced as follows.

2.2.2 Introduction to demonstration enterprise—Shanghai Baosteel Corporation

Baosteel Corporation is a super large steel conglomerate established on November 17, 1998. Being the largest productive, the most diverse and competitive steel corporation in China; Baosteel has an annual production capacity of approximate 20 million tons, including high-added-value special steel. Since there are sinter and electric furnace processes in Baosteel, dioxins release and pollution will occur in steel making. The No.1 sinter machine in Baosteel branch and 100t electric furnace in special steel branch were selected as demonstration units for UP-POPs release reduction project.

At present, the effective area of No.1 sinter machine is 495 m2 (See Figure 1) and its annual production capacity was designed to be 5.5 million tons. 86.5% of the homogenous ore for sintering is imported. The rest is cyclic mixed ore in the corporation, including the compression materials, ESCS dust, iron slag, granular iron,

iron oxide and steel slag. The auxiliary materials added to sinter machine mainly contains lime(420 t/d), lime stone(600 t/d), dolomite(380 t/d) and serpentine(190 t/d)。The solid fuel includes coke powder(550 t/d) and anthracite(150 t/d)。The weight of these materials was automatically calculated according to the ratio. Then, the output was controlled by CFW. Finally, the materials were transported by belt conveyor to the primary mixer and the secondary mixer to be mixed with water and granulated. The typical composition of sinter mix was listed in Table 6.

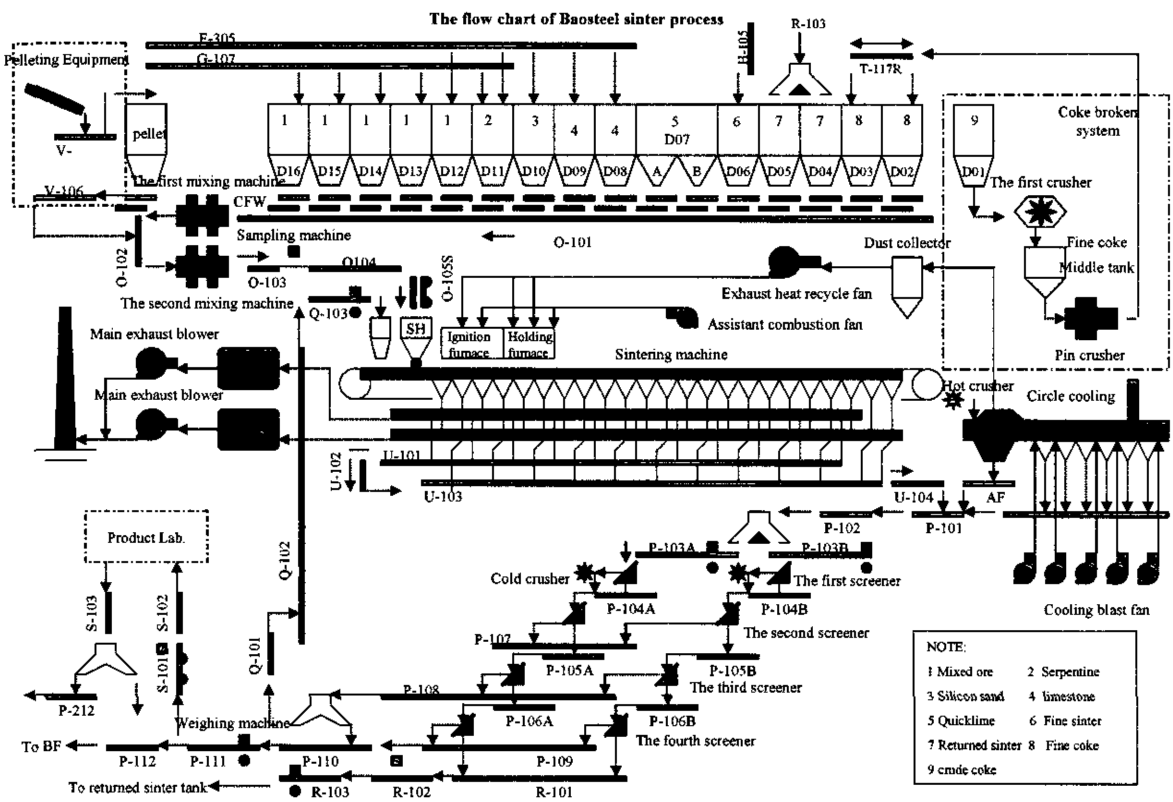


Figure 1. Process flow diagram of No.1sinter machine in Baosteel branch

Table 6. The chemical composition of sinter mix （%）

	TFe	CaO	SiO_2	Al_2O_3	MgO	TiO_2	P_2O_5	S
Sinter mix	52.4	7.9	3.8	1.4	1.1	0.1	0.11	0.02

After sintered on the table-car, the sintered ore was discharged at the end of sinter machine and entered into a round sinter cooler, where the sintered ore was cooled by forced air generated from 5 blowers. After dust precipitation, hot exhaust gas from the hot crusher process and the discharge zone was sent to the ignition furnace and holding furnace for recycle。Cooled sintered ore entered into the sieving and size gradation system, where 5-50mm sintered ore would be transported to the blast furnace as finished products and -5mm fine-granular was sent back as return ore to the raw and auxiliary material system. The typical chemical composition and quality of sintered ore is listed in Table 7.

Table 7. Quality data of sinter

TFe %	FeO %	SiO_2 %	Al_2O_3 %	S %	C/S	TI %	RDI %	MS mm	RI %
58.8	7.8	4.6	1.7	0.01	1.8	75.4	29.6	23.1	68.6

In addition, diagram of extract system and exhaust gas collecting system was shown as Figure 1. The air above the sinter machine was extracted by two main air extractors to 23 air tanks, which was below the sinter machine. The exhaust gas collecting system was divided into 2 sub-systems, i.e., N sub-system for non-sulfur elimination and S sub-system for sulfur elimination. The air tanks were grouped as follows, (1) N sub-system: 11#-19#; (2) S sub-system: 1#-6#, 22#, 23#. 7#-10#. 20# and 21# could be switched to N or S sub-system according to the actual situation. The air flow of each main air extractor was 1,260,000m^3/h. Before being discharged into the environment, the exhaust gas was precipitated by electrostatic precipitators (ESCS-A and ESCS-B) to reduce the dust emission. Two sets of electrostatic precipitators (ESCS) could meet the dust removal efficiency of approximate 84-97% (See Table 8). The exhaust gas processed by ESCS was discharged into the environment through a chimney with the diameter of 6.2m and the height of 200m. The concentration of particles in the discharged gas was less than 80 mg/Nm^3. The exhaust gas from the circular cooler(390,000 m^3/h)was processed by an individual electrostatic precipitator. After being cooled and broken in the precipitator, the exhaust gas was discharged into the environment through a chimney with the diameter of 4m and the height of 50m. The concentration of particles in the discharged gas was less than 100 mg/Nm^3.

Table 8. Removal efficiency of electrostatic precipitator for exhaust gas (ESCS) (Jun.19, 2005)

Parameters		velocity (m/s)		Temperature (°C)		Flow (Nm^3/min)		Dust concentration (mg/Nm^3)	
		inlet	outlet	inlet	outlet	inlet	outlet	inlet	outlet
ESCS	N sub-system	14.5	16.38	122	110	9,977	10,898	811.7	74.8
	S sub-system	16.3	18.2	161	150	10,055	10,632	857.1	79

The largest electric furnace in Baosteel special steel branch is a 100t single graphite electrode electric arc furnace (EAF) with the annual production capacity of about 550,000 tons. It was chosen as a demonstration unit for UP-POPs release reduction project. The production and process information is listed in Table 9. The raw materials for steel making were steel scraps. The routine operating procedures are as following, pretreatment and storage for steel scrapes→ loading to electric furnace→ smelting→ tapping and slag removal→ ladle furnace refining→ vacuum degassing → continuous casting.

Table 9. Production and processes information of 100t electric furnace in Baosteel special steel branch

Type	Information
Starting date for production	Mar. 28, 1997
Electric furnace type	DC, UHP
Amount of graphite electrode	1
Product categories	Carbon steel, low alloy steel and high alloy steel, etc.
Rated capacity (t)	100
Batch capacity (t)	106
Metal charge (t)	120.8
Raw materials	steel scrapes
productivity (t/h)	84.8
Annual production capacity (t/y)	550,000
Operation days (d/y)	323
auxiliary fuel	coal, coal gas
Amount of auxiliary burner	6 (1 oxygen lance， 5 oxycoal lance)
Nitrogen, argon or other inert gas blowing from furnace bottom	none
smelting time each furnace of steel (min)	75
cooling system	Water-cooled wall, water-cooled adjustor, air-cooled heat exchanger
tapping system	Eccentric Bottom Tapping (EBT)
exhaust gas collecting	Direct pump out (the second hole), dog-house, canopy
exhaust gas purification system	bag precipitator
heat recovery	none
secondary refining	LF furnace, vacuum degassing

The primary exhaust gas from the smelting processes passed through the second hole, water-cooled adjustor, entered into air-forced cooler and was discharged from the inner air blast into the exhaust pipe（See Figure 2）。Loading materials to the furnace, tapping and releasing from electrode hole and furnace door in the routine smelting evoked the secondary smoke. The smoke was extracted through a canopy and an enclosed hood above the electric furnace to main air pipe. Through the bag precipitator, the smoke was discharged into the environment. The flow of exhaust gas from the electric furnace was approximate 850,000 Nm^3/h. However, the actual flow of exhaust gas would vary with the flow of secondary smoke and production cycle (loading, smelting and tapping). The primary and secondary smoke was collected to the same air pollution control system (bag precipitator) to remove dust. The dust removal efficiency of the bag precipitator was estimated to be approximate 99%. The collected dust, approximate 15 kg each ton of steel could be re-used as the cement additive and for Zn recycle. The purified exhaust gas, with the flow of 850,000 Nm^3/h and temperature of 60-110°C, was discharged into the environment through a chimney with the diameter of 5m and the height of 20m (See Figure 2). The particle concentration of discharged exhaust gas was less than 10 mg/Nm^3.

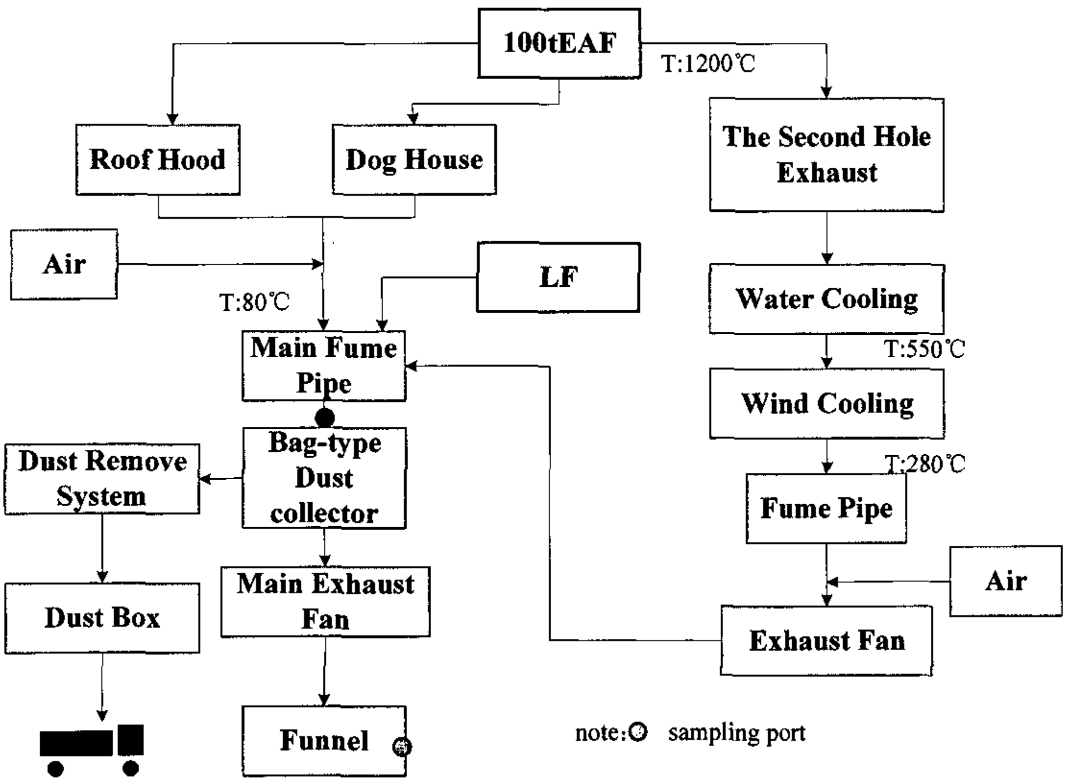


Figure 2. Smoke collection and purification system of 100t electric furnace in special steel branch

2.2.3 Introduction to demonstration enterprise—Taiyuan Iron & Steel (Group) Co., Ltd. (TISCO)

Taiyuan Iron & Steel (Group) Co., Ltd. (TISCO) is a super-large iron and steel complex in China and a stainless steel producer with the greatest capacity and most advanced equipment and technology known to the world. In 2006, 6.26 million tons of steel was produced in TISCO, including 3 million tons of stainless steel. TISCO also have sinter machines, electric furnace and production processes, which are typical and at scale. In addition, TISCO helps to protect the environment positively. "Study on the technical methods of clean production" and "Planning for circular economic development" written in TISCO brought theories and practices into clean production and circular economics. In the corporation strategy and plan, they are in consistent with the target of POPs release reduction. TISCO is willing to invest money and manpower to reduce the release of dioxins.

The annual production capacity of sintered ore in TISCO, 4.3 million tons is used for blast furnace iron-making. At present, there are 4 belt sinter machines (two sets of 90 m^2 and two sets of 100 m^2), 3 sets of stackers and reclaimers, 2 sets of car dumps in storage and transportation system in TISCO. There are multi-pipes precipitators at the head of No.1# and 2# sinter machine, with the design capacity of 480000Nm^3/h, and electrostatic precipitators at the head of No. 3# and 4# sinter machine, with the design capacity of 540000Nm^3/h. Moreover, there are 2 sets of multi-pipes precipitators and 12 sets of electrostatic precipitators in the sintering system, 2 and 14 sets of bag precipitators in the feeding system and storage & transportation workshop, respectively. The sinter machine chosen as demonstration unit for UP-POPs releasing reduction project has an effective area of 100 m^2. Its process flow diagram and principle is shown as Figure 3. Mine powder (rich-mine powder, concentrate ore powder and other fine iron-containing materials) is mixed with flux (lime stone, dolomite, lime, etc.) and fuel (coke and coal powder) at a certain ratio. After being mixed, granulation, preheated, distribution and ignition, high temperature from the oxidation of furnace charges (fuels) kept water in raw sintering materials evaporated and led to a serial of chemical reactions. The liquids generated in the reactions bonded and blocked when cooled. Sintered ore would be got after the blocks' rationalization of breaking and sieving. In TISCO, powder made from self-prepared iron ore is used as main raw materials for sintering.

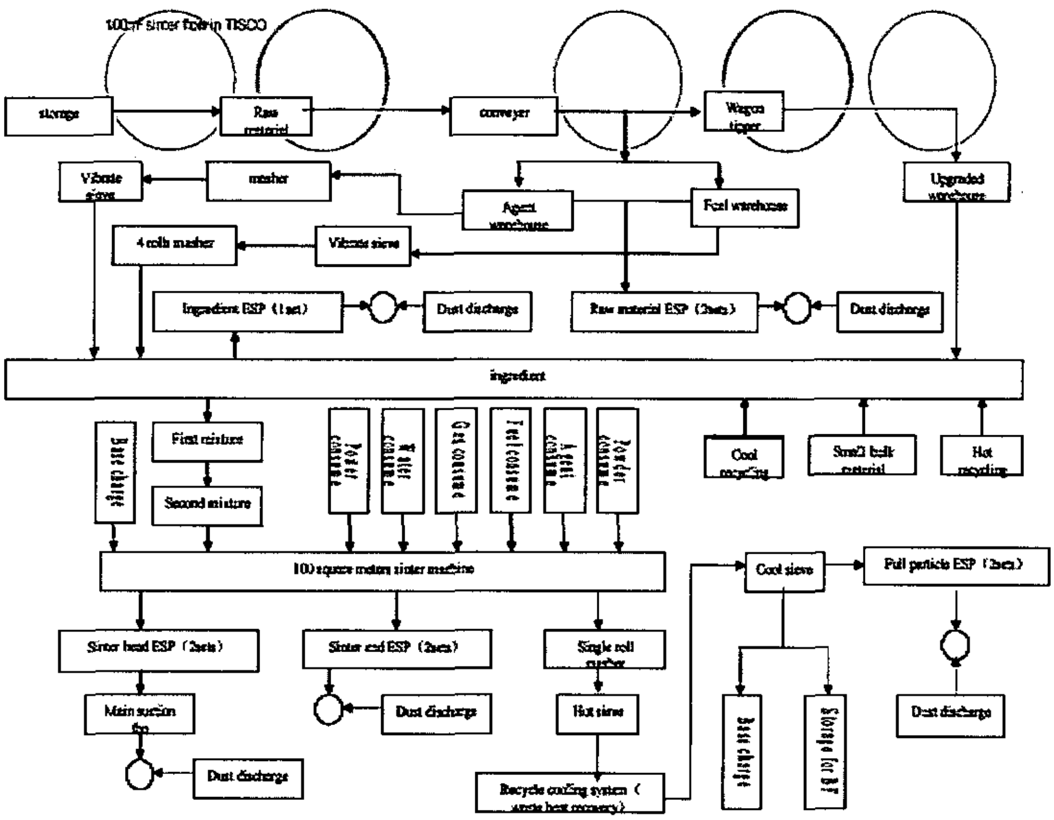


Figure 3. Flow diagram of 100m² sintering process in TISCO

Pollutants' sources and types in working procedures of TISCO were listed in Table 10.

Table 10. Analysis of pollutants' sources and types in working procedures of TISCO

Working procedures	Sources of pollutants	Major pollutants
Raw material preparation	discharge cargo/breaking/sieving/drying/mixing /belt conveyance	dust
Mixing materials	mixing/granulation	dust
Sintering, roasting	combustion of coal gas, coke powder and coal powder, etc /sintering/roast	Smog(dust)/SO_2/NO_x/CO/CO_2/dioxin
Production granulation	break/sieving	dust

In the 50t electric furnace steel making processes of TISCO, steel scraps and reduced iron are used as raw materials and electricity is used for smelting and refining (See Figure 4). Moreover, molten iron added into the raw materials is approximate 50%. The possible sources of dioxin in the electric furnace steel making of TISCO are similar to those of Baosteel, which are in the primary smoke, releasing from loading materials for electric furnace and steel scraps smelting processes and the secondary smoke, releasing in the smelting processes to above the workshop and collected by the canopy. The dust precipitation of smoke is shown as Figure 5.

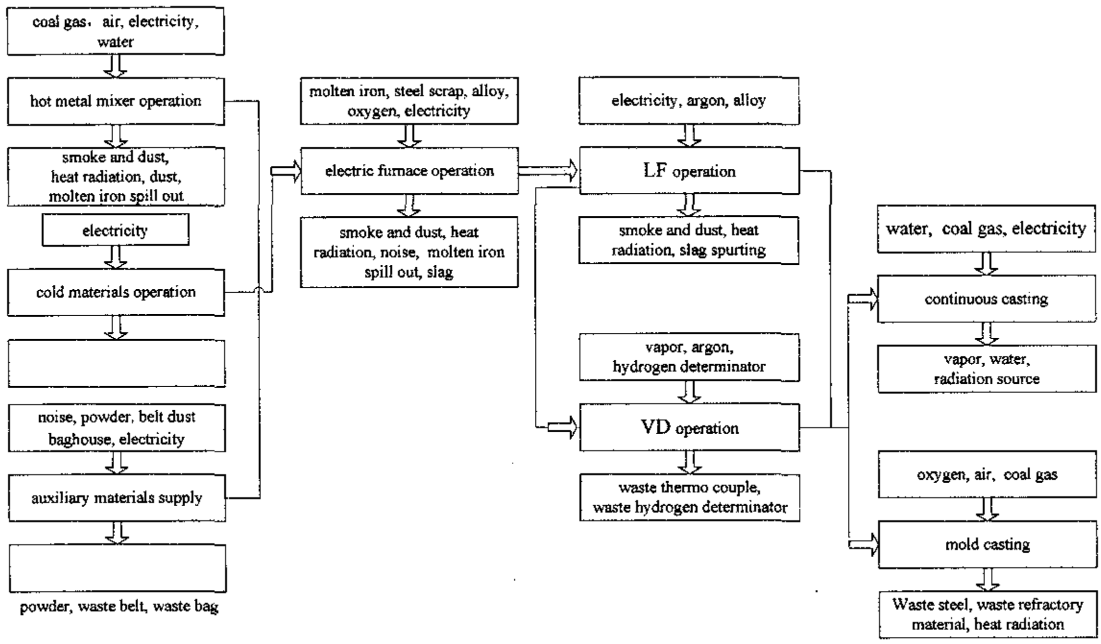


Figure 4. Flow diagram of 50t electric furnace process in TISCO

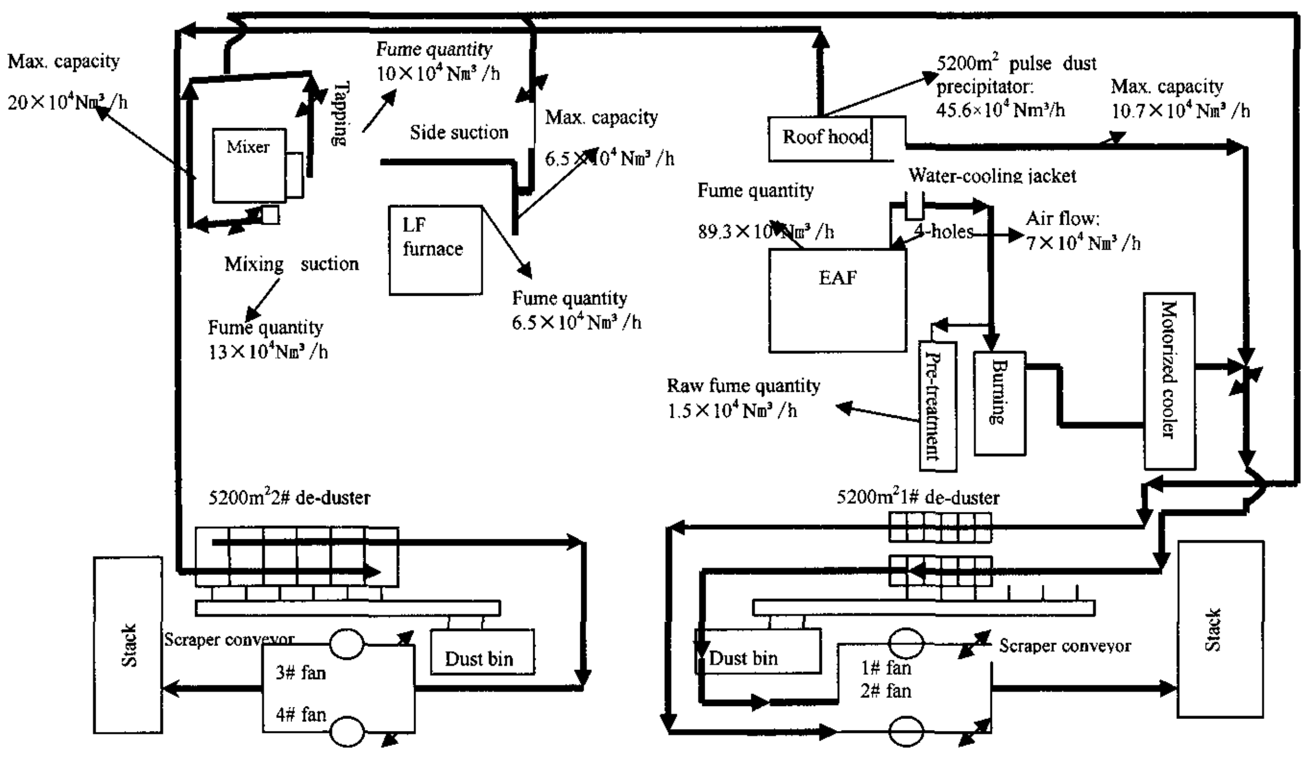


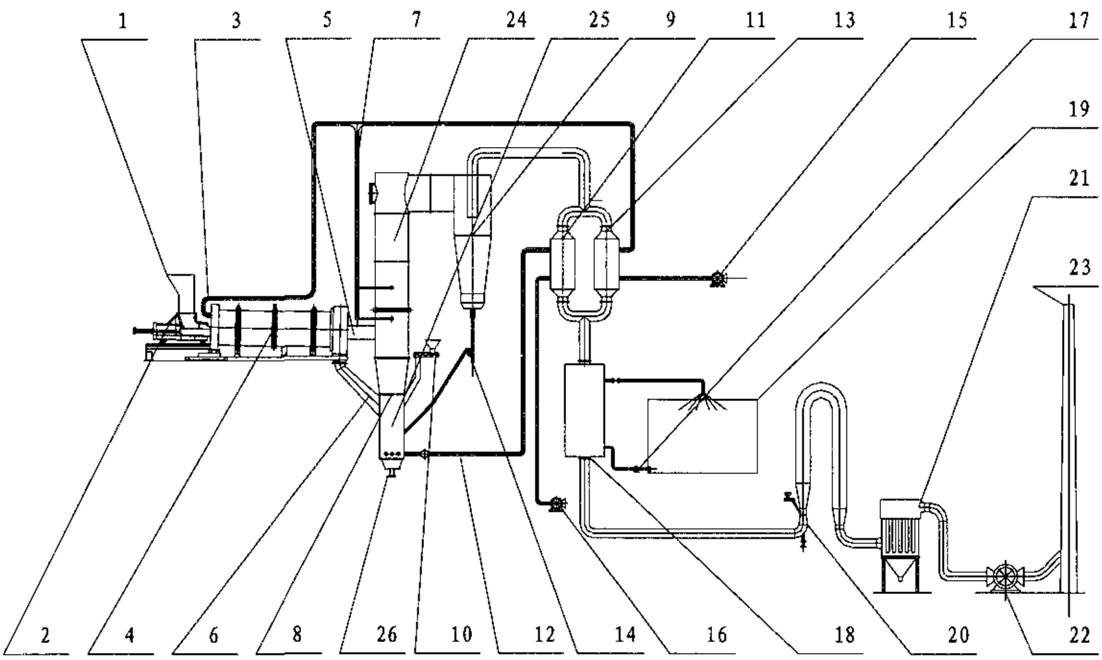
Figure 5. Processes diagram of dust precipitation in TISCO electric furnace steel making

2.2.4 Introduction of Demonstration Enterprise: Huzhou Century Clean

Huzhou Century Clean Solid Wastewater Treatment Center (the Center for abbreviation) is comprehensive private enterprises. Authorized by local government, the Center has carried out the centralized treatment and market operation since 2002 and has received significant effects. Till now, solid wastes of 22 hospitals at or above the county level, 111 hospitals of rural townships, and 323 private clinics have been treated by the center, which gives 100% treatment rate. In early 2004, together with Zhejiang University, the center devoted itself to construction a new type rotary fluidized multiple stage incineration system for medical waste, and put it into operation for 10t/d medical wastes successfully in November, 2004. The rotary fluidized multiple stage incineration system, developed by Zhejiang University, is an advanced integrated technology for medical wastes, which have complex composition and fluctuating combustion value. It receives advantages of both rotary kiln and fluidized bed, provides steadily good performances of pyrolysis and incineration, and causes relatively low pollution.

The specific technical data of project for medical wastes disposal in Huzhou are as follows:

Daily capacity of one set:	400kg/h
Combustion value for medical wastes:	6974 kJ/kg（1427kcal/kg）
Temperature of incinerator	≥850°C
Residence time of flue gas	≥2.0s
Combustion efficiency	≥97%
Removal rate for organic pollutants	≥99.99%
Weight loss during calcination	<3%



1. Waste hopper, 2. Feeder, 3. Pyrolysis/gasification air, 4. Rotary kiln, 5. Connect pipe with gas, 6. Connect pipe with solid, 7. Secondary air, 8. Fluidized bed furnace, 9. High temperature cyclone, 10. Lime stone feeder, 11. Air preheater, 12. Fluidized air, 13. Secondary air preheater, 14. Recycling device, 15. Secondary air fan, 16. Blower fan, 17. Water pump, 18 Quench, 19. Cooling tower, 20 Semi-dry scrubber, 21. Bag filter, 22. ID 23. Stack, 24. Thin phase zone in fluidized bed, 25. Dense phase zone in fluidized bed, 26. Slag outlet

Figure 6. Schematic of the rotary kiln and fluidized bed multi-stage incineration technology

The system will be described specifically under the scope of demonstration project for medical waste treatment.

(1) Feeding system

The designed daily capacity of the project is 10t. Medical wastes are delivered into the medical waste incineration and disposal center by specialized trucks. After weighed, they are directly dumped into the storeroom under the instruction of storeroom operators. The whole storeroom is airtight, except for an unloading head. At the unloading head, air curtain is used to prevent air leakage. Above the storeroom, exhaust system operates continuously, with the purpose of controlling odour and methane. Exhaust pipes connect with fans. Air needed for incineration comes from above the storeroom, and is also sent into incinerator by fans. Forklifts in the storeroom are in charge of stacking and loading. Medical wastes are sent into feed hopper by means of hoister and rotary kiln by means of hydraulic pressure feeding system.

(2) Incineration system

✧ First pyrolysis/gasification chamber of rotary kiln

In this medical waste pyrolysis-incineration configuration system the rotary kiln is responsible for the pyrolysis and gasification of the waste. Medical waste is fed by feeding system into the first combustion chamber (rotary kiln) and moves towards the rear end of the kiln while the kiln is rotating. During the movement inside the kiln, the medical waste undergoes several stages including preheating, moisture vaporization, pyrolysis, gasification and partial combustion. At the head end of the rotary kiln, there is a burner for ignition and ensuring the temperature inside the kiln for pyrolysis to be 500°C-800°C.

The fuel gas yield during pyrolysis goes into the freeboard of the circulated fluidized bed (CFB) for the combustion. The solid residue goes into the dense area and is burnt there. The medical waste rolls inside the kiln and is exposed to the hot air alternately. As the temperature inside the kiln is moderate, the waste is heated equably and slowly, and the moisture and the volatile yield equably, which solves the problem of plastics deflagration by CFB solely.

The residence time of medical waste inside the kiln and the treating capacity of the rotary kiln can be regulated by adjusting the angle of inclination or rotary speed. The large capacity ability of rotary kiln can deal with the increasing amount of medical waste to be disposed of, and ensure the medical waste to be treated in time during equipment maintenance.

✧ Second and third combustion furnaces of CFB

In the incineration system, the CFB is responsible for the afterburning of gas and solid residue produced from pyrolysis, gasification and partial combustion. The range of temperatures inside the CFB is usually 850°C~1100°C. Air supply offers high intensity turbulence and oxygen, which produces intensively combustion. The solid residue is fluidized after entering the CFB and its residence time is over 40~60 minutes, which ensures the burn out of the solid residue. The ratio of not completely burnt material in discharged ash is less than 2%, which is far lower than the State Regulation for Hazardous Waste Incineration

After entering the CFB, the gas from rotary kiln pyrolysis combusts quickly while air supply offers high intensity turbulence and oxygen. The residence time of gas inside the CFB is more than 3~4 seconds, which can ensure the complete burning of combustible components of the gas and inhibit the yield of PCDD/F effectively.

Limestone is added into the chamber and the calcium oxide reacts with acid gases like HCl produced by medical waste combustion, thus reducing their emission and avoiding the corrosive problem to the equipments after combustion stage.

The flue gas outlet from fluidized bed with high temperature firstly is cooled down to 500 by air pre-heater of high temperature, meanwhile, the assistant wind for pyrolysis, fluidized and burnout are heated to around 500°C, which can improve the temperature condition in combustion chamber without addition of complemented fuel.

The flue gas outlet from air pre-heater of high temperature is fast cooled down to 200 °C below by flue gas quencher. Water-pipe heat exchanger was adopted as flue quencher, i.e. hot flue gas flowing along outside of pipe as cooling water flowing inside of pipe without direct contact of the two media, so as to avoid the water pollution as well as its necessary treatment. As the stay of flue gas in quencher is within 0.5 s, the formation of dioxin in this temperature shall be effectively reduced.

(3) Residual heat reclaiming system

A high temperature preheater has been designed in order to preheat the air which enters into the furnace, so as to reclaim some part of the heat. The generated air with high temperature can be used as pyrolysis gasification air of the rotary kiln, or first air and second air of fluidized bed.

(4) Flue gas treatment system

✧ Flue gas quenching system

Flue gas quenching system includes heat exchanger, water supply pump, and pipes. In the flue gas quenching system, flue gas temperature rapidly reduces even below 200°C, and inhibits effectively the PCDD/F regeneration.

✧ Flue gas purification system

The flue gases from flue gas quenching system enter the absorption tower via Venturi pipe located under spray drying desulphurization tower. Hydrated lime is delivered to absorption tower for the mixing with flue gas by screw feeder lied under absorption tower, and reacts with SO2 in the flue gas, and form CaSO4, CaSO3, etc. After primary separating dry reactants from absorption outlet into cyclone separator, these mass enter absorption tower reactor, then come into bag filter dust collector via primary dust precipitator. Fly ash collected in bag filter dust separator is sent to ash combustion furnace. A funnel like absorbent device is used for adding activated carbon to the flue gas to eliminate the PCDD/F.

✧ Dust collection and bottom ash recycling system

The dust collection system is composed by a bag filter. It includes bag-type dust separator, bag-type dust ash hooper and conveying ash apparatus.

The flue gas system is composed of induced draft fan (ID fan) and flue. The actual capacity of ID fan can not be increased too much and must limit around the design value. If the actual capacities exceed this value, the flow rate of the bag filter system would be excessive, and affected the normal performance of the bag filter system. In this case, the capacity must be adjusted to adapt the designed air capacity value.

Bag filter system is composed of bag filter, compressed air source for purging filter, and conveying ash apparatus. It is also equipped with preheater cycling system and bypass system in order to prevent dew phenomenon of filter bag surface on the condition of start-up.

More than 99.8% fly ash discharged from incinerator are collected by the bag filter, then emitted via pump and specialized pipes to the ash burnt furnace, melted and solidified together with the first combustion generated slag.

Cement solidification system is employed for slag pretreatment. After cooled by slag cooler to less than 200°C, slag is transported to temporary slag yard manually. Cement solidification occurs in the temporary slag yard, and whereafter, the products are delivered to secure landfill by trucks.

The disposal of products should be done after qualitative analysis. If they can be comprehensive utilized, they will be used as additive for cement plants, as well as construction materials, such as floor tiles of sidewalk. If not, they will be delivered to secure landfill.

✧ Secondary pollutants control for combustion system

With the help of rotary fluidized incineration technology combined with flue gas purification, pollution control for the combustion system can be concluded as follows:

The multi-stage air supplying technology used in this plant, in addition of the low nitrogen content of the medical waste, can efficiently decrease the NOx concentration in the flue gas.

Heavy metals contained in the waste enter into the furnace chamber and combust with the waste. During the combustion process, different heavy metals can be transformed in two way; most of them are coagulated to the slag or solidified by reacting with sulphur and chlorine; the other part enter into the flue gas as the gas phase metals. Some analyses carried out previously indicate a low concentration emission of these heavy metals. The gas phase metals contained in the flue gases can be adsorbed by the low-temperature basic lime slurry and deposit in the purification tower.

The furnace temperature of the rotary kiln designed in this project is about 850~1200°C, and the flue gas has a 2 second retention time at 1200°C in the second combustion furnace, thus reducing the risk of presence of PCDD/F precursors. Moreover the flue gas quenching tower and the activated carbon absorption device also reduces the PCDD/F formation and emission.

Adopting control measures above, pollutants emission in flue gas are listed in Table 11 when incinerating designed waste under designed condition.

Table 11. Pollutants Emission in Flue Gas of Incinerator of Huzhou Century Clean

Item	Unit	Value	Standard
Dust	mg/Nm^3	60	65
CO	mg/Nm^3	60	80
SO_2	mg/Nm^3	60	200
HF	mg/Nm^3	<4.0	5.0
HCl	mg/Nm^3	<60	60
NOx (Calculated by NO_2)	mg/Nm^3	200	500
Hg & related compounds (Calculated by Hg)	mg/Nm^3	<0.1	0.1
Cd & related compounds (Calculated by Cd)	mg/Nm^3	<0.1	0.1
As, Ni & related compounds (Calculated by As+Ni)	mg/Nm^3	<1.0	1.0
Pb & related compounds (Calculated by Pb)	mg/Nm^3	<1.0	1.0
Cr, Sn, Sb, Cu, Mn & related compounds (Calculated by Cr+Sn+Sb+Cu+Mn)	mg/Nm^3	<3.0	4.0
Dioxin	I-TEQ ng/Nm^3	0.1	0.5

2.2.5 Introduction of Demonstration Enterprise: Jinan Hanyang

In May 2003, Jinan Environmental Protection Industrial Technological Development Service Station and Shenzhen Hanyang Investment Holding Co., Ltd. set up Jinan Hanyang Solid Waste Treatment Co., Ltd., which is in charge of centralized medical wastes treatment in Jinan city. A LXRF vertical rotary pyrolysis/gasification incinerator, with the capacity of 24t per day, is employed for medical wastes treatment. The main technical support comes from Jinan Environmental Engineering Design Institute.

Medical wastes combust in vertical rotary pyrolysis/gasification incinerator, and combustible gas combust in secondary chamber. Flue gas with high temperature is firstly quenched by residue heat boiler and semi-dry acid gas scrubber, then dedusted by bag filter, and finally enters into activated carbon adsorption tower for further removal of dioxin.

The temperature of high temperature zone of the first chamber achieves about 1100°C, and of the secondary one achieves about 1200°C; The residence time in secondary chamber is above 2s, and oxygen content reaches around 11%. All of these conditions are favorable for dioxin elimination. With the help of residue heat boils, flue gas is cooled from 600°C to 200°C sharply in 3-4s. Combination of semi-dry acid gas scrubber and bag filter effectively eliminates acid gas and dust, as well as most of dioxin. Flue gas is emitted after further purification by activated carbon adsorption tower.

In addition, the incinerator and processes for flue gas treatment adopted by Jinan medical wastes treatment center have some characteristics as follows:

As the vertical rotary pyrolysis incinerator, wastes are fed at the top of the chamber. When operating, the chamber rotates, and medical wastes are evenly distributed.

Newly fed wastes, at the top of the chamber, do not rotate, so the incinerator produces moderate fly ash and dioxin. As most of the medical wastes can be pyrolyzed to combustible gas in the furnace, high temperature combustion in the secondary chamber can be maintained with the combustible gas. Quenching equipment not only effectively reclaims heat, but also reduces humidity of the flue gas, which benefits stable operation of the whole system. The bag filter removes dust and most of dioxin, it reduces adverse effects for activated carbon adsorption tower, which extends the service time of activated carbon.

2.2.6 Introduction of Demonstration Corporation--Shandong HUA Tai

HUA Tai Corporation, a large-scale state corporation with paper making as its main production, combining chemical engineering, print, thermal electricity, goods circulation, forest industry and economical services, is one of the 520 large-scale state corporations, and one of the 24 key large-scale backbone corporations attempered by Shandong province. HUA Tai Corporation has the first postdoctoral research station among our national paper making sectors and a national industrial technique exploitation centre. And it has passed the ISO9001 normative attestation of international quality (2000), ISO14001 normative attestation of international environment and ISO10012 normative attestation of measurement. Its benefit has been staying the top in national equivalent sectors since 1996. In 2004 it had a sale income of 5.1 billion yuan and a benefit tax of 750 million yuan, keeping good development potential.

The technical procedure of paper making in the corporation is as below: wheat grass → reamer roller grass cutting machine or scattering packaging machine → material storehouse → strap transporter → waterpower grass smashing machine → inclined helix machine → pre-braising → helix material supplying machine → adding alkali → three-tube continuous braising and boiling → spraying → pressure decreasing →

vacuum backwash extraction → two-stage pressured selection → washing and dewatering → slurry and chlorine mixing →chlorination → washing and dewatering → slurry and alkali mixing → alkali treatment → washing and dewatering → bleaching → washing and dewatering → paper delivering.

2.2.7 Introduction of Demonstration Corporation—Hunan Tigering Paper

Hunan Tigering Paper Ltd. Corporation is a first-degree state corporation combining slurry/paper making and forest exploitation. Ranking the 216th in the 520 large-scale state corporations, it is the chief corporation of the "10 symbol projects" implemented by Hunan province for the purpose of accelerating the process of industrialization. Tigering has a 900 thousand tons productivity of paper and cardboard and its total assets has been 10.7 billion yuan in the late 2006, with forest area of 253,000 hectares and reed base 23,000 hectares.

Two sub-factories, Yueyang and Ruanjiang Paper Sectors are demonstration corporations selected for the reduction let of UP-POPs. Yueyang Paper Industry adopts two product lines, one using horsetail pine sulphate to bleach wood slurry and the other bleaching reed slurry by sulphate, with annual productivity of 80-100 thousand tons. With hypochlorite as an accessorial bleaching reagent, it takes a three-stage bleaching process of C (chlorination), E (alkali treatment) and H (hypochlorite bleaching), and an additional bleaching by H2O2. These two slurry production lines containing chlorine are the main source of dioxin and furan in Yueyang Paper Industry. Ruanjiang Paper Industry consumes 290 thousand tons of raw materials annually, including 220 thousand tons (18% of water content) reed and waste paper and 70 thousand tons wood, producing 250 tons reed slurry and 110 tons wood slurry everyday. Its bleaching process includes further removal of xylogen by braising and boiling technology, closed screening and product line of O(xylogen removal by oxygen)-D0(ClO2)-E-D1(ClO2) without chlorine. Ruanjiang Paper

Industry's braising, boiling, washing, and selecting technical process is shown in Figure 7.

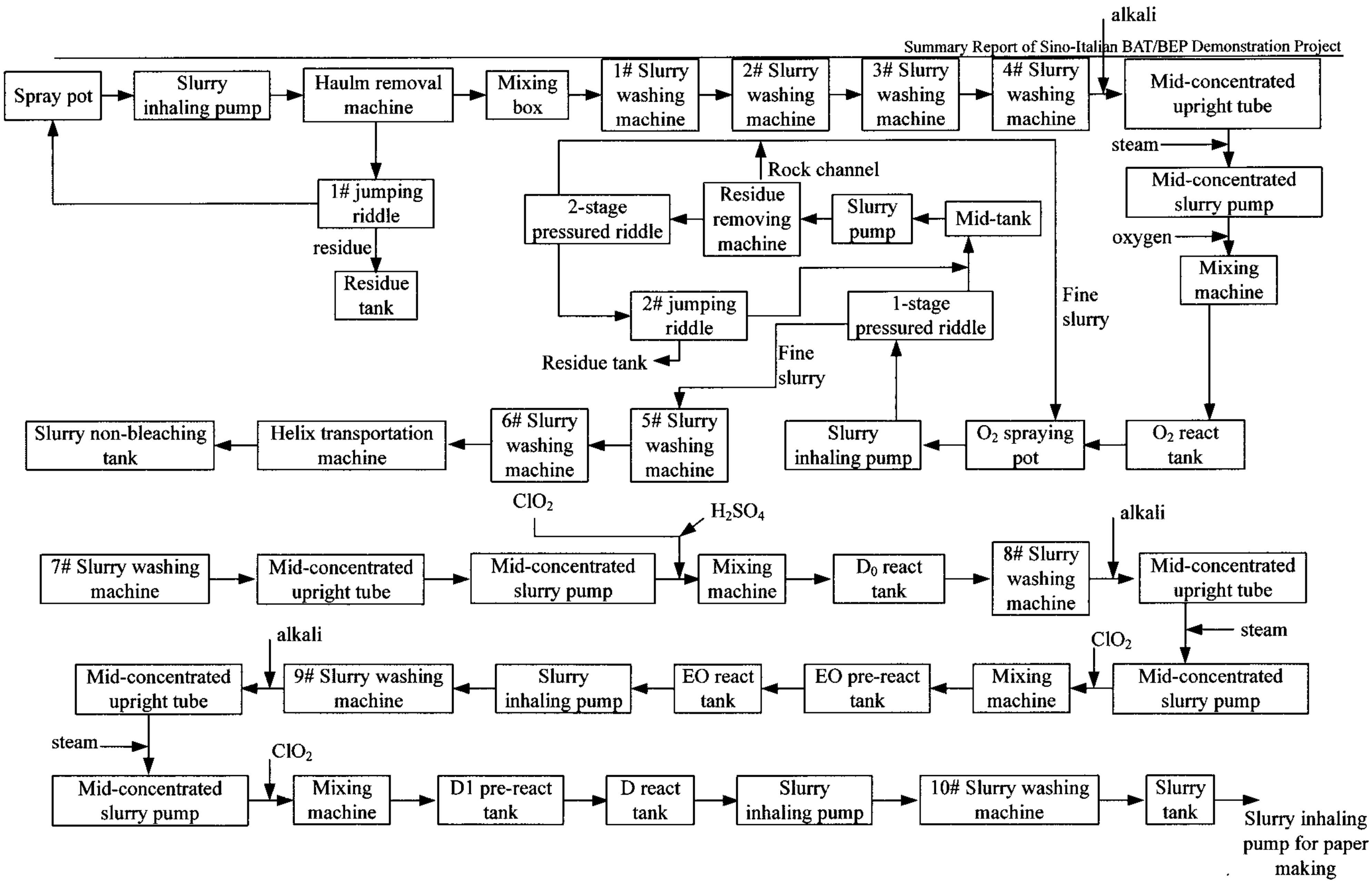


Fig. 7 The braizing, boiling, washing, and selecting technical process in Ruanjiang Paper Industry

3. The applied BAT/BEP scheme for demonstration enterprises

After finished BAT/BEP project, the operational status of these demonstration enterprises would have a direct effect on the evaluation for the applied BAT/BEP scheme. In order to effectively evaluate the performance of reducing emission of unintentional POPs, the monitoring in some special sampling points along the flow line of enterprise must be dealt with. So the positions of these sampling points need to be determined, which should obviously indicate the emission status of unintentional POPs in the flow line. Based on the analysis result of these sampling points, it can be evaluated to the emission level of POPs and the performance of BAT/BEP scheme. Therefore, this project include two sampling work. One is the investigation for POPs during the common run; other is the investigation for comparison after the implement of BAT/BEP.

The demonstration enterprises should cooperate with the concerned experts and organizations to conduct the monitoring work. Moreover, these enterprises need assign the indispensable technician to learn the BAT/BEP for application in order to the successful implement of the project. The elaborate BAT/BEP scheme are explained in terms of different sectors and enterprises as follows.

3.1 Steel Corporation

To control dioxin release from sintering and electric furnace steel making, first of all, is to control dioxin formation in these processes, i.e., source control.

3.1.1 Shanghai Baosteel Corporation

As to specific processes in Shanghai Baosteel, references of present main technologies for dioxin release reduction and for the consideration of economic and technical capacity, dioxin release reduction scheme is suggested as following.

(1) Dioxin release reduction by stopping insufflations of $CaCl_2$ in sintering

With the No.1 sinter machine's production, the returned sintered ore in the blast furnace slot was stopped in use for 3 days or insufflations of CaCl2 on the surface of the sintered ore was stopped for 3 days. The dioxin release in the experiments was compared with that in routine production. The research department was in charge of the calculation of increment cost with the help of the sintering branch. Before the experiments, the raw and auxiliary materials scheme for improving deficiency was provided by the research department and affirmed by the sintering branch in order to reduce the chlorine and copper in the raw materials.

(2) Dioxin release reduction by stopping using solid scraps

With No.1 sinter machine's production, a stockpile of the homogenous ore was chosen and all kinds of recycling solid materials such as return ore, dust, mill scale, pellets and miscellaneous materials were stopped in use. The actual impact of dioxin release when using recycling scraps in the routine production was in comparison with that when free of using recycling scraps. The finance clerks were in charge of the calculation of increment cost with the help of the sintering branch.

(3) Effect of different grades of steel scraps on dioxin release in the electric furnace process

Dioxin formation and release in the electric furnace steel making process is closely correlated with appendiculate paint in the steel scraps, plastics, metal cutting oil and other foreign matters. Chlorides are from 3 different kinds of steel scrapes, i.e. scraps containing plastics, oil and salt, scrapes containing chloride and oil, and scrapes containing PVC. With the 100t electric furnace's production in the special steel branch, cleaner steel scraps were use in 3 batches. Dioxin formation and release was monitored. The finance clerks were in charge of the increment cost with the help of the special steel branch.

3.1.2 TISCO

As to specific processes in TISCO, reference of present main technologies for dioxin release reduction and for the consideration of economic and technical capacity, the dioxin release reduction scheme is suggested as following.

(1) Effect of feeding with different ratios for sintering on dioxin release

At present, some of feedings are imported and others are self-exploited in TISCO. To investigate the effect of feedings on dioxin release, the ratios of different ores were adjusted to find out the best ratio of ores.

(2) Effect of different grades of steel scraps on dioxin release in the electric furnace process

Dioxin formation and release in the electric furnace steel making process is closely correlated with appendiculate paint in the steel scraps, plastics, metal cutting oil and other foreign matters. Chlorides are from, 3 different kinds of steel scrapes, i.e. scraps containing plastics, oil and salt, scrapes containing chloride and oil, and scrapes containing PVC. Cleaner steel scraps were use for 3 batches. Dioxin formation and release was monitored. The finance clerks were in charge of the increment cost with the help of the special steel branch.

3.2 Incineration Enterprise

3.2.1 Huzhou Century Clean

Referring to main technologies for dioxin control and their feasibilities, following dioxin reduction measures are proposed on account of the specific technology employed by Huzhou medical waste incineration system.

(1) Raw material Control

Before feeding, medical wastes are shredded to smaller size, so as to make a good contact with combustion air.

(2) Combustion Control

Good management of incineration plant is significant for dioxin production. Keeping full load of incinerator, operating according to "3T" principle are important measures for eliminating dioxin production and emission.

The designed capacity of Huzhou medical waste incineration system is 10t/d. However, the actual amount of wastes is less than 7t/d. Therefore, the incineration system can not operate continuously. Now, the system operates 16 h per day, and shut down more than 4h. The frequent start and stop makes it difficult to operate, requires more maintenance; and more important, during the processes of start and stop, unstable condition may induce production of dioxin. This problem is ubiquitous among the medical waste incineration system. Therefore, continuous operation, *reduced stop of the system may be significant for reducing dioxin production.*

(3) Post-combustion Control

After completely combusted, the problems left are to restrain the regeneration of dioxin and to remove dioxin produced and by means of reducing temperature, both of the problems can be effectively solved. In the quencher, temperature of flue gas will be reduced to 250－400°C. Similarly, residue time and catalytic activity of fly ashes will be controlled. All of the measures above will result in less production of dioxin. It is also effective to control dioxin production by adding ammonia in flue gas. As NOx can be reduced to N_2 by ammonia, it can be used to simultaneously control NOx and dioxin.

Bag filter is the mainstream technology to removal dioxin. Generally, the temperature of inlet end is below 150°C, while the one of catalytic reaction for dioxin production should be 300°C, so the precursor can not be transformed to dioxin in bag filters. Different from electrostatic precipitator, when operating, on the surface of the bag filter there forms a particle layer. Dioxin in the flue gas is adsorbed and removed by the layer, and then goes to slag treatment system. Therefore, it is very important to maintain the security and high efficiency of the bag filter.

(4) End-of-pipe Control

The end-of-pipe control includes dioxin adsorption by activated carbon, dioxin decomposition, as well as catalytic reduction.

Thanks to its large surface area and strong adsorption capacity, activated carbon can adsorb not only dioxin, but also NOx, SO2, heavy metals and their compounds. Flue gas enters into the activated carbon-containing mobile adsorption tower, of which the temperature ranges from 120°C to 180°C, and dioxin in the flue gas can be adsorption. In this system, it reduces dioxin emission to the greatest extent to employ activated carbon in the exhaust treatment system. The catalyst for NOx selective catalytic reduction (SCR) can be used to decompose dioxin. In the absence of ammonia, SCR catalyst based on TiO2 can make the concentration of dioxin below 0.1ng/m3, if the temperature is controlled between 200°C and 350°C.

Specific technology employed should be decided according to the monitoring results of dioxin. Therefore, monitoring methods for dioxin should include sampling and monitoring condition at different working conditions and positions, so as to find the key factor for emission control.

3.2.2 Jinan Hanyang

Referring to main technologies for dioxin control and their feasibilities, following dioxin reduction measures are proposed on account of the specific technology employed by Huzhou medical waste incineration system.

(1) Quencher building

Major problem of this incineration system lies on ineffectiveness of flue gas quenching. That is, "with the help of residue heat boils, flue gas is cooled from 600°C to 200°C sharply in 3-4s".

It is proposed to build a quencher to control the retention time of flue gas in the temperature range of 200—600°C less than 1s, and therefore prevent the regeneration of dioxin. All the indicators must be definite, such as inlet end temperature, outlet end temperature, retention time for flue gas, size of quencher, inflow, heat exchange system, as well as atomizer. When wet quenching is employed, the materials of equipments need to pay attention to, such as ID fan.

It is effective to control dioxin production by adding ammonia in flue gas. As NOx can be reduced to N2 by ammonia, it can be used to simultaneously control NOx and dioxin.

(2) Combustion Control

The designed capacity of Jinan medical waste incineration system is 24t/d. However, the actual amount of wastes is around 10t/d. Therefore, the incineration system can not operate continuously. Now, the system operates 8-12 hours per day, and shut down more than 4h. The frequent start and stop makes it difficult to operate, requires more maintenance; and more important, during the processes of start and stop, unstable condition may induce production of dioxin. This problem is ubiquitous among the medical waste incineration system. Therefore, continuous operation, reduced stop of the system may be significant for reducing dioxin production.

(3) Post-combustion Control

Bag filter is the mainstream technology to removal dioxin. Generally, the temperature of inlet end is below 150°C, while the one of catalytic reaction for dioxin production should be 300°C, so the precursor can not be transformed to dioxin in bag filters.

Different from electrostatic precipitator, when operating, on the surface of the bag filter there forms a particle layer. Dioxin in the flue gas is adsorbed and removed by the layer, and then goes to slag treatment system. Therefore, it is very important to maintain the security and high efficiency of the bag filter.

Acidic contents in flue gas are significantly high in the medical waste incineration system of Jinan, so the equipments have suffered seriously corrosion. Meanwhile, since major acidic substance is HCl, chloride content in the flue gas is relatively high, which makes it possible to produce dioxin. Low effectiveness of the semi-dry acid gas scrubber in the incineration system could not meet the requirement, and this problem must be solved. According to the practices of medical waste incineration system in Huzhou by Zhejiang University, some agents can be added into the incinerator with the purpose of reducing HCl. Further researches involved should be carried out in future.

(4) End-of-pipe Control

The end-of-pipe control includes dioxin adsorption by activated carbon, dioxin decomposition, as well as catalytic reduction.

Thanks to its large surface area and strong adsorption capacity, activated carbon can adsorb not only dioxin, but also NOx, SO2, heavy metals and their compounds. Flue gas enters into the activated carbon-containing mobile adsorption tower, of which the temperature ranges from 120°C to 180°C, and dioxin in the flue gas can be adsorption. In this system, it reduces dioxin emission to the greatest extent to employ activated carbon in the exhaust treatment system. The catalyst for NOx selective catalytic reduction (SCR) can be used to decompose dioxin. In the absence of ammonia, SCR catalyst based on TiO2 can make the concentration of dioxin below 0.1ng/m3, if the temperature is controlled between 200°C and 350°C.

Specific technology employed should be decided according to the monitoring results of dioxin. Therefore, monitoring methods for dioxin should include sampling and monitoring condition at different working conditions and positions, so as to find the key factor for emission control.

3.3 Paper Making Corporations

3.3.1 Shandong HUA Tai

After synthetically considering on demonstration and the adoption of BAT technique, the alteration of washing and screening in the chemical wood slurry and chemical reed slurry product lines, as well as the bleaching plan of adding H_2O_2 after three-staged CEH bleaching are adopted. The total predicted investment of the project would reach 80 million yuan. The corporation is going to lay off the chlorine bleaching completely and meanwhile turn to ECF bleaching in the near layout as if fund is available. In Ruanjiang Paper Plant region of the corporation, the braising and boiling technique for further removal of xylogen, closed screening, as well as the product line of O (xylogen removal by oxygen)-D(ClO2)-P(H2O2) without chlorine are adopted for the reduction of dioxin emission.

The corporation takes on site measurement and accessorial on site sampling at all the potential sources of POPs. The relevant procedures include raw materials preparing, ink removal from wastepaper and slurry producing, chemical slurry bleaching (traditional three-staged CEH bleaching), alkali reclaiming, and wastewater treatment etc. The on site measurement focuses on the material and water balance obeying by the demand of Clean Production.

The initially designed sampling and monitoring positions of dioxin are as follows: (1) samples respectively from horsetail pine and reed which are raw materials of slurry (2 samples); (2) samples respectively from sulphate wood slurry and reed slurry before bleaching (2 samples); (3) samples from C(chlorination), E(alkali treatment) and

H(hypochlorite bleaching) in the procedure of sulphate wood slurry and reed bleaching (6 samples); (4) samples of wastewater from C, E and H in the procedure of sulphate wood slurry and reed bleaching (6 samples); (5) paper samples from the bleached chemical wood slurry and reed slurry (2 samples); (6) samples of wastepaper before and after the removal of ink in the product line of wastepaper ink removal (2 samples); (7) sludge sample from wastepaper ink removal (1 sample); (8) samples from the inlet and outlet of wastewater treatment plant (2 samples); (9) sludge sample from wastewater treatment plant (1 sample); (10) alkali ash sample from the alkali reclaiming pipe (1 sample); (11) white mud from alkali reclaiming (1 sample). That is 26 samples in all.

The corporation is going to reconstruct the product line of bleaching according to the proposal above. The present two product lines, using traditional three-staged CEH bleaching and producing 150 tons chemical wood slurry and 150 tons chemical reed slurry daily, will be reconstructed to four-staged bleaching with the bleaching procedure of CEHP. After reconstruction, under the same whiteness degree of the paper slurry after bleaching procedure, the amount of chlorine used in the C section will be reduced.

The corporation will carry out on site measurement and accessorial on site sampling in chemical slurry bleaching and other procedures. The on site measurement would focus on the material and water balance according to the demand of Clean Production. Additionally the relevant data of financing and technique are provided in order to estimate the expenses and the increase of cost about the execution and operation of the reconstruction plan. The corporation is also required to hand in the research report about the increase of cost and the reconstruction technique.

3.3.2 Hunan Tigering Paper

The corporation takes on site measurement and accessorial on site sampling at all the potential sources of POPs. The relevant procedures include raw materials preparing, ink removal from wastepaper and slurry producing, chemical slurry bleaching (traditional three-staged CEH bleaching), alkali reclaiming, and wastewater treatment etc. The on site measurement focuses on the material and water balance obeying by the demand of Clean Production.

The initially designed sampling and monitoring positions of dioxin are as follows: (1) sample from wheat grass which is raw material of slurry (1 sample); (2) sample from wheat grass slurry under alkali method before bleaching (1 sample); (3) samples from C(chlorination), E(alkali treatment) and H(hypochlorite bleaching) in the procedure of wheat grass slurry bleaching (3 samples); (4) samples of wastewater from C, E and H in the procedure of wheat grass slurry bleaching (3 samples); (5) paper sample from the bleached wheat grass slurry (1 sample); (6) samples of wastepaper before and after the removal of ink in the product line of wastepaper ink removal (2 samples); (7) sludge sample from wastepaper ink removal (1 sample); (8) samples from the inlet and outlet of wastewater treatment plant (2 samples); (9) sludge sample from wastewater treatment plant (1 sample); (10) alkali ash sample from the alkali reclaiming pipe (1 sample); (11) white mud from alkali reclaiming (1 sample). That is 17 samples altogether.

The corporation is going to reconstruct the product line of bleaching according to the proposal above. The present production line with traditional three-staged CEH bleaching and daily productivity of 130 tons chemical wheat grass slurry will be reconstructed to xylan enzyme pre-bleaching + CepH bleaching, or HDp bleaching technique. After reconstruction, the amount of chlorine used in the C section will be reduced or eliminated completely.

The corporation will carry out on site measurement and accessorial on site sampling in chemical slurry bleaching and other procedures. The on site measurement would focus on the material and water balance according to the demand of Clean Production. Additionally the relevant data of financing and technique are provided in order to estimate the expenses and the increase of cost about the execution and operation of the reconstruction plan. The corporation is also required to hand in the research report about the increase of cost and the reconstruction technique.

4. The implement process of BAT/BEP for demonstration enterprises

During the implement of BAT/BEP project, the demonstration enterprises firstly carry out the monitoring of dioxin emission in the selected sampling points. Secondly, on the basis of the BAT/BEP scheme suggested by experts, the operational process *in situ* is properly adjusted to reduce the dioxin release. After the adjustment, the monitoring is conducted again in the previous sampling point in order to evaluate the implement performance of BAT/BEP. Finally, the incremental cost for the above BAT/BEP is analyzed. The implement processes of the BAT/BEP project to different enterprises are summarized as follows.

4.1 Shanghai Baosteel Corporation

4.1.1 No.1 sinter machine

4.1.1.1 Dioxin monitoring sites setting

To make clear the status in quo of dioxin release of No.1 sinter machine in Baosteel branch, the first sampling was conducted in the sinter machine as a comparative benchmark on Aug. 10, 2005. Under the routine working condition, 13 samples were taken and analyzed. The detailed sampling sites were shown in Figure 8.

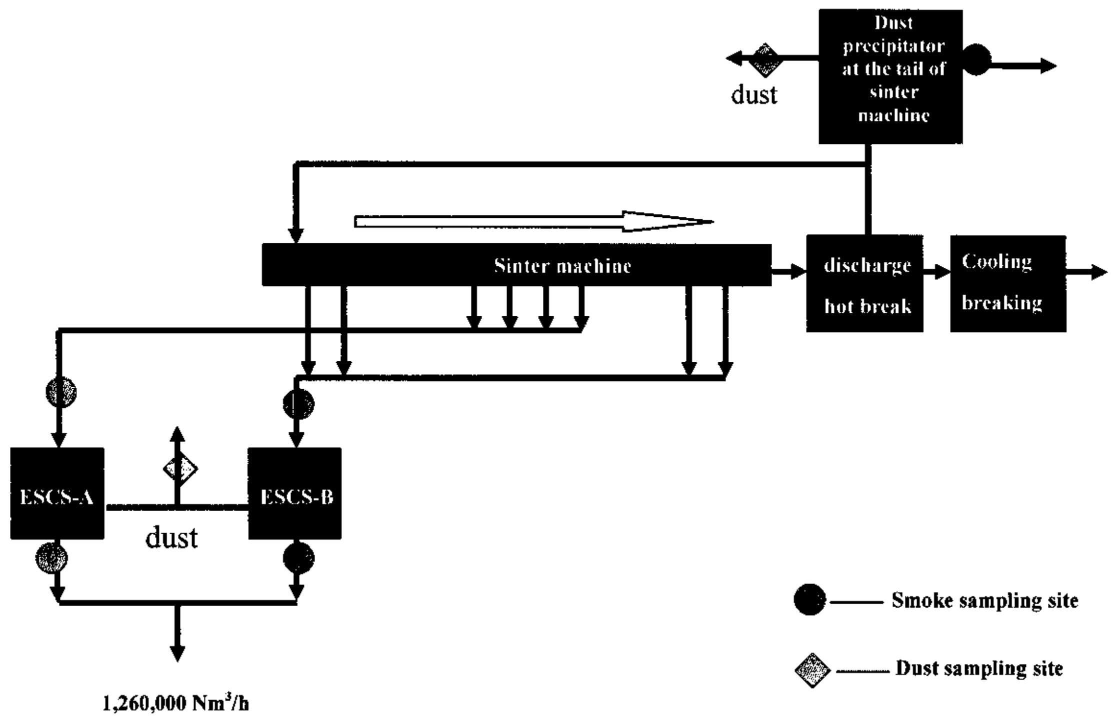


Figure 8 Sketch map of dioxin sampling site of the No.1 sinter machine in Baosteel branch

4.1.1.2 Dioxin release reduction measures

To reduce dioxin release of No.1 sinter machine in Baosteel branch, industrial experiments were made in the No.1 sinter machine line on Dec.19-28.2005. In the experiments, the guideline was source control of dioxin formation in sintering, then realization of dioxin release reduction. On production site of No.1 sinter machine, control techniques and measures were taken to reduce dioxin formation as following.

(1) Before the experiments, a stockpile of homogenous ore, 235000 tons in total was specially prepared, in which 5 recycling solid materials such as iron oxide scale(ZSC-S), blast furnace dust (ZBG-S), sintering dust (ZES-S), sinter fines (S1C-F) and iron slag (ZFG-S) were not mixed.

(2) In the experiments, pellets were prohibited in sinter mixtures.

(3) To avoid the adverse effect of insufflations of CaC12, the returned sinter fines from the blast furnace slot were not mixed into the No.1 sinter materials.

4.1.1.3 Results and discussion

To get release data of demonstration period, the second sampling was conducted on Dec.21, 2005 after measures on release reduction in the No.1 sinter machine. The results were shown in Table 12. In convenience of comparison, data of the benchmark period (the first sampling) were also listed in the Table.

Table 12. Dioxins concentration of No.1 sinter machine in Baosteel branch during release reduction demonstration period

Sample tag		Concentration ng I-TEQ/Nm^3 (benchmark) (Aug. 10, 2005)	Concentration ng I-TEQ/Nm^3 (experiment) (Dec. 21, 2005)
Inlet smoke of electrostatic precipitator(ESCS A)	1	4.60	2.76
	2	2.88	3.47
	average	3.74	3.12
Outlet smoke of electrostatic precipitator(ESCS A)	1	0.006	1.31
	2	1.28	1.77
	average	1.28	1.54
Inlet smoke of electrostatic precipitator (ESCS B)	1	5.71	2.89
	2	4.24	4.10
	average	4.98	3.50
Outlet smoke of electrostatic precipitator(ESCS B)	1	2.91	1.72
	2	3.69	0.58
	average	3.30	1.15
Outlet smoke of electrostatic precipitator (EP)	1	0.26	-
	2	0.22	-
	average	0.24	-
ESCS dust	No.1 and 2 electric field	267	336
	No. 3 electric field	2551	1186
EP dust	dust	46	25

The results above indicated that in the No.1 sinter machine of Baosteel branch, dioxin concentration in the discharged smoke was 0.58-1.77 ng I-TEQ/m3 after electrostatic precipitation (ESCS A and ESCS B). Before electrostatic precipitation ESCS, dioxin concentration in the smoke was 2.76-4.10 ng I-TEQ/m3. The average dioxin concentration in the outlet smoke of ESCS was 1.35 ng I-TEQ/m3. It decreased 41% in comparison with the average concentration in benchmark period.

During the experiment period, dioxin concentration in the front electric field (No.1 and 2) and the back electric field (No.3) of electrostatic precipitator (ESCS) was 336 and 1186 ng I-TEQ/kg, respectively. Compared with the benchmark period, dioxin concentration in dust of No.1-2 electric field kept unchanged, while it decreased 53% in No.3 electric field.

Dioxin concentration in tail EP dust decreased 45%, i.e., from 46 ng I-TEQ/kg (benchmark period) to 25 ng I-TEQ/kg (experiment period).

The release factors of sintered ore per ton were calculated by the results (See Table 13). In the industrial experiments, dioxin release factor in the exhaust gas of No.1 sinter machine decreased from 9.201 (before the experiment) to 5.541 μg I-TEQ/t-sintered ore (after the experiment), dioxin release factor in the dust from 0.817 to 0.380 and total dioxin release factor from 10.018 to 5.921.Therefore, taking release reduction measures in these industrial experiments, can reduce more than 40% dioxin release of No.1 sinter machine.

Table 13. Release factor of No.1 sinter machine in Baosteel branch during dioxin release reduction experiments

Item	Unit	Production and release of No.1 sinter machine			
Operation days	d/y	352.2			
Production of sintered ore	t	5,500,000			
		Benchmark (Aug. 10)		**Experiment (Dec. 21)**	
Releasing position		Head ESCS	Tail EP	**Head ESCS**	**Tail EP**
Annual production of exhaust gas	Million Nm^3	21301.56	7607.70	**21301.56**	**7607.70**
Annual production of dust	t	1761		**1761**	
Dioxin concentration in exhaust gas	ng I-TEQ/Nm^3	2.29	0.24	**1.345**	**0.24***
Dioxin concentration in dust	ng I-TEQ/kg	2551		**1186**	
Annual release of dioxin in exhaust gas	g I-TEQ/y	48.781	1.826	**28.651**	**1.826**
Annual release of dioxin in dust	g I-TEQ/y	4.492		**2.089**	
Release factor of dioxin in exhaust gas/each ton of sintered ore	μg I-TEQ/t-sintered ore	9.201		**5.541**	
Release factor of dioxin in dust/each ton of sintered ore	μg I-TEQ/t-sintered ore	0.817		**0.380**	
Total release factor of dioxin/each ton of sintered ore	μg I-TEQ/t-sintered ore	10.018		**5.921**	

* Dioxin concentration in tail EP exhaust gas was assumed to keep unchanged.

4.1.2 100t electric furnace in special steel branch

4.1.2.1 Dioxin monitoring sites setting

To make clear the status in quo of dioxin release in electric furnace, the first dioxin sampling was conducted on the 100t electric furnace production site of special steel branch on Aug. 9, 2005 as a benchmark for release reduction demonstration. Under the routine production, 5 samples in total were taken and analyzed. The detailed sampling sites were shown as Figure 9.

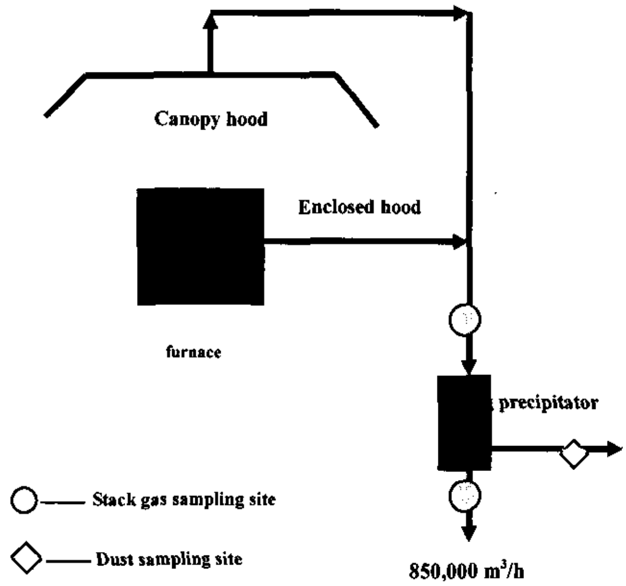


Figure 9 sketch map of dioxin sampling sites for 100t electric furnace in special steel branch

4.1.2.2 Dioxin release reduction measures

Dioxin formation and release in the electric furnace steel making process is closely correlated with appendiculate paint in the steel scraps, plastics, metal cutting oil and other foreign matters. Chlorides are from, 3 different kinds of steel scrapes, i.e. scraps containing plastics, oil and salt, scrapes containing chloride and oil, and scrapes containing PVC.

Similar to the guideline of dioxin release reduction industrial experiments on the No.1 sinter machine of Baosteel branch, major measures taken in industrial experiments of the 100t electric furnace in special steel was also aimed at source control of dioxin formation in electric furnace steel making processes. Under the routine production, cleaner steel scraps were used in 3 batches of steel on Dec. 19, 2005. Samples were taken for dioxin release reduction evaluation.

Table 14 showed steel scraps used for the experiment and benchmark. In the experiment, heavily polluted steel scraps were prohibited in use, such as second grade slag steel cold steel, slag steel super grade cold steel, and Cr alloy constructional steel crops, while cleaner crops of ordinary carbon tool steel, carbon structural steel were in use.

Table 14. Steel scraps used for dioxin release reduction experiment and benchmark in 100t electric furnace

Description	Consumption, t/t-steel	
	Benchmark (Aug. 9)	Experiment (Dec.19)
steel making iron	0.200	0.207
crop of ordinary carbon tool steel, carbon structural steel	0.000	0.148
heavy machinery steel (qulaified)	0.070	0.156
machinery steel electric furnace machinery steel (qulaified)	0.572	0.527
second grade slag steel cold steel	0.108	
slag steel super grade cold steel	0.049	
Cr alloy constructional steel crop	0.038	

4.1.2.3 Results and discussion

To get release data of the demonstration period, the second sampling was conducted after being taken measures on release reduction in the 100t electric furnace process. The results were shown in Table15. In convenience of comparison, data of the benchmark period (the first sampling) were also listed in the Table.

Table 15. Dioxins concentration of 100t electric furnace in special steel branch during release reduction demonstration period

Tag	Sampling site position	sampling	Benchmark ng I-TEQ/Nm^3 (Aug. 9)	Experiment ng I-TEQ/Nm^3 (Dec. 19)
smoke	Before bag	1	0.29	0.62
	precipitator	2	0.099	0.63

		average	0.195	0.625
	In the middle of the chimney	1	0.11	0.071
		2	0.048	0.011
		average	0.079	0.041
Dust	Dust on bag precipitator		610	300
The flow of smoke in the chimney (dry smoke)			850,000 m^3/h	
Dust production			15 kg/t-steel	
Steel production			106 t each furnace	

The average results in Table 15 indicated that in the 100t electric furnace of Baosteel special steel branch, dioxin concentration in smoke discharged into the environment was 0.041 ng I-TEQ/m3, which was decreased approximate 50% with comparison to the benchmark data. Dioxin concentration in the dust was 300 ng I-TEQ/m3 and decreased more than 50%.

The release factors of the 100t electric furnace were calculated by the results (See Table 16). In the experiments, dioxin release factor in the exhaust gas and dust decreased to 0.491 and 4.50 μg I-TEQ/t-steel, respectively. Taking release reduction measures in the industrial experiments can decrease total release factor to 4.991μg I-TEQ/t-steel, i.e., 50% dioxin release reduction with comparison to that in benchmark period.

Table 16. Comparison and calculation of release factor of 100t electric furnace in special steel branch during dioxin release reduction experiments

Item	Unit	Production and release of 100t electric furnace	
Operation days	d/y	323	
Production	t	550,000	
Annual production of exhaust gas	Nm^3	6,589,200,000	
Annual production of dust	t	8,250	
		Benchmark (Aug. 9)	**Experiment (Dec. 19)**
Dioxin concentration in exhaust gas	ng I-TEQ/Nm^3	0.079	**0.041**
Dioxin concentration in dust	ng I-TEQ/kg	610	**300**
Annual release of dioxin in exhaust gas	g I-TEQ/y	0.521	**0.270**
Annual release of dioxin in dust	g I-TEQ/y	5.033	**2.475**
Release factor of dioxin in exhaust gas/each ton of	μg I-TEQ/t-steel	0.946	**0.491**

steel			
Release factor of dioxin in dust/each ton of steel	μg I-TEQ/t-steel	9.150	**4.500**
Total release factor of dioxin/ each ton of steel	μg I-TEQ/t-steel	10.096	**4.991**

4.1.3 Increment cost of release reduction industrial experiment

4.1.3.1 No.1 sinter machine in Baosteel branch

On Dec.19-28, 2005, the dioxin release industrial experiment was made in the No.1 sinter machine of Baosteel branch to reduce release dioxin formation and release mainly by controlling and adjusting the sintering materials. compared to the stockpile of homogenous ore in benchmark period (BA1-326), the stockpile of homogenous ore were free of 5 recycling solid materials such as iron oxide scale(ZSC-S), blast furnace dust（ZBG-S）, sintering dust（ZES-S）, sinter fines（S1C-F）and iron slag（ZFG-S）in the experiment, which led to the greater usage of raw materials. The increment cost of homogenous ore and sintered ore was provided by financial department of Baosteel branch (See Table 17).

Table 17. Cost of homogenous ore and sintered ore in dioxin release experiment compared with that in benchmark period in No.1 sinter machine of Baosteel branch

Item	Benchmark Aug. 10, 2005	Experiment Dec. 21, 2005	Production in 2005
Production number of homogenous ore stockpile	BA1-326	BB1-334	
Homogenous ore	371.55	495.53	451.82
Cost of homogenous ore proportioning per ton (Yuan)	497.49	524.76	
Auxiliary material for sintering	47.86	26.49	61.62
Fuel and public utility	46.74	50.70	46.48
Sum of variable cost	466.16	572.73	559.92
Sum of fixed cost	28.27	28.27	28.27
Cost of sintered ore per ton	494.43	601.00	588.19

As is known from Table 17, no using of 5 recycling solid materials during the experiment and benchmark period （BA1-334） led to the increase of major sintering materials costs, i.e., increased 27.27 Yuan per ton of homogenous ore in comparison with that during the benchmark period. Moreover, in dioxin release reduction experiments, cost of auxiliary material for sintering decreased, while cost of fuel and public utility increased, which led to the increase of sintered ore's cost. In comparison with the benchmark period and average production in 2005, it increased 106.57 Yuan/t and 12.81 Yuan/t, respectively, i.e., increased 21.5% and 2.2%。

Calculated by annual sintered ore production capacity of the No.1 sinter machine, 5.50 million tons and the increment cost of sintered ore, 12.81 Yuan/t, taking dioxin release reduction measures would bring the total increment cost of more than 70.45 million Yuan/y. In 2006, 3 sinter machines produced more than 17 million tons in total. It was calculated that total increment cost of 3 sinter machine was up to more than 217.7 million Yuan.

It is worth to observe that indirect cost was not counted in above increment cost analysis. If recycling materials such as blast furnace dust, sintering ESCS dust and iron oxide scale were prohibited, how to dispose and reuse them would inevitably increase indirect cost.

4.1.3.2 100t electric furnace in special steel branch

To control dioxin formation and release in electric furnace steel making process, cleaner steel scrapes were used in the dioxin release reduction industrial experiment in the 100t electric furnace of special steel branch on Dec. 19, 2005. Because measures taken in dioxin release reduction experiment were comparatively simple, only the increment cost of outsourcing steel scrapes needed to be considered. The cost analysis of steel making materials in the experiment and benchmark period was listed in Table 18 provided by the financial department in special steel branch.

Table 18. cost of raw materials in dioxin release reduction experiment of 100t electric furnace in special steel branch in comparison with that during benchmark period

Item		Benchmark Aug. 9, 2005		Experiment Dec. 19, 2005	
Batch number		511-2966~2968		511-3838~3840	
production		315 t		330 t	
description	Price per	Consumption	Cost of per	Consumption	Cost of per

	unit Yuan/t	per tons of steel t/t	ton of steel Yuan/t	per tons of steel t/t	ton of steel Yuan/t
steel making iron	1950	0.200	391	0.207	403
crop of ordinary carbon tool steel, carbon structural steel	2100	0.000	0	0.148	311
heavy machinery steel (qulaified)	1850	0.070	130	0.156	289
machinery steel electric furnace machinery steel (qulaified)	1780	0.572	1017	0.527	939
second grade slag steel cold steel	1320	0.108	143		
slag steel super grade cold steel	1780	0.049	87		
Cr alloy constructional steel crop	2100	0.038	80		
Raw material cost of per ton of steel				1848	

It showed in Table 18 that during dioxin release reduction experiments, the production cost of the 100t electric furnace was 1942 Yuan/t-steel and increased 94 Yuan, i.e., increased 5.1% in comparison with that during the benchmark period. Calculated with annual steel production of 0.55 million tons, taking dioxin release reduction measures would lead to the total increment cost of 51.7 million Yuan/y.

4.2 TISCO

4.2.1 Results and discussion

In sintering process of TISCO, samples were exhaust gas and mixed fly ash from ESP of the head of No.3 sinter machine. At the first stage (before release reduction), Jianshan refine ore was in proportion to 80.06% and 88.64% respectively and free of mixed powder (all kinds of dust). At the second stage (after release reduction), Jianshan refine ore was in proportion to 83.63%, mixed powder 5.8%, and the ratio free of serpentine and lime decreased 29.11% in comparison with that at the first stage. The content of Si and Mg in raw materials decreased. The results demonstrated that after taking release reduction measures, dioxin concentration in exhaust gas decreased

0.94 times and dioxin concentration in fly ash increased 1.01 times after dust precipitator at the head of No.3 sinter machine (See Table 19).

In electric furnace steel making process of TISCO, samples were exhaust gas and fly ash from outlet of canopy dust precipitator and electric furnace smoke dust precipitator. At the first stage, smoke from electric furnace and after canopy precipitator was monitored simultaneously. The ratio of steel scrapes and steeling mud ball (ball made from steel making dust) were in proportion to 69.8% and 1.4%, respectively. At the second stage from Jun.19 to 20, electric furnace smoke dust precipitator was used for monitoring; from Jun.21 to 22, canopy dust precipitator was used for monitoring, with steel scrapes and steeling mud ball ratio of 26.1-32.2% and 1.5%, respectively. The results indicated that after release reduction measures, dioxin concentration in exhaust gas from outlet of canopy dust precipitator and electric furnace smoke dust precipitator was 6.6 and 10.77 times of that before release reduction, while dioxin concentration in fly ash was from outlet of electric furnace smoke dust precipitator and canopy dust precipitator 4.58 and 0.12 times of that before release reduction (See Table 19).

Table 19. Dioxin release of $100m^2$ sinter machine and 50t electric furnace of TISCO

Name of equipments	Sampling position	Operation days (d)	production (t)	Annual production of exhaust gas (Nm^3)	Annual production of fly ash (t)	Dioxin concentration in exhaust gas (ng I-TEQ/Nm^3)	Dioxin concentration in fly ash (ng I-TEQ/g)	Annual release of dioxin in exhaust gas (g/y)	Annual dioxin release in fly ash 飞灰 (g/y)	Per unit annual dioxin release (μg/t-y)
$100m^2$ Sinter machine	head of sinter machine ESP	300	950,000	2.02×10^9	1200	0.25 (before release reduction)	0.188 (before release reduction)			0.736 (after release reduction)
						0.235 (after release reduction)	0.19 (after release reduction)	0.47	0.23	
50t electric furnace	EAF-BF	320	390,000	1.01×10^9	6400	0.02 (before release reduction)	0.063 (before release reduction)			1.923 (after release reduction)
						0.132 (after release reduction)	0.0075 (after release reduction)	0.13	0.05	
	EAF-BF	320	390,000	2.33×10^9	3200	0.0155 (before release reduction)	0.012 (before release reduction)			
						0.167 (after release reduction)	0.055 (after release reduction)	0.39	0.18	

4.2.2 Increment cost of dioxin reduction

(1) Increment cost analysis in sintering process

Release reduction measures were taken at the first stage. Mixed powder was not added, while Jianshan ore concentrate and serpentine increased 4.8% and 1% in comparison with that in the second stage. The cost of refine ore increased 17.67 Yuan/t-sintered ore. The labor cost for serpentine process increased 1.33 Yuan/t-sintered ore. The total cost increase 19 Yuan/t-sintered ore.

(2) Increment cost analysis in electric furnace process

At the first stage, the proportions of steel scrapes and steeling mud ball were approximate 69.8% and 1.4%, respectively. At the second stage, they were 29.15% and 1.5%. Because release reduction measures were taken, the cost of raw materials increased 86.75 Yuan/t-steel. Although the usage of steel scrapes decreased, those steel scrape were screened by manpower, which increased the cost of 1.18 Yuan/t-steel. In comparison with high iron ratio smelting, the energy consumption of low iron ratio smelting would increase 50.28 Yuan/t-steel. Therefore, after taking release reduction measures, the cost would increase 37.65 Yuan/t-steel. In 2006, the annual steel production of 50t electric furnace in TISCO was 0.39 million tons. If release reduction measures were taken, the cost of steel from electric furnace would increase 14.6835 million Yuan/y. 9600 tons of steeling mud balls would be used in a whole year, which would not only be beneficial to comprehensive utilization, but also remove sulfur and phosphorus rapidly.

(3) Total increment cost analysis

After release reduction process, the cost of sintering process increased 19 Yuan/t-sintered ore. In 2006, the annual steel production of one 100m2 sinter machine in TISCO was 0.95 million tons. If release reduction process was applied, the cost of sintering process would increase 18.05 million Yuan/y. The annual steel production of sintering process was 3.8502 million tons in total. If release reduction process was applied, the cost would increase 73.1538 million Yuan/y. In 2006, 651009 tons of mixed powder was used in sintering process. If release reduction process was applied, those mixed powder should be disposed in another way for consideration of cyclic economy and comprehensive utilization.

4.3 Huzhou Century Clean

4.3.1 Implementation Scheme of Dioxin Emission Reduction

In accordance with the original system and the suggestion from domestic and abroad specialists, a improvement plan for equipments and operation has been settled, which includes:

(1) To add another activated carbon adsorber

The specific system design needs to be further chosen from sprayer, fixed bed or moving bed. It was planned preliminarily to install another AC sprayer in flue gas treatment system. The tentative position can be chosen as: middle part or exit end of semi-dry adsorber.

(2) Storage of slag and fly ash

In the west of the plant, a separated room will be set to store the slag and fly ash.

(3) Equipment of a bottom slag sorter

To improve the operation performance, a bottom slag sorter is supposed to be constructed. The sorter is responsible for separating glass slag, as well as taking fine slag back to fluidized bed.

(4) Modification of quencher

To satisfy the request of temperature testing and disposal of medical waste with high heating value, the quencher would be modified to realize the exhaust gas temperature lower than 200°C when the furnace exit temperature is over 1100°C. The preheater is supposed to be modified as quencher with directly water injection, with which the performance of quencher will be enhanced.

(5) Improvement of bag filter

As the particulate concentration is relatively high at exit of stack, leakage of bag filter was observed in first round testing. The old bag filter was planned to replace by new one to stop leaking. A gas-proof valve was installed in the bypass of bag filter, which can prevent flue gas and fly ash leaking to induced fan then to stack.

(6) System operation, testing and management

Compare and analyze the technical and economical performance for batch operation and quasi-continuous operation in the following aspects: operation performance, emission characteristics, device depreciation and maintenance, especially the increment cost. Improve the integrated medical waste management system. Optimize operational condition of the incinerator, and add inhibitor based on sulfur to the feed of MW to reduce the dioxin formation.

4.3.2 Testing results of dioxin emission from incinerator

The testing results before BAT/BEP retrofit project were shown in table 20. The results indicated the dioxin concentration of flue gas in the points where behind heat exchanger, in front of semi-dry flue gas pipe and the dioxin concentration of fly ash were relatively high, which was due to the poor performance of flue gas quencher. It was also relatively high in the sampling position of stack, which was mainly due to the broken of some bag filter and the malfunction of bypass valve, which leads to leakage of flue gas and fly ash. The dioxin concentration of bottom slag was relatively low, which proved the excellent performance of fluidized bed incinerator of treating pyrolysis residue of rotary kiln. The dioxin concentration of fly ash collected from bag filter was 21 ng I-TEQ/g. This makes the fly ash be properly treated as hazardous material.

The second round test for dioxin emission was conducted on the retrofitted incinerator of Huzhou century clean treatment centre. The result shows the reduction rate of dioxin concentration in flue gas was 90%-97%. It can be concluded that the implementation of BAT/BEP obtained notable dioxin reduction effect.

Table 20. Dioxin Testing Results of Incinerator (10t/d) in Huzhou Century Clean MW Treatment Center Before and After Retrofit

	Testing result ng I-TEQ/Nm^3 (flue gas) ng/g (solid)		Flow rate Nm^3/h	
	Before	After	Before	After
First sampling behind heat exchanger, in front of semi-dry flue gas pipe	130	79	4365	5745
Second sampling behind heat exchanger, in front of semi-dry flue gas pipe	130	—	4156	—
First sampling in Stack	74	1.9	6573	7042
Second sampling in Stack	42	4.3	3727	2190
Sampling during Startup	91	—	4197	—
Fly ash	21	27	24 kg/h	—
Bottom slag	0.003	0.03	100 kg/h	—
Operating hours	330day/year, 12h/day			
Feeding rate	400kg/h			

4.3.3 Increment cost analysis for dioxin emission reduction

Increment costs include expense for equipment retrofit, and increased expense for maintenance, which are listed in Table 21. In addition, the benefits before and after the retrofit are also shown in the table.

Table 21. Expense Comparison of Dioxin Reduction for Huzhou Century Clean MW Treatment Center

	Emission Level (mg TEQ/year)	Equipment Investment (RMB)	Operation Cost (RMB)	Benefit (RMB)
Before	1926	3,930,000	1,024,800	6,255,000
After	53	4,060,000	1,069,700	6,277,000

4.4 Jinan Hanyang

4.4.1 The sampling positions of incineration system for dioxin monitoring

In order to evaluate the performance of BAT/BEP project in this enterprise, some representative sampling point in the flow line were determined through the discussion between the experts and local managers. These sampling points can stand for the situation of dioxin emission, which are shown in Figure 10.

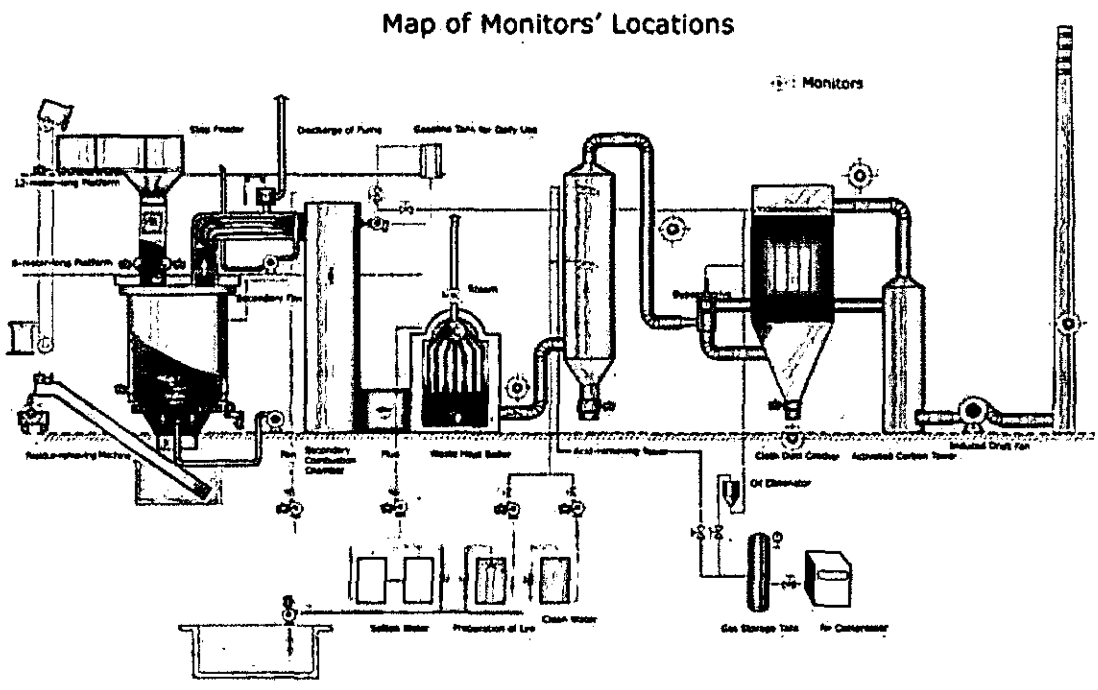


Figure 10 The sampling position in Hanyang's incineration system for dioxin monitoring

4.4.2 Implementation Scheme of Dioxin Emission Reduction

(1) Processes Control

✧ As medical wastes collected are much fewer than the treatment capacity of the incinerator, reduction of dioxin emission could be achieved by extending incineration time and reducing time of startup and stop of the incinerator.

- Strengthen the operation management; make sure the temperature of incinerator and retention time of flue gas are satisfied to related requirements.
- Clean the soot on the heat side of residue boiler in order to maintain good performance of heat transfer, and cool the flue gas as soon as possible.

(2) Pollution Control

- Maintain the acid gas scrubber; change the atomizer timely to guarantee good performance for acid gas removal and flue gas cooling.
- Add activated carbon sprayer before bag filter. Make full use of the bag filter for filtration and adsorption for the hazardous materials in the flue gas.
- Change the bag filter more frequently to ensure the particle removal.
- Set up a steel or glass stack, so as to avoid corrosion, and keep the system stable. In addition, test holes and platforms are established as required.
- Renew the adsorbents in the activated carbon adsorption tower more frequently, which ensure adsorption efficiency of the tower.

4.4.3 Testing results of dioxin emission from incinerator

The dioxin emission situation before or after the BAT/BEP project in the selected sampling points is shown in table 22.

Table 22. The monitoring results of dioxin emission in incineration system of Jinan Hanyang

SAMPLE	CONCENTR. 1 ROUND ngTEQ/Nm^3 (gas) pg TEQ/g (solid)	CONCENTR. 2 ROUND ngTEQ/Nm^3 (gas) pg TEQ/g (solid)	INPUT/OUTPUT PER YEAR 1 ROUND mgTEQ/year	INPUT/OUTPUT PER YEAR 2 ROUND mgTEQ/year
AFTER HEAT EXCHANGER1	18	66		
AFTER HEAT EXCHANGER2	4.0			
AFTER FILTER	26	54		
STACK 1	21	6.2	672	198
STACK 2	12	11.0	48.0	44
STACK START	19		3.8	
FLY ASHES	9.1	11.0	1820	2200
BOTTOM ASHES	0.2	1.2	160	960
STACK MASS FLOW RATE m^3/h	8000			

FEEDING RATE Kg/h	1000
FLY ASHES PRODUCTION RATE Kg/H	
SLAGS PRODUCTION RATE Kg/h	

According to the testing results before and after retrofit, dioxin concentration after the residue heat boiler even increases, indicating that the simple treatment measures are useless. Unless further retrofits are adopted, no better results will be gained. The testing data from behind the bag filter show after retrofit, dioxin concentration in the flue gas decreased somewhat, but not obviously. Further test and improvement for the activated carbon sprayer should be done. Regarding stack, Better results are gained in second round tests than in first round ones. The results also show the significant effects of AC adsorption tower, indicating that the positive effect of AC adsorption tower if under good management.

4.4.4 Increment cost analysis for dioxin emission reduction

The incremental costs of the BAT/BEP project for Jinan Hanyang include the expense for the added monitoring facility and operation and maintenance. In addition, the cost for equipment renovation means that the emission amount of dioxin can attain a high quality level, which needs a relatively high investment. The relevant data are listed in Table 23.

Table 23. The incremental annual expense after BAT/BEP project for Jinan Hanyang's incineration system

	Monitoring System cost (y/a)	Operating and maintenance cost (y/a)	Equipment renovation (y: RMB)	Reducing amount after BAT/BEP (mg TEQ/a)
Stack	12300			
Monitoring device between afterburning chamber and heat exchange	—			
Contingency allowance	45000			
Electricity (unit price and overall cost)		30000		

Fuel consumption		24000		
Cleaning of the heat exchange pipelines		4000		
Cost of adsorber for scrubber		27000		
Maintenance of spray dryers for scrubber		3000		
Active carbon consumption for Fabric Filter		55200		
Cost of bags replacement for Fabric Filter		15000		
Cost of charcoal material		19000		
Labour cost		54000		
Feeding system			160000	
Supply of combustion air			50000	
Vertical Rotary kiln			3950000	
After burning chamber			2860000	
Heat exchanger			680000	
Water supply			310000	
Active Carbon injection device			13000	
Bag Filter			20000	
Carbon tower			8000	
Total	182300	183200	*	239

* If this enterprise want to have a good effect and finish the BAT/BEP with high quality, it should replace all parts of gas treatment and perfect the systerm with combined investment hitting 20 million yuan。

4.5 Shandong HUA Tai

4.5.1 Reduction Plan and Monitoring Result

In the BAT/BEP plan implemented by Shandong HUA Tai Paper Corporation, the biological enzyme pre-bleaching section is added to the existed three-staged CEH bleaching, and small amount of H2O2 is added at E section (alkali treatment) in order to enhance the alkali treatment effect. The exact technique process and technical parameters in the slurry production and bleaching plant after technical change are shown as follows:

(1) The section of extraction and screening of black slurry

Standard Baume degree of reclaimed alkali treated black liquid	4.0-5.0 °Be' (80°C)
Fibre content of reclaimed alkali treated black liquid	≤50 mg/L
Extraction rate of black liquid	≥80%
Addition of xylose enzyme	45 g/t slurry
Addition of hydrochloric acid	3-5 kg/t slurry

(2) The section of bleaching

Residue chlorine after chlorination tank	≤0.056 g/l
Residue alkali of slurry in slurry adjusting tank	≤0.10 g/l
Residue chlorine after washing	≤0.021 g/l
pH value after basification (after addition of H_2O_2)	8.5-10.5
Amount of alkali	2-3 %
Amount of H_2O_2	0.3-0.7 %
Amount of bleaching liquid (available chlorine)	4-5 %
Slurry concentration in NaClO bleaching section	6-9 %

The last slurry washing machine in the section of closed selection is followed by the biological enzyme pre-treatment. After washed by 5# vacuum slurry washing machine which follows the closed selection, the paper slurry is pre-bleached by biological enzyme. Then the biological enzyme and HCl are added, with which the paper slurry continuously react in the bleached-slurry tank until the chlorine-bleaching section.

The comparison of data before and after the execution of BAT/BEP plan by HUA Tai Paper Corporation's demonstrative product line is shown in Table 24.

Table 24. Data before and after the execution of BAT/BEP plan by HUA Tai Paper Corporation's demonstrative product line

Sample	Measured base line value pg TEQ/g (L)	Measured value after the BAT/BEP plan pg TEQ/g (L)	Annual generated base line value mgTEQ/Y	Annual generated base line value after the BAT/BEP plan mgTEQ/Y

Wastepaper (before ink removal)	1.2	—	432	—
Wastepaper (after ink removal)	0.70	—	252	—
Wheat grass	0.25	—	18	—
White sludge	0.18	—	1.5	—
Alkali ash	0.69	—	1.17	—
Grass slurry before bleaching	0.31	—	8.0	—
Paper slurry in C	0.45	2.9	10.8	128.2
Paper slurry in E	0.33	0.73	7.9	31.0
Paper slurry in H	0.53	—	12.7	—
Wastewater in C	1.9	0.72	1.1	0.76
Wastewater in E	2.2	1.6	1.3	1.63
Paper product (raw material of wastepaper)	0.6	—	94.5	—
Paper product (raw material of wheat grass)	1.2	1.2	43.2	43.2
Sludge	2.8	5.7	16.8	38.76
Wastewater	—	0.67	—	10.25

4.5.2 Analysis of cost increase concerning about dioxin reduction

While implementing the BAT/BEP plan, Shandong HUA Tai Paper Corporation invests 310 thousand yuan as the technical reformation fund into the product line of bleached wheat grass slurry whose annual production is 40 thousand tons. The increased annual operation cost is 782.7 thousand yuan, which is 19.6 yuan per ton slurry. The amount of chlorine used per ton slurry is reduced by 17 kg. Since the monitoring data of PCDD/F is higher than the base line after the BAT/BEP plan, the part of environmental benefit is simplified.

4.6 Hunan Tigering Paper

4.6.1 The Dioxin Reduction Plan and Monitoring Result

With reed as its raw materials, Hunan Tigering Paper Corporation's demonstrative product line adopts the procedure of dry material supply, intermittent braising and boiling and three-staged CEH bleaching. The implemented BAT/BEP plan adopts the procedure of wet/dry material supply, continuous braising and boiling, xylogen removal by oxygen and the bleaching process (D0-E0-D1) without element chlorine.

The comparison of data before and after the execution of BAT/BEP plan by Hunan Tigering Paper Corporation's demonstrative product line is shown in Table 25.

Table 25. Data before and after the execution of BAT/BEP plan by Hunan Tigering Paper Corporation's representative product line

Sample	Measured base line value in Yueyang pg TEQ/g (L)	Annual generated base line value in Yueyang mgTEQ/Y
Reed	0.36	43.2
Reed paper slurry before bleaching	0.13	7.1
Reed paper slurry in C	3.8	206.7
Reed paper slurry in E	2.8	152.3
Reed paper slurry in H	2.9	157.8
Wood slurry before bleaching	0.2	12.2
Wood slurry in C	4.4	269.3
Wood slurry in E	2.4	146.9
Wood slurry in H	2.4	146.9
Alkali ash	0.24	1.63
Sludge	8.2	69.7
Sample	**Measured base line value in Ruanjiang after BAT/BEP plan pg TEQ/g (L)**	**Annual generated base line value in Ruanjiang after BAT/BEP plan mgTEQ/Y**
Reed paper slurry before bleaching	0.43	40.94
Reed paper slurry after bleaching	0.67	56.95
Wastewater from bleaching in D	0.43	0.82
Wastewater from bleaching in D_1	0.45	0.103
Paper product (raw material of reed)	0.65	61.88
Wastewater	0.48	4.08
Sludge	1.5	4.59

Hunan Tigering Paper Corporation implements BAT/BEP plan (adoption of xylogen removal by oxygen, and replacement of traditional three-staged CEH bleaching with bleaching without element chlorine) in the product line of reed slurry bleaching, and the PCDD/F reduction is obvious, showing excellent benefit in investment and environment. The amount of PCDD/F generated per dry bleached slurry is reduced by 3.12 μg TEQ.

4.6.2 Analysis of cost increase concerning about dioxin reduction

According to the measurement result of demonstrative product line, based on the measurement data and occurrence factor, the increased cost of the product line is calculated. The results are shown in Table 26 and 27.

Table 26. Comparison of investment and operation cost between chlorine bleaching section and ECF bleaching section

Item / Product line	Investment (yuan/ton)	Operation cost (yuan/ton)	Income (yuan/ton)	Generated dioxin (μg TEQ/AdT)
Chlorine bleaching section	508	307	490.1	4.1
ECF bleaching section	1001	335	595.4	0.68
Increased cost for the reconstruction from chlorine bleaching section to ECF bleaching section	1001	28	105.3	-3.42

Table 27. Comparison of investment and operation cost between product line of chlorine bleaching (including braising/boiling, washing/ riddling sections) and product line of ECF bleaching

Item / Product line	Investment (yuan/ton)	Operation cost (yuan/ton)	Income (yuan/ton)	Generated dioxin (μg TEQ/AdT)
Chlorine bleaching section	831	1029	490.1	4.1
ECF bleaching section	1247.5	1120	595.4	0.68
Increased cost for the reconstruction from chlorine bleaching section to ECF bleaching section	416.5	91	105.3	-3.42

5. Conclusions and Suggestions

5.1 Iron and Steel Industry

Several opinions and suggestions about the implementation of BAT/BEP in Chinese iron and steel sectors are proposed as follows:

5.1.1 Strengthen the Monitoring and Evaluation of Dioxins Emission Level from Sintering and Electric Furnace

Detection technologies for dioxins are composed of sampling technology, detection technology of ultra-low level, rapid and low-cost testing technology and secure technology of environment monitoring, et al. Professional dioxins detection experts and institutions should be supported who are familiar with certain requirements and standards of special industry areas and production processes. Because of the trace level of the objective compounds, it is time consuming for operators to remove other *interferential substances from the samples.*

Because of the continuity of the iron and steel producing process and the particularity of raw materials, less monitoring data is obtained in this project and also with weak character of representation. For the high difficulty and complexity in ultra-low level analysis and sampling for dioxins, lacking of sampling experience of technicians in Chinese iron and steel sectors and particularity of steel production process, inadequate dioxins sampling and monitoring data is obtained in this project neither, and there are some contradictions among the data. Moreover weak logicality and credibility exists in the data. Take the data obtained in Bao Steel filiale for an example, dioxins level in the released fume after the ESCS A and ESCS B electric dust cleaners of 1st sintering machine are 1.28, 3.30 ng-TEQ/m3 respectively, while the dioxins level in the fume before ESCS electric dust cleaner is 2.88-5.71 ng-TEQ/m3. Under current normal *operating condition,* that is the base period, the *dioxins emission level is equivalent* to the ones of the similar sintering plants without dioxins emission reduction measures in Western Europe.

There could be a great deviation between the calculated total emissions data and the actual ones if based on the above data. International cooperation projects and the state financial support for special projects are expected to develop a series of monitoring activities and reveal the dioxins emission rule and level in Chinese iron and steel sectors. Therefore, it is suggested to proceed the monitoring and assessment of the actual emission level of dioxins formed in sintering and electric furnace through more international projects and the national financial support.

5.1.2 Constitute Dioxins Emission Standards for the Iron and Steel Sectors in Environmental Sensitive Regions

According to the study and practice on dioxins issues, measures have been proposed to prevent dioxins formation in steel scrap processing by metallurgical sector, including control technology of electric arc furnace smelting. By using this dioxin emissions emitted into atmosphere can be reduced to 0.04-0.06 ng-TEQ/m3, quite lower than the emission standard of 0.1ng-TEQ/m3 regulated by developed countries. Chinese steel industry should have sufficient knowledge and take the necessary technical measures to effectively resolve the dioxins pollution possibly occurring during steel production.

Japan has formally promulgated the assessment standards, promoted various departments to take measures and achieved obvious results after studying European experience and the 1997-1999 census in 2000. Electric furnace, sintering and zinc reclamation are included in the assessment of the steel industry.

Table 28. Dioxin Emissions of National and Iron/Steel Sectors in Japan (g-TEQ/a)

Items	1997	1999	2000	2002	2003
Total	7910	3040	2460	891	390
Electric Furnace	228.5	141.5	131.1	130	80.3
Agglomeration	135.0	101.3	89.8	93.2	35.7
Reclamation of Zinc Industry	47.4	21.8	26.5	13.8	6.5

Large-type equipments, such as sintering machine with the type of 450 m2 coke oven 7.36M, high furnace with the capacity of 4350 m3, converter with the capacity of 300 ton, ultra high power electric furnace with the capacity of 150 ton and lager-sized continuous hot-cold slat rolling mills have been used in our iron and steel industry. But there is still a long way to turn the all-round large-scale equipments into reality with coexisting of all level process equipments.

In some backward energy enterprises, high energy-consuming equipments are still used such as 4.2 m coke oven, small sintering machine less than 4.2 m, small high furnaces less than 300 m3, small converter with the capacity of less than 20 t, small electric furnace with the capacity of less than 20t, and transverse-style or double-dual style small rolling mills for wire/rod materials. These backward equipments are not only energy-consuming but also fail to reclaim waste heat by taking energy-saving techniques in place.

By the end of the "10th Five-Year Plan", there were still 1130 high furnaces with the capacity of lower than 1,000 m3 which occupied more than 60% iron making capacity. Moreover, with China's low grade iron ore, inadequate resources such as lack of scrap resources, henceforth the iron and steel sectors should change the mode of growth, improve the industrial concentration degree, optimize the overall steel manufacturing processes and accelerate the eliminating of high furnace with the capacity of lower than 200 m3, converter lower than 20 t and backward rolling mills. For small-type sintering machines, high furnaces, coke ovens and electric furnaces, there is little feasibility to allocate the whole environmental protection equipments. On the other hand, since single-station equipment has limited production capacity and there are a large number of devices involving dioxin, it is very difficult to make all the dioxins monitoring under control and ensure all monitoring data scientific and reliable. Considering the huge work and high cost of monitoring, it would be better to put more funds to improve and modify correlative equipments to reduce the emission of dioxins.

During the "11th Five-Year Plan", the ratio of iron to steel will be continuously lowered from 0.92 in 2004 to 0.85 in 2010, thus the usage percent of sinter can be reduced and more large-scale equipments can be widely spread. Finally effective monitoring of dioxin emissions will be achieved.

The distribution of steel sectors should be more reasonable, the process and product structures be of better optimization and the steel manufacturing equipment be larger-sized, efficient, continuous, automatic and environmental friendly. So not only should the future development policy of steel industry and the equipment level of new projects should be strictly controlled but also new dioxin emission standards for the new steel sectors close to important cities or environmental sensitive regions should be reestablished.

5.1.3 Strengthen the Research and International Cooperation on Dioxins Emission Reduction Technology

Through the Sino-Italian cooperation projects, more control technologies about dioxins, furans and benzopyrene have been well-known by our national steel sectors. For example, while activated carbon and gas cleaning equipments dealing with sintering waste gas, dioxin level can be reduced and the concentration of SO2, NOx, and other pollutants can be effectively lowered down.

A British company Corus UK has already developed a technology to reduce the formation and emission of dioxins in iron ore sintering process. After 94 times measurement, results showed that the concentration of exhaust emissions ranged from 0.28 to 4.4 ng I-TEQ/m3 in five British sintering plants and the total average value is 1.19 ng I-TEQ/ m3 which is slightly higher than the limited emission value 1ng I-TEQ/ m3 set for the new sectors by the Britain environmental protection agency. The main measure is achieved by several parts: reducing the chlorine and the precursor compounds in raw materials, adding a small amount of urea to the mixture or spraying ammonia particles to the last four bellows before sintering to inhibit the formation of dioxins, rapidly cooling the sintering smoke to reduce dioxins formation and condense the dioxins to the dust particles surface, using activated carbon adsorption tower to remove dioxins after the desulfurization device and finally through wet electrostatic dust cleaner to remove dioxins in sintering exhaust.

Appropriate cooling technology should be used to ensure that the exhaust temperature is reduced to lower than 250°C as soon as possible to inhibit the formation of dioxins. For example instantaneous flowing nozzle mode, very subtle drop with huge surface area can be formed and useful for the condensation and adsorption of dioxins.

Through intercommunion with Japanese steel industry on environmental protection technologies, several technologies to control dioxin release have been learned by our Chinese iron and steel industry as follows:

(1) Technical measures to reduce dioxins emissions of electric furnace

Through a systematic study on the dioxins forming mechanism and changes during furnace processes, including scrap preheating and dust cleaner, conclusions were reached as follows:

a. Reduce the chlorine content in scrap to inhibit the formation of dioxins significantly;

b. Raise the first fume combustion temperature of electric furnace to improve the decomposition efficiency of dioxin significantly (decomposition rate at 900°C is 99.9%);

c. Reduce the fume outlet temperature of fast-cooling spray tower to 250°C, which can inhibit the reformation of dioxins;

d. Lower down the inlet gas temperature of bag filter to reduce the formation of dioxins in smoke.

Clean technology for the mixed elements. The mixed elements are the biggest problem in the reuse of steel scrap. Copper, affecting the steel quality badly, is important factor obstructing the reuse of scrap. Copper in steel scrap comes mainly from waste automobiles, home appliances and the electrical wiring and in the future the copper content in steel scrap will be of increasing trend. In the past years such mixed elements have been removed by extension refining and strengthening the artificial separation solutions while harmless methods are studied recently.

(2) Dioxins emission reduction measures in iron ore sintering

The research by the SDD seminar composed of seven Japan high steel plants and three universities on dioxins changes through two sintering machines with different fume treatment methods–single dry electrostatic dust cleaner and both desulfurization and denitrogen dry/wet electrostatic dust cleaner-revealed the preliminary points:

a. The chlorine level in raw materials has a direct relation with dioxins level in the fume but the shape of chlorine has little influence;

b. Dioxins concentration will reach the highest point when stack temperature is close to the peak value;

c. Dioxins contained in the raw materials has been totally decomposed;

d. Types of coal and coke added and level of copper have greater impact on the dioxins level.

Based on the above points, anthracite with less dioxin formed should be used and the usage of materials with high copper and oil contents should be reduced. Other measures such as strengthening dust clean to reduce the release of dioxins and letting fume pass a sintered layer to decompose dioxins can also be taken.

In addition, Germany Baden Steel Engineering Company (BSE) and the Xingcheng Iron and Steel Company Limited in Jiangyin, China have recently signed a technical cooperation contract about dust clean. BSE will provide a set of BSE-HTQ high temperature exhaust quench system to improve the dust clean system of 100t DC electric arc furnace of Xingcheng Steel Company Limited. Additionally the dust clean system can also reduce dioxin and furan emissions formed during the EAF steelmaking process. The combustion of materials containing chloride will lead to the formation of PCDD/Fs. As to the EAF steel plant, the steel scrap containing polyvinyl chloride (PVC) plastics, chlorinated oils and solvents are the main source of chloride which resulted in the formation of dioxins and furan. Dioxin is the outcome of the low-temperature combustion (300-700°C) process of EAF furnace. BSE-HTQ exhaust temperature quench system can effectively prevent the formation of dioxin and furans. In 1990, BSW installed the HTQ system. This system has ensured that the BSW dioxins emission concentration is below 0.1 ng TEQ/Nm3. Up to now the HTQ system has been used for 12 years and in the last 7 years the dioxins emission concentration has always been 0.1ng TEQ/Nm3 or even lower. HTQ technology can replace the exhaust cooler. In a few seconds water mist will reduce the EAF exhaust temperature from over 800°C to below 300°C which makes no time and conditions for dioxins formation. HTQ system can also eliminate the peak temperature of the emissions through spraying water which allows the usage of oxygen enhanced operation accelerating the melting process. Thus we can make better use of the capacity of dust bag room. The exhaust is cooled by evaporating water, so the DEC cooler with poor efficiency is avoided and then the system pressure is reduced.

Circle sintering technology is one of the environment protection and energy saving technology which allows part of the hot sintering emission gas to return to the trolley after ignition device, thus not only recovering the waste heat of sintering fume but also reducing the handling capacity and discharge quantities of dust fume up to 50%. Since the fume emission is reduced, the fume temperature is under control and adsorption treatment technologies, the dioxin pollution is greatly reduced. A new sintering exhaust circulatory system has been developed by Voestalpine Stahlt and VoestAlpine industrial equipment manufacturing company (Siemens VAI). The system is reconstructed from the original sintering machine of Voestalpine Stahlt in Linz city of Austria. The new technology has significantly reduced the soot and pollutantlevel in the fume, moreover the usage of waste heat and the secondary combustion of CO in fume has reduced the fuel consumption.

More international cooperation on the in-depth R&D is expected to promote the using of technology to reduce dioxin emissions.

5.2 Incineration Industry

5.2.1 The Status of Incineration Process of Hazardous Waste and Medical Waste in China

Hazardous waste incineration technology in China has experienced the stages of single chamber incinerator and double-chamber incinerator. Now the fixed bed incinerator and liquid-spray incinerator have been practically used, and the mechanical furnace-bed and rotary-kiln incinerator has been popular Other types of incinerators and related technologies are still batch scale.

Our country has a 20-year history of producing medical waste incinerator from the beginning of small incinerator. The earliest incinerator was quite small with a handling capacity of about dozens of or one hundred kilograms per hour and also had relatively simple fume treatment process. In recent years because of the state emphasis on environmental protection and the medical waste handling needs, many universities, scientific research institutes and environmental protection technology enterprises have developed medical waste incineration technologies and facilities and a small number of companies have already developed a certain production capacity. Now there are more than 20 small enterprises producing small medical waste incinerators nevertheless the enterprises producing large and medium sized incinerators are not many.

There are many types of incinerators and combustion fashion for medical waste incineration. From the point of burning manner, there are superfluous-oxygen combustion, thermal gasification and so on, while from the point of furnace type, there are rotary kiln, reciprocating grate furnace, chain furnace and vertical rotary furnace and so on. Generally speaking, the incinerator has exhaust gas purification system but relatively simple feed system and the monitoring system. The incinerators for medical waste which have been used well and show a good incineration effect. The representative large and medium size medical waste incinerators are of the following categories:

(1) Rotary kiln incinerator

Rotary kiln incinerator is suitable for handling the large-scale medical waste with a capacity of more than 8tons per day. The incinerator has a good treatment effect, strong adaptability and operating stability characteristics, which is suitable for handling concentrated medical waste in larger cities and regions. Among all the incineration technology, rotary kiln has the best treatment effect, more suitable for continuous operation, but the treatment cost is higher. It's now used in Shijiazhuang, Chengdu, Fuzhou, Daqing and so on. But there are some disadvantages of rotary kiln medical waste incinerator made in china, such as long time for ignition warming and shutdown cooling, relative high cost under non-continuous operation condition; and also the auxiliary fuel consumption is large during the burning process. At present only a few companies such as Beijing Electrical and Mechanical Institute have mature technology to produce such kind of incinerators.

(2) Thermal gasification incinerator

Thermal gasification incinerator, mainly used for treating medical waste and other hazardous waste garbage, has obvious advantages in treatment effect and handling cost. It has relatively higher burning rate, lower consumption of auxiliary fuel, pollutant concentrations in the fume, post-processing load and dust entrainment merits and less smoke. Presently several manufacturers in China can produce such kid of incinerators such as Shenzhen Hanshi Solid Waste Processing Equipment Co. Ltd., Beijing Fajing Green Engineering Co. Ltd, Shandong Lufeng Environmental Technology Co. Ltd, Shanghai Wanqiang Science and Technology Development Co. Ltd., Fujian Fengquan Environmental Group, Tsinghua Unis Taihetong Environmental

Technology Co. Ltd., Shenyang Institute of Environmental Science, et al.

(3) Grate incinerator (Fixed-bed furnace)

Grate incinerator is used in Guangzhou, Anshan, Jilin, Dalian, Guiyang, Shunde and other cities. But it has shown obvious defects like lower burning rate and high consumption of auxiliary fuel in the practical application. The main manufacturers of grate incinerators are Shandong Lufeng Environmental Technology Co. Ltd, Guangzhou Universal New Production Development Co. Ltd., Fujian Fengquan Environmental Group, Guizhou Hangfa Environmental Mechanical Engineering Co. Ltd. and so on.

Fixed bed incinerator is suitable for handling small or medium-sized medical waste of 1.5-8.0ton per day and it has the merits of low investment, simple and stable operation, low handling cost and so on. But it is lack of a sound and mature fume purification system, resulting in secondary pollution to surroundings. Such kind of incinerators is suitable for scattered medical waste disposal in remote districts.

In the future, based on the strict management and control of medical waste collection, transportation and other aspects, the centralized medical waste disposing method and medical waste incinerator with large handling capacity should be further studied and developed., which will facilitate the strengthening of management and reducing the formation of secondary pollution effectively. For some special medical waste incineration at specific time and specific location as well as incineration in remote areas, the small incinerators should be further improved in continuous feeding, fume purification, automatic control technology and other aspects. The vast majority of cities in China should focus on selecting the grate incinerator and rotary kiln incinerator which operate stably and made by mature technology.

5.2.2 Development Trend of Hazardous Waste and Medical Waste Incineration Technology

5.2.2.1 construction plan for national hazardous waste and medical waste disposal facilities

In 2002, hazardous industrial waste has an amount of 10.0016 million tons, of which about 40% was generated by chemical raw materials and chemical manufacturing sectors. In 2002 the amount of national medical waste reached up to about 650,000 tons with an average production per day about 1,780 tons. It is estimated that in 2010, the amount of medical waste amount in the whole country will reach over 680,000 tons and the average production will be 1,870 tons per day.

'Construction plan for countywide hazardous waste and medical waste disposal facilities' was approved by the State Council in October, 2003. In the plan, a total investment of 14.92 billion yuan was planned, 14.42 billion yuan on disposal facilities for hazardous waste, medical waste concentrating and depository construction for radioactive waste and 500 million yuan for the capacity building. There will be 31 projects for synthetic hazardous waste disposal facilities, 300 projects for concentrated medical waste disposal facilities and the gap-filling, expansion transformation of depository for radioactive waste in 31 provinces.

By 2003, a number of exemplary hazardous waste and concentrated medical waste disposal projects with good pre-foundation should be constructed. By 2004, centralized medical waste disposal projects will be built in cities and towns and by 2006, other hazardous waste disposal projects should be constructed. At the same time, the safe storing capacity of radioactive waste should be improved, and the whole process environmental management system for hazardous waste, medical waste and radioactive waste should be basically actualized.

According to the large region allocation plan, seven dioxins monitoring centers will be built in Beijing, Shenyang, Hangzhou, Guangzhou, Xian, Chongqing and Wuhan. These centers will account for the nationwide supervisory monitoring task for the dioxins pollution sources such as hazardous waste and concentrated about medical waste disposal facilities and municipal solid waste incineration.

5.2.2.2 National policy oriented for hazardous waste and medical waste incineration process

(1) Selection of incinerator

Rotary kiln incinerator, with strong adaptability to all kinds of waste, should be preferentially used. When selecting an incinerator with capacity larger than 10t/d, rotary kiln incinerator shall be preferentially adopted and continuous pyrolysis incinerator can also be recommended. Otherwise continuous pyrolysis incinerator or high-temperature cooking process should be preferentially used, especially the single chamber incinerator or grate furnace is strictly prohibited.

(2) Requirements for equipment performance

Incinerator should have the character of mature technology, high level of automation and stable operation. The incinerator should have a certain overload capacity with design life not less than 10 years, achieving continuous automatic feeding and cleaning. Online monitoring devices for operating conditions on temperature, furnace pressure, carbon monoxide and oxygen, automatic control and recording devices are essential. Explosion vent or other explosion-proof facilities should be equipped, and emergency emission chimney should be located after the combustion chamber. The emergency emission chimney is controlled by interlocks and only start at the state of emergency. The incineration system includes feed system, burning furnace, air combustion system, auxiliary combustion device, residue processing system and emergent emission chimney. Feed system is composed of feeder, storage bin, transmission belt and hydraulic stowing tool. The incineration must be equipped with a primary and secondary combustion chamber. Generally the combustion air system consists of primary blower, secondary blower, air heater and other auxiliary devices. The auxiliary combustion devices include oil storage tank, oil pump, pressure reducing valve, flame arrester, cut-off door, filter, atmosphere valve and burner. The oxygen content in the fume of incinerator export should be 6-10% (dry gas). The burning temperature should be higher than 850°C of primary combustion chamber and 1100°C of secondary combustion chamber. The thermal lapse of incineration residues should be less than 5%. The burnout rate of waste should be higher than 99.99%. The residence time of fume with temperature higher than 1100°C should be more than two seconds.

There must be quench system which ensuring the fume temperature dropping to below 200°C quickly. Acid gas removal device, dedusting device and dioxin controlling device should be also installed. And there should be anti-corrosion, anti-acid, anti-alkali, moisture-proofing and heat-resistant measures. Bag filter with sprayed activated carbon should be preferentially used as dedusting device. When using wet dedusting device, there must be waste water treatment facilities to remove heavy metals, organic compounds and other harmful substances. It is not allowed to use electrostatic or mechanical dedusting devices.

(3) Quench room

Quench room must be equipped to ensure the residence time of fume with temperature between 200 and 600°C less than one second to prevent the reformation of dioxins. The inlet temperature, outlet temperature, residence time of fume, quench room size, inlet water flow, parameters of volumetric heat transfer system and atomizer should be clarified. When using wet quench method, attention should be paid to the material requirements of fan and other devices.

(4) Removal of acid gas

The semi-dry process includes absorption tower, atomizer and so on. It should comply with the following requirements:

a. Absorption tower height should be able to meet with the necessary reaction time;

b. Fume temperature of adsorption tower export should be higher than the dew point temperature to ensure not occurring condensation for the fume in following pipes and equipments;

c. The atomization fineness of atomizer should ensure that the neutralizer in the reactor will fully evaporate.

The wet process has certain advantages in disposal of hazardous waste and medical waste with high level of chlorine for simultaneously purifying particle pollutants and gaseous pollutants. If the particle content in the wastewater can be controlled to certain degree, the treated wastewater of wet process can be reused. The wet process should comply with the following requirements: a. absorption tower height should be able to provide the necessary reaction time, and the materials should be acid-resistant; b. the filler should have good durability, non-corrosibility, large specific surface area and good absorption effect; c. sprinkler pipe should be equipped; d. wastewater treatment. For the wet process, attentions should be paid to the impact of the significant reduction of fume temperature after purification on the final fume emission and spread. There should be measures to reduce the water content in fume. When using lime as absorbent, the equipment scaling problem should be paid attention to.

(5) Activated carbon adsorption device

The activated carbon adsorption device is used mainly for strengthening the removal efficiency of dioxins and heavy metals such as mercury. It can be located between the absorber and dust cleaner. Coconut shell activated carbon or treated activated carbon should be preferentially used.

(6) Dedusting

Both wet and bag dedusting devices are suitable for hazardous waste and medical waste incineration. The widely used dedusting devices are spraying tower, venture scrubber and bag filter. The fume purification system should give priority to using dust bag filter and it is not allowed to use electrostatic or mechanical devices. The quench water should completely evaporate before entering into the bag.

5.2.3 Suggestions for Dioxins Emission Reduction Measures of Medical Waste Incineration Industry in China

In view of the specific process of medical waste incineration system in our country, referring to the current main dioxins emission reduction technology and the affordability of economy and technology, the following dioxins emission reduction programs are proposed for our incineration sectors.

(1) Control of raw materials

All the medical waste should be broken into small particles before incineration to strengthen its contact with the combustion air leading to homogeneous combustion.

(2) Control of combustion

Strict measures should be taken during the management of the incineration plant to lower down the dioxin emission. The incinerator should be maintained at full load operation, and strict accordance with the "3 T" operation principle is the important measure to reduce formation and emission of dioxins.

The design capacity of the model enterprise, Medical waste incineration system of Huzhou City, is 10t/d. However, the largest practical handling capacity is only 7t/d nowadays for some reason, resulting in the discontinuous operation of the incinerator for lack of sufficient feed. Huzhou medical waste incineration system runs about 16 hours a day, and the rest time is longer than 4 hours. The frequent start-up and shutdown of the incinerator will cause big operation difficulties and more equipment maintenance. Especially, during the process of start-up and shutdown, unstable burning behavior and the inability to meet the design burning conditions may result in the formation of a large amount of dioxins. This is a quite common existing in our medical waste incineration facilities. Above all, increased continuous run-time and reduced start-up and shutdown frequency will possibly be an important means to reduce dioxins formation and emission.

(3) Control after combustion

The main problem to be resolved is the reformation of the remaining dioxin precursors and the trapping of formed dioxins after complete combustion. Reducing temperature will both inhibit the reformation of dioxins and improve the absorption efficiency effectively. Controlling the fume temperature between 250 and 400°C by quench chamber, minimizing the particle residence time and controlling the fly ash surface catalytic activity can reduce the emission of dioxins effectively. Adding ammonia to fume can inhibit the formation of dioxins on the fly ash surface for NOx can be reduced to N_2 by ammonia resulting in the control of the emission of NOx and dioxins simultaneously. Bag filter can be used to trap dioxins released effectively. Usually the inlet temperature of a bag filter is lower than 150°C while the catalytic reaction temperature for the formation of dioxins is 300°C, so it is quite impossible to form dioxin from its precursor by catalytic reaction in bag filter.

A granular layer will be formed and dioxins in the exhaust gas of bag filter will be easily adsorbed onto the layer and then released to ash residue system, which is quite different from electrostatic dust cleaner. Therefore, it is very important to maintain the bag filter operating with safety and high efficiency.

(4) Terminal control

The terminal control includes activated carbon adsorption, decomposition or catalytic reduction of dioxins.

Activated carbon is a good adsorbent with strong adsorption capacity because of its larger specific surface area. It can adsorb not only dioxins but also NOx, SO_2, heavy metals and related compounds. he adsorption process is mainly composed of absorption and desorption sections. The fume comes into the mobile absorption tower containing activated carbon, and the fume temperature is controlled between 120 and 180°C. Dioxins will be adsorbed in this tower. If activated carbon adsorption tower is used in this exhaust system, the dioxins emissions will be minimized. Catalyst used for the selective catalytic reduction of NOx also has the ability to decompose dioxins. Maintaining the temperature at 200 to 350°C, the dioxins level in fume can be reduced to below 0.1ng/m3 by the TiO2-based selective reduction catalyst without ammonia.

As to take what kind of specific emission reduction measures, it all depends on the dioxin test results. So the dioxins detecting program should include the sampling and analysis conditions of different sampling locations and operation behaviors to find the key factor of dioxins emission reduction.

5.3 Paper manufacture

5.3.1 Status of Technology in China

Materials involved in pulp and paper industry include fiber and chemical materials. Fiber materials contain wood fiber, non-wood fiber, and waste paper; chemical materials contain calcium carbonate, 2-propenamide homopolymer, sodium sulphide, sodium hydroxide et al. The main sources for non-wood fiber are mostly reef, bamboo, bagasse, cotton linen, devil's rush herb, rice straw, and one-year plants' straw. In the worldwide pulp and paper industry, there are more than 90% demand on wood, weighing in the pulp fiber materials (waste paper is not inclueded); whereas, the ratio of wood application is smaller than the types of herb and other non-wood materials in China, and China is also the biggest producer of straw pulp in the world. Historically, national paper fiber material are almost made from wood and herb, such as pine, masson pine, poplar wood, and birch wood for the wood, and reef, bamboo, bagasse, wheat straw, rice straw, devil's rush herb linen, cotton for the herb.However, the ratio of wood has increased recently, which mainly results in input of wood chips and pulp (wood pulp is in the 65% of total amount or so). In 2005, the ratio of wood is up to 22%, and the ratio of pulp from waste paper increased from 28.2% in 1990 to 54% in 2005 (the input is 26%). In contrast, the involvement of non-wood fiber decreased in ratio year by year, that is 57.2% in 1990 to 24% in 2005; however, the absolute amount still keeps increasing and the increasement will continue in the short run of development.

Waste water, gas, solid, as well as noises are caused during the pulp and paper production. To great degree, emission from the pulp and paper plants is from the burning of fuel. Carbon dioxide from the buring of renewable biofuels (pulp black liquor, wood bark) will not aggravate the green-house effect; whereas, the energy consumed in pulp and paper industry in China at present is still from the buring of minerals. Moreover, oxides of sulphur and nitrogen can also be emitted from vehicles for transportation, power plants, and alkaline recycling boiler in the pulp and paper industry, which acidifying the atmosphere, deteriorating the regional environment, as well as the direct exposure of particles and smelly gas around the plant.

The waste water of pulp and paper industry is from the process production, or the waste water to remove chemical residues and chemical components of fiber. Chemical bleaching pulp includes pulp black liquor (the inorganics is treated by alkaline recycle system, and the organics are used for thermaol energy) and organic chloride chemicals. Chemical reagents in the pulp from mechanical process and waste paper, or fiber scraps separated during production are released as waste water. Water in the production of paper manufacture is mostly recycled for reuse in workshop after proper disposal, and some waste water containing organics and inorganics are output. All in al, waste water would be finally inducted into waste water treatment plant of the enterprise, and released after phsiochemical and biological treatment. The solid waste is produced in the whole procedure of pulp and paper manufacturing, e.g. sludge disposed outside the plant may affect the aroundings during final treatment. Introduction of clean production technology or the improvement of resources application will all apparently reduce the damage of waste gas, water, as well as solid to the environment.

Organic chlorides involved in the pulp and paper industry----dioxins are induced in the form of by-product during the manufacturing, which is also related to the materials for pulp-making (including waste paper), types of chemical materials (i.e. bleach, foam-killer), and technologies and instrument for the pulp-making, bleaching, washing and screening.

5.3.2 Estimation of total Dioxins released into the environment

The national consumption of pulp is 52,000,000 tons in 2005, in which 11,300,000 for wood pulp, 28,100,000 tons for waste paper pulp, and 12,600,000 for non-wood pulp. The input of pulp in 2005 is 7,590,000 tons (most is ECF wood pulp, and the rest is TCF wood pulp), and the output if 47,000 tons. Concequently, with the exception of waste paper pulp and input pulp, the total amount of wood (3,700,000 tons) and non-wood (3,700,000 tons) pulp is summed to be 16,300,000 tons in 2005.

Chlorine bleach attaches great importance in the present pulp technology; in addition, chlorine dioxide, kind of non elemental chlorine bleach, has been used more and more in the field, whereas a few of total non chlorine bleach and mechanical pulp-making. With the rough estimation, TCF pulp is minor in the 16,300,000 tons; bleach pulp of ECF is about 10%, as the production of 1,500,000 tons; mechanical pulp is around 2,000,000 tons; natural semi-chemical straw pulp is 4,800,000 tons or so; the production of sulphate process as involving chlorine bleaching is probably 8,000,000 tons. The total national emission of Dioxins of paper industry is listed in table 29 as follow.

Table 29. Emission list of Dioxins of paper industry

Programs	Production/tons	Aqueous		Products		Sludge	
		μgTEQ/ Adt	PCDD/Fs /g TEQ	μg TEQ/ Adt	PCDD/Fs /g TEQ	μg TEQ/ ADt 子	PCDD/Fs /g TEQ
Sulphate process (Cl_2)	8,000,000	4.5	36	8	64	4.5	36
TCF	NA	1		3		1.5	
ECF	1,400,000	0.06	0.084	0.5	0.7	0.2	0.28
Sulfite process (Cl_2)	100,000	ND		1	0.102	ND	
Mechanical	2,000,000	ND		1	2.0	ND	
Recycling paper (carbon-free)	8,000,000	ND		10	80		
Recycling paper (carbon)	15,000,000	ND		3	45	ND	
Input	7,590,000			0.5	3.80		
Black liquor boiler	5,000,000	0.07(Air)	0.35(Air)				
Sum			36.08		195.60		36.28
Total				267.97			

As a result, PCDD/Fs released during pulp and paper industry is totally 268g TEQ in 2005。

5.3.3 Alternatives in technology to reduce dioxins emission in national paper industry

Reduction and elimitation of dioxins for paper industry is diversity and multi-layers in technology, which is presented as below in details:

(1) More effective pulp-washing methods;

(2) Non involvement of wood or reef for pulp productiong with, which have been contaminated by higher-chlorinated chemicals;

(3) Applying chlorine dioxide (ECF) rather than chlorine;

(4) Introduction of extended lignification technology to reduce residual lignin into the bleaching workshop;

(5) Applying oxygen technology for further stripping of residual lignin;

(6) Pre-bleach by bio-enzyme to reduce the application of chlorine;

(7) The introduction of Hydrogen peroxide and ozone;

(8) Disposal of controlling sludge;

(9) Sound control of wood and reef pulp for the alkaline recycling burning technology;

(10) Effective disposal of sludge from deinking waste paper.

According to requirements in the national policy for paper industry "the pulp and paper industry involved in chlorine bleach should gradually reduce or elimitate chlorine bleaching, and new-built enterprises should inhibit the application of chlorine bleach technology", technologies probably be different as for new-built enterprises and ever-built ones. For the new-built enterprises involving bleaching, the preferred technologies are: oxygen deliginification technology (oxygen treatment, further removal of residual lignin after cooking) and the combination of non elemental chlorine bleaching technology; application of bleaching with hydrogen peroxide, ozone et al. For the present enterprises involving chlorine bleaching, the main chooses could be reduction of chlorine, more introduction of chlorine dioxide rather than chlorine, application of extended delignification technology to reduce the input of residual lignin into bleaching workshop, and pre-bleaching with bio-enzyme, as well as proper control on the disposal of sludge contained dioxins, and so on.

No matter for the new-built ones or the present ones, technologhical alternatives should attach importance to the following aspects, including more effective methods for pulp-washing, avoidance of wood or reef contaminated by higher-chlorinated chemicals potentially, sound control on alkaline recycling burning technology for wood and reef pulp, and effective disposal of sludge produced during waste paper deinking.

5.3.4 Estimation on reduction of dioxins emission and increase on cost

As for the present pulp and paper industry involving 8,000,000 tons chlorine for bleaching, the total cost for reformation into non elemental cholorine technology is

80.08 billion yuan by estimating one ton pulp for 1001 yuan.

In the perspective of coming ten years (to 2015), the national production of pulp is up to 21,150,000 tons, more than the total amount in 2005 by 4,850,000 tons, in which 2,800,000 tons for the bleaing pulp. By estimating one ton pulp bleached by ECF instead of chlorine with cost increase of 416.5 yuan, the whole investigation will be 11.66 billion yuan. Increased cost on operation due to the reformation on production line is compensated by profits by the improvement of paper quality.

The sum of above two costs is 91.74 billion yuan, which is equal to 11.8 billion dollars.

5.3.5 Obstacles in the impletation and corresponding methods

Strategy should first identify and clear the obstacles, and be made full use of the effects of lever during the carry-out of program. The probable effects of lever could be caused as a result that: alternatives of chlorine bleach by non elemental chlorine bleach in enterprises is promsing, they are also the obligation and responsibility for these enterprises. Progagation on impletation of POPs convention, consultation and introduction on the technology in alternatives to chlorine bleach in paper industry with national supportion, will be carried out thoroughly. In addition, trials on developing fields will keep making progress; the provinces of Shandong, Guangdong, Zhejiang and Jiangsu are initially considered for the promption of alternatives to chlorine bleach technology for pulp and paper industry. Further work will be carried out nationally step by step based on the ground achievements.

The potential obstacles include: even though dioxins and other persistent organic chlorine chemicals would be caused by chlorine bleach process, chlorine or bleach containing elemental chlorine has the advantages of low investigation and operation cost, as well as effective performance on deliginication. At present, most national pulp and paper plants still apply chlorine and hypochlorite for bleaching. Consequently, obstacles and difficulties will be encountered in reduction and elimitation of chlorine bleach technology; making out strict plans and executive systems is necessary and indispensible. In the capital system, national and regional financial support is inevitable for the enterprises introducing alternative technologies or reducing the application of chlorine bleach, to encourage voluntary immpletation of obligation and responsibility required in POPs convention.

Without cautious measures in technology and investigation, it is impossible to implete the POPs convention. At present, national paper industry still face technological difficulties in convention impletation; moreover, non wood fiber is still applied in scale, which is different from the case in developed countries with the application of wood fiber. Due to the differences in materials, pulp technologies, bleaching systems and consumption of products, technologies and mechanism on reduction and elimitation of dioxins from wood pulp bleaching process could not be applied directly in China.

5.3.6 Mechanisms of Political measures on convention

On May 22th, 2001, united nations environmental programme (UNEP) organized and passed through "Stockholm convention on persistent organic pollutants", in which induced dioxins in the control list of 12 persistent organics pollutants (POPs) in primary. On May 23th, 2001, China took part in the convention, and in 2004, the Chinese government ratified "Stockholm Convention" formally, solidating the carry-out of programme. Furthermore, in order to implete the convention, China also made out national impletation program (NIP), comfirmed it by State Environment Protection Administration (SEPA), State Development and Reform Commission, and other 11 national departments, and finally ratified by the State Council. More chances will be provided for the stakeholders, and improvement on industrial structure and workforce levels will also be achieved by emission reduction strategy. With the realization of the whole programme goal by goal in different levels, difficulties would be overcomed gradually. Reduction and elimitation of dioxins involved in paper industry would be completed through the promption and impletation of BAT and BEP.

National policies issued for paper industry has constricted the application of chlorine bleach in new-built program, and pointed out the phase-out of this technology, ensuring the political and powerful impletation of convention in paper industry.

Chinese gonverment presently engages in prompting economic structure, and transforms from extensive to intensive mode in economic growth; energy-efficient, water-efficient and other policies for sustainability have been advocated. Reduction of POPs by BAT and BEP for carrying out the convention can be concluded as clean production technology, which not only benefit the reduction on POPs, but also enhance the saving on water and energy. ECF is one of the primary technologies in water closed recycling for pulp and paper industry. The sustainability of paper industry will be strengthened continuously by improving the impleting ability, propagation and puplic sense for the convention.

5.3.7 General statement on reduction strategy

In order to realize the elimitation and phasing out of dioxins-like POPs in paper industry in China, it is necessary to make corrections on related industrial policies, regulations for program ratification, and emission standards of pollutants and other laws in nation; meanwhile, corresponding to the activities on the convention, technologies, information, encouragement mechanisms and other insurance systems would also be set up.

(1) Advices on policies

In the national program referred to Chlorine or chlorine related bleaching technology in pulp and paper industry, measures should be taken step by step for all the new, reformed or extension projects according to the POPs convention, regardless of the levels in nation or region, or scale of projects; in the perspective of project proposal, project ratification, as well as the evaluation of environemenal influences, regulations and requirements should be made out in the chlorine or chlorine-produced bleach technology.

(2) Phasing out mechanisms

Make out impletation plan and mechanisms cautiously; in the capital system, enterprises, which take actions positively to reduce and elimitate pollutions during bleach process, should be supported financially by the national and local government, to encourage the voluntary completation of obligation.

(3) Insurance on the development and investigation in technology

The correct carryin-out of convention impletation depends on the insurance of well-established technological development and investigation; on the other hand, the present paper industry in China is still trapped in obstacles and difficulties. In order to carry out the plan properly, insurance system on technological investigation for evaluation, technology, instrument and craft should be constructed relatively。 Reduction on chlorine bleach and alternative technologies, instrument, and craft suitable for straw pulp technologies in China should be investigated and tried for production. The writing and compilation of the emission standards for pulp and paper industry, researches on the uniformed method for thorough investigation on the sources of pollution, analyzing technology for emission evaluation, and developing low-cost methods for detection and estimation, are all included.

(4) Information management system

Internet platform for service, which is special for the paper-making technology, would be constructed, in order to overcome the drawbacks in the technical ability, identification of current new technologies, and deficiency in recognization of small and medium enterprises, and accelerate the application of suitable and feasible best clean production technology, as well as to avoid the crisis due to blindness measures and immature technology involved in the enterprises. Moreover, reliable decisions can be mapped out by related governmental departments in adjusting the structure of industrial materials and enterprises' scale, and preventing pollution from paper manufacturing. Finally, it can also provide sound support in technology for the enterprises, which are still straddling and expecting on the application of dioxins reduction and elimination technologies. The system will benefit on the further activities in convention implement by providing information management, strengthening the corresponding ability in nation wide.

(5) Demonstration on BAT & BEP by pulp and paper enterprises in project

There are kinds of obstacles, such as technology, craft, capital, and mechanisms, will be encountered during the application of BAT & BEP for the reduction and elimitation of dioxins-like chemicals. As a result, it is necessary to take the proper BAT & BEP for the demonstration according to the regions, fiber materials and enterprise scale, and advance the BAT & BEP in the whole line sequently.

Demonstration of BAT & BEP in pulp and paper industry includes the reformation of bleach technology. Considering the situation in China, reformation chlorine bleach into totally chlorine free and non elemental chlorine bleach technology by adapting wheat straw, reef, bamboo and other non-wood fiber, this consequently advances the application of BAT & BEP with non wood fiber bleach. Both of large and medium scale enterprises should be regarded for the demonstration, and the impletation of demonstration by the enterprises, it is of great importance for clearing the obstacles for the industry, facilitating the application of BAT & BEP for the other lines of the similar type, and encouraging the carry-out of BAT & BEP for more enterrises.

5.3.8 Potential effects in the frame of GE

Impletation of project will provide insurance in policy and technology for the smooth going of GE in the next step.

Status of pulp and paper industry and corresponsive amount of POPs produced has been initially recognized through project impletation. Another important outcome is to accelerate the national policy of “inhibition on application of chlorine bleach technology in the new projects and phasing out on the present craft involving the chlorine-contained bleach” addressed clearly in “pulp and paper industry”. The execution of the policy provides powerful and important insurance in policy for the pulp and paper industry to implete the convention in the near future.

To promote the recognization on the convention, with the positive effects of demonstrationon of POPs reduction activities, and training and propagation for the stakeholders in the line, suitable atmosphere will be initially achieved, and solidate base will also be made for the GE plan.

Due to the differences between the material structures in home and aboard paper industry, the production line with representative non wood fiber like wheat straw and reef would be selected from the demonstration enterprises on POPs reduction; the production line in waste paper deinking has been detected, and calculate the increasement of cost based on the available data as a result of reformation on unit amount of pulp, providing the objectives for GE plan in supporting technologies and capitals on convention carry-out.

The program has multi-layer effects in the frame of GE plan; in addition, convention impletation meets the requirements of sustainable development in the country, progress in technology, adjusting of industrial structure, up-date of industry, and public health. With the application of GE plan, progress will be achived in the expectation in the pulp and paper industry.