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PRODUCTIVITY ENHANCEMENT IN DRY PROCESS CEMENT PLANTS

DP/IND/84/020/11-08

Technical report

Prepared for the Government of India by
the United Nations Industrial Development Organization

Based on the works of Tage H. Danø,
expert in Productivity Enhancement in
Dry Process Cement Plants.

United Nations
Industrial Development Organization
VIENNA

ABSTRACT

DP/IND/84/020/11-08

PRODUCTIVITY ENHANCEMENT OF DRY PROCESS CEMENT PLANTS IN INDIA THROUGH IMPROVING KILN UTILIZATION

The mission was realized during the period from October 14, 1986 till December 6, 1986.

The objective of the mission is to strengthen the capability of the National Council for Cement and Building Materials (NCB) in productivity enhancement in Dry Process cement plants. The thrust area is investigation of the causes for low kiln utilization and evolving remedial measures. Through interaction with NCB and plant personnel is expected that the expertise of NCB is strengthened in effectively diagnosing technological problems and productivity constrains as well as in formulating programmes and methologies for solving technical problems.

During the mission were causes for low utilization of Dry Process kilns investigated at visits to a number of selected cement plants, accompanied by specialists from NCB.

Through this interaction with NCB and plant personnel was identified a number of productivity constrains, and strategies for improving productivity were formulated.

Reports prepared on t..e plant visits will further enable NCB to use similar methology in general and implement, in cooperation with the individual plants, solutions to the technical problems identified.

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I INTRODUCTION

The mission as expert in Productivity Enhancement in Dry Process kilns in India was realized from October 14, 1986 till December 6, 1986.

During this period in total eight selected cement plants in various parts of the country were visited together with specialists form NCB. These visits with plant personnel and the NCB specialists was the main body of the mission.

In between the plant visits were discussed with NCB personnel the findings at the plants and general topics in connection with kiln operation, kiln optimization and kiln utilization.

These discussions took place partly at the NCB Ballabgarh unit and partly at the Hydrabad unit. Lectures on:

Optimization of process and operational parameters
Optimization of kiln control
Optimization of cooler operation
were given at four occations, in CCI´s training center at Nayagaon, in Hydrabad, in NCB, Ballabgarh and in NCB, Delhi.

Participating in the lectures and discussions were technical personnel from many cement plants and NCB personnel.

II CONDITIONS FOR CEMENT KILN UTILIZATION IN INDIA

A. General

At present is the cement production 33 Mill.t/year compared with installed capacity at 44 Mill.t/year. The cement industry has expanded very fast over the last few years, specially since the partial decontrol of sales in 1982.

Nearly all the 65 Dry Process kilns, in 45 plants, have been commissioned in the last 7 years and Dry Process kilns now cover about 2/3 at the total installed production capacity in the industry. At the same time has the change to sofisticated Dry Process kilns with cyclone preheaters and precalciners taken place and the capacity of the units has increased beyond limits previously known. In the industrialized world took this development place over a long period, actually starting around 1950, and many problems encountered were solved over this long period up till present state of the art. The problems met within the early days were mainly connected to the conditions imposed from outside on the kiln systems, such as control of chemical conditions, draught conditions and feeding accuracy. But it was also realized that the complex kiln systems require a very strict industrial discipline in operation and maintenance of such installations.

The transfer to India of this modern technology includes often the most sofisticated equipment and of course manuals and operational instructions for this equipment.

From many of the plants visited and from previous experience in India it is noted, however, that the software for technical management of the advanced plants has not been transferred in many cases.

The change-over from Wet Plants requires a different industrial way of thinking and with the rapid growth it has in many plants been difficult to recruit technical management staff with sufficient background in modern industry.

This underlines the need for training in this area. The transfer of modern technology has often been made without taken the special Indian conditions into consideration, such as relative costs of labour, fuel and power, infrastructure and the human element.

B. Technical conditions

The technical conditions in India for cement manufacture and specifically for kiln operation differ quite essentially from conditions in most of the industrialized contries, when considering raw materials and fuel.

The limestone is generally of very marginal quality and the raw materials available does not to obtain an optimal composition of the raw mix when considering the strength level of the cement. But the raw materials result in very easy burning raw mixes, which has important and advantageous effects on kiln operation.

When dealing with dry kilns with cyclone preheaters is the load in the rotary kiln no restriction for the production capacity. If other constrains permits could in fact very high specific load be obtained. The easy burning raw mix is also resulting in a good and stable protective coating in the kiln permitting the use of high-alumina bricks with very good lining life.

Further results the easy burning raw mix in low evaporation in the kilns of volatile components so that problems with coatings in the preheater are practically non-existing when comparing with the magnitude of such problems elsewhere.

The other area, where special conditions prevail in India is the coal quality.

The coal used in most parts of the industry are in fact good bitumenous coal, but contaminated with very high and varying ash content.

When heating with dry preheater kilns with efficient clinker coolers will the high ash content, say 35% ash, in itself not represent an operational problem and does not reduce the kiln capacity. But it is unavoidable that the high ash content severely reduces the potential cement strengths; the ash cannot be incorporated homogeniously in the clinker. In kilns with precalciner is the effect of high-ash coal on strength level however much reduced.

The real problem for kiln operation are the very large variations in ash content of fine coal to the kiln, seen in most of the plants. The unpredictable variations in ash cannot be compensated for in the kiln operation and they represent generally the most important constrain in kiln capacity.

Also when considering the strength level of cement it is evident that with the same average ash content will a constant content give much higher potential strength than obtained with variations in ash content.

It is outside the scope of this report to discuss the problems in India with supply of uniform coal.

III PLANT VISITS

In total eight Dry Process plants, selected as representative by NCB, were visited, accompanied by NCB experts. In most of the plants were all requested informations given and detailed discussion on kiln operation and constrains in kiln utilization took place with the technical staff.

Out of the eight plants two were operated up to normal standards for the industry elsewhere with run-factor exceeding 85% and output close to rated capacity.

Two of the plants were operated with output above to rated capacity, but low run-factor resulting in low kiln utilization.

The remaining four plants showed very poor performance with low output and low run-factor. All the plants visited had equipment of comparable standard, being nearly identical, and similar raw materials and coal.

The large range of results obtained is thus not explained by differences in conditions, but is caused by management problems. It is outside the scope of this technical report to deal with this problem.

Compared to national average, the plants visited appear to be representative.

Out of the 45 Dry Process plants in India, operating in total 65 kilns, 10 plants show a productivity equal to expectations, which is rated capacity and 85% run-factor. 20 plants obtain a productivity exceeding 85% of this goal.

IV IDENTIFICATION OF CONSTRAINS

Detailed reports on each plant visit has been prepared and are attached in the Annexes. Some of the problems are specific for the individual plants and discussed in the Annexes.

The decisive constrains for productivity enhancement are common for most of the plants and listed below, according to priority.

1. The low run-factor seen in all the plants with two exeptions only is mainly caused by mechanical repairs and lack of preventive maintenance. Problems in operation are of minor importance only for the run-factor, and kiln stops for lining repair are within acceptable limits.

   Lack of coal supply or power is not of importance at the plants visited, most of them having generator sets, but might be important on a national scale.

2. Variations in ash content in fine coal to kilns is a major problem for kiln operation and clinker quality in all plants with one exception. Few of the plants only make any effort in trying to reduce ash variations by mixing raw coal with the limited means at hand and equipment, for effective blending does not exist.

3. Draught limitations is the common reason for low kiln output. Even with reduced output are preheater fan and specially ESP fan running with full capacity. The design capacity of the fans is ample, but very large amounts of false air in the system restricts the draught through the kiln.

4. O_2-meters at kiln inlet and after preheater are imperative as control parameters for combustion control. They are in many cases not used or not maintained.

5. Kiln feed composition shows generally bigger variations then permissible in prehaeter kilns. Adequate equipment for raw mill control and raw meal blending is found in all plants.

6. Coal mill operation is often inadequate, resulting in high moisture in fine coal, too much primary air or leaking of mill air with coal to atmosphere.

The problems here identified are of paramount importance for kiln utilization. Only when these basic problems are solved will it be possible to identify and remedy other constrains in kiln utilization, at present of very miner importance.

V SUGGESTIONS FOR PRODUCTIVITY ENHANCEMENT

To improve the total productivity following remedial measures are suggested as general measures for most of the plants visited.

1. Introduction of efficient preventive maintenance in accordance with systems used in efficiently operated plants.

2. Reduce variations in ash content in fine kiln coal. It will be necessary to motivate the plants for making serious effort.
   Preliminary solution is with existing means to intensify testing of coal and perform mixing with extra handling.
   Final solution is to install coal blending stores at all the plants. Such blending stores should be designed as simple plants, suited for Indian conditions.

3. Analyse causes for false air in kiln gas handling system by testing O_2-content at the gasses through the system and calculate the amount of gas volume to be compared with fan capacities. Orsat tests can be used for O_2-determinations, but easier and more reliable measurements could be obtained using portable O_2-meters.
   All excessive leaks should then be sealed.

4. O_2-meters at kiln inlet and after prehaeter should be installed and maintained. Sampling at kiln inlet could be facilitated by using sampling systems with water spray.

5. Kiln feed homogenity should be investigated by frequent analyses. By using three components in raw mill feed should be aimed at a constant LSF, adjusted to cope with the ash absorbtion and at a constant silica-ratio on a level as high as permitted with the raw materials available.

6. Investigation of coal mill operation aiming at optimum drying and minimum amount of primary air. Hot air to the mill should be supplied with high temperature, preferably by using hot air from the cooler.

VI IMPLEMENTATION

The suggestions made deal with simple but basic problems.

Most of the proposals can be implemented by the technical personnel at the individual plants, provided that sufficient motivation exists.

For the suggestions requiring more elaborate investigations, NCB has the means and the capability to assist the plants.

It can be assumed that other plants have problems similar to those here identified, and it is within the capability of the NCB experts to analyse the constrains in other plants and suggest remedial measures.

VII CONCLUSION

The objective of the mission is to strengthen the capability of NCB in productivity enhancement through improving kiln utilization.

It is of course not possible to measure or even evaluate to which extend NCB has derived benefits from the mission.

The target group has been the rather few NCB experts being competent and knowledgeable. It is more doubtfull whether lectures and discussions have had any longlasting influence on the capability of other members of the NCB staff.

The NCB organization has a number of young qualified and interested engineers. Their experience within the cement industry is naturally limited and they would benefit from on-the-job training as volonteers over a lengthly period in well operated cement plants preferably in contries without language barriers.

NCB is running a large number of very usefull training courses for personnel of all levels from the industry.

Within the kiln section it seems that kiln operators generally are well qualified for their job. The need for further training is specially pronounced on the level of technical management, a very demanding task for NCB with their present resources.

LIST OF ANNEXES

Annex 1

Mission support

In addition to the assistance from the project management and the NCB personnel in Ballabgarh and Hydrabad valuable contributions to the mission had been given from the experts participating in the plant visits :

Dr. S.N. Yadav
Mr. A.K. Dambla
Mr. A. Pahuja
Mr. P.S. Sasturkar
Mr. C.D. Elkunchwar
Mr. V.K. Arora

Annex 2

VISIT TO UDAIPUR CEMENT

20-22 OCTOBER 1986

During the visit, kiln operation was discussed in detail with the interested and competent plant staff, giving all requested informations about the operation. This report is based on these informations:

GENERAL:

The plant operates two kilns, 3.75 x 54 m and 3.75 x 58 m with 4-stage preheaters and grate-coolers 814 and 750 x 950, commissioned in 1969 and 1980 respectively. The design capacity for both kilns was 600 t/24 h, but with later modifications, the capacity increased to 700 t/24 h and 800 t/24 h respectively giving normal load of the kiln tube. The higher capacity of kiln 2 is due to bigger preheater and cooler.

An ambitious programme for expansion of the plant has been initiated including calciners with external hot air duct for both kilns, preblending plant for limestone, roller-mill for raw-grinding, X-ray analyzer and later on a new control room. For kiln 2 the calciner is to be commissioned this month with expected capacity of 1200 t/24 h, at a later stage, increased further to

1600 t/24 h with new bigger cyclones. For kiln 1, hot air duct and calciner is erected to be commissioned next year, aiming at 1000 t/24 h. With the assumed purpose of increased capacity, the inlet opening in all cyclones has been increased in height. I was done four years ago in kiln 1 and prepared in kiln 2. In kiln 1, it has caused some instability in operation, but then the output has not been increased yet. The arguments behind increased inlet openings are not clear; normally you would expect dimensions of risers to be the limiting factor in preheaters.

The plant has at present some problems and restraints in the kiln performance which it would be advisable to study further and try to reduce, as the problems otherwise will tend to aggravate, when the expansion programme is preceeding. These problems are discussed in the following with the reservations caused by the short stay at the plant.

KILN UTILIZATION

At present the kilns are producing 650 and 750 t/24 h, but considerably higher output has been obtained in previous periods. The constraints are in the conditions imposed on the kiln with kiln feed and coal. Preheaters, ID fans and coolers have capacity for higher production.

In the last two years the clinker production for kiln 1 has been 156,000 and 151,000 t and for kiln 2 212,000 and 198,000 t.

The run-factor has for both kilns in these two years been between 66 and 71%. These low figures may to some extend be caused by external factors, but the main reason is a large number of stops for repairs. A detailed study of the causes for kiln stops and corresponding strengthening of preventing maintenance would be required to bring the run-factor to a normal level of 80-85%.

The present output for the two kilns, about 360,000 t per year falls thus about 80,000 t short of the expected output with optimal operation and 80% run-factor.

KILN FEED

The raw materials are a low titration limestone with high content of free quartz and magnesia. On average is added about 2% China clay and 2% iron ore. The kiln feed is analyzed weekly and an example shows S.M.=1.9, A.M.=1.3, LSF=1.19 and 1.9% MgO. The raw mix appears very hard to burn and that is the main reason for the low output. It is, at the plant, believed that the quartz in the limestone is causing the burnability problem. The quartz content was increased considerably when mechanised quarrying was introduced a few years ago. It is of cource correct that coarse silica particles, plus 0.2 mm, have great influence on burnability. The raw meal is ground to 18% residue on 170 mesh and 2% residue on 72 mesh. Finer grinding, specially lower residue on 72 mesh will improve burnability and clinker quality, but the practical possibilities are limited and hardly sufficient to solve the problem.

Much more important is the high LSF. The high ash content in coal means that about 9% ash is absorbed in clinker, resulting in a decrease in LSF of 0.31. A typical clinker analysis, made daily, showed S.M.=2.4, A.M.=1.4, LSF = 0.96, free CaO=3.6 and 2.8% MgO. Considering that the ash is not absorbed homogeniously in the clinker, it will hardly be possible to obtain an LSF more than about 0.85 without excessive free CaO in the clinker. With the low S.M. and high MgO and a reasonable LSF an easy burning raw mix would be expected, when the raw meal fineness is adjusted to 1.5% residue on 72 mesh. The LSF should be adjusted to give 1-2% free CaO at normal burning. It would be expected that cement quality will not suffer from such adjustments, but it is of course unavoidable that the high ash absorption results in low strength level.

The analysis quoted does not correspond well. Samples are presently being tested by NCB to compare results.

The kiln feed shows considerable variations. The pre-blending plant, of course, will reduce the variations. Presently mill control is performed by keeping China clay constant and vary the addition of iron ore. Less variations in composition would be expected with constant addition of iron ore.

Raw meal blending is performed in two 1800 t batch blending silos. By dividing the mill-product to both silos could be obtained that each silo respresents more mill hours and thus help to reduce the variations in feed. Also some improvement could be obtained by using continuous sampling instead of spot samples for the mill control.

Kiln feeders are constant head feeders and give considerable variations in the amount. This is seen in variation in the exit temperature after preheaters. It might be possible to install solid flow meters after the feed screws and use them for automatic control of the feed screws.

COAL

The coal is presently of very poor quality with 36% ash on average and variation between 32% and 40%. The calorific value is 3600 Kcal/kg (gross). Both kiln burning and cement quality suffers seriously from such variations specially considering the very marginal average.

The stock of raw coal normally exceeds one months consumption, and a simple coal blending plant could be arranged at low cost.

The coal is ground correctly to 17-18% plus 170 mesh. The amount of primary air is not known, but visually the flame in both kilns appears correct.

KILN OPERATION

The operation is not hampered by any problem in preheaters or kilns like coatings or rings. With normal burnability the kilns offer the possibility for a very steady operation.

The heat consumption is stated to be 940-950 Kcal/kg (gross) on yearly basis. The high figure, probably, is due to the many kiln stops.

The most important problem noticed in kiln operation is that combustion control is missing completely. None of the O_2-meters are working. Orsat samplings during the visit showed for the two kilns:

Kiln inlet: 4 and 5% O_2, top cyclones: 8 and 6.4% O_2, after ID fan: 9 and 7% O_2.

The high excess air in the kiln will lower the flame temperature and make the charge appear more difficult to burn. With the high excess air, CO peaks and ESP trippings are minimized. With the O_2-meters working it should be possible, however, to maintain about 2% O_2 in kiln inlet by adjustments of coal feed and draught.

The Orsat analysis also indicate very important leakages in preheaters, mainly in kiln seal but apparently also at other places. A thorough investigation of the problem is called for.

The temperature profile of the preheaters may not be representative at the present low output. An evaluation of the preheaters needs instrument readings at full output and normal excess air, and might then disclose the affect of the enlarged inlet opening to the cyclones.

There is a marked difference between the two kilns. In kiln 2, the lining life is about 3 months only compared to 8 - 9 months in kiln 1.

Also the clinker in kiln 2 contains much more dust than in kiln 1, although the visibility still is good. Kiln 2 has less coating and more free CaO. It is probably all results of a lower flame temperature in kiln 2. It could be due to consistently higher excess air in kiln 2. Another possibility is lower combustion air temperature either caused by false air in kiln hood or less efficient cooler performance.

The coolers are manually controlled. Automatic control of kiln hood pressure to reduce false air in the seal being in poor condition, would be valuable. Improvement of cooler efficiency could probably be obtained by working with thicker clinker bed and proper air distribution in the different compartments. It would, however, require a detailed study of the cooler performance.

The ESP have poor efficiency, to some extent due to false air in the system, but with the low output you would expect a low gas flow so that the condition of the precipitators must be quite poor.

The power consumption for the kilns including kiln, fans and coolers is very high, 31 Kwh/t. The ID fan alone absorbs 14.5 Kwh/t, a high figure in view of the modest underpressure. Electrical losses due to reduced fan speed may be responsible.

SUMMARY:

Summarizing the above comments, following suggestions can be made:

1. Reduce LSF to improve burnability and increase output.
2. Finer grinding of raw meal.
3. Reduce variations in kiln feed composition with constant addition of iron ore.
4. Improve raw meal blending.
5. Improve kiln feeders with solid flow meters.
6. Install preblending of coal.
7. Analyse causes for kiln stops and strengthen preventive maintenance.
8. O_2-meters in correct and continuous operation.
9. Investigate and optimize heat recuperation from coolers.
10. Investigate false air, and close leakages.
11. Introduce automatic control of kiln hood pressure.
12. Compare analyses of feed and clinker with NCB results.

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Annex 3

VISIT TO CCI - NAYAGAON

22-25 OCTOBER 1986

Discussions with plant personnel during the visit were very limited, and this report is partly based on second-hand informations.

GENERAL:

The general impression of the plant is poor maintenance and lack of general house keeping. The plant seems to have few process problems, the problems noticed could all be solved by strengthening the plant organisation. The plant operates one kiln 4.35 x 64 m with 4-stage preheater with rated capacity of 1200 t/24 h commissioned in 1979. A new 3000 tpd kiln line is under construction.

KILN UTILIZATION

The clinker production in the last three years has been 264,000 t, 271,000 t and 228,000 t, to be compared with a reasonable target of 350,00 - 370,000 t. The main reason for the low output is the run-factor, but also kiln production below capacity. Looking through the stop-list, it appear that operational problems do not cause down-time, lining repair is also of minor influence while mechanical breakdown and repairs account for a major part of the down-time, specially cooler and drag-chain repairs.

RAW MIX:

The raw materials are a limestone with average titration 80%, laterite and sweetener, 94% titration. Laterite is used in a constant addition, 3%, and acceptable homogenity of the raw mix seems to be obtained although the blending suffers by mechanical problems.

A typical kiln feed shows LSF=1.03, S.M.=1,9 - 2,0, A.M.=1,1 - 1,2 and a fineness of 17% plus 170. The kiln feeder is working with good accuracy.

COAL:

The coal has a constant ash content, 28-30% and gross heat value, 4400 - 4500 Kcal/kg. The feeder for coal meal gives a constant feed rate.

The conditions imposed from outside on the kilns is thus quite good with all possibilities for a steady and efficient kiln operation.

KILN PERFORMANCE:

The kiln operates, at present, below capacity; figures of 1000 tpd to 1150 tpd were given. The heat consumption, 900 - 950 Kcal/kg, is presumably on a yearly basis, including losses caused by the kiln stops, but even then a high figure. The heat consumption in continuous and correct operation should not exceed 800 Kcal/kg (net).

The kiln operation seems to be very easy, no coating or ring problems and a lining life of 4-6 months due to good coating.

The instrumentation seems to need calibration, and present readings at low output does not allow an evaluation of the kiln and preheater efficiency. The O_2-meter was not working and may never have been put in operation.

The control panel is equipped with an adequate amount of automatic control loops for cooler control and draught control but none of these loops were in operation.

The actual limitation for the kiln output is the ESP fan, due to large amounts of false air, although no Orsat test was made to evaluate the amount.

The kiln inlet seal was completely missing, a new pneumatic seal is at hand but not installed. Also air from raw mill carries heavy load on the ESP fan. When the mill is stopped, the kiln output can be increased by about 100 t. The amount of gas through the mill should be minimized, leaks sealed and pressures adjusted to be close to zero at mill inlet.

The raw mill is equipped with an emergency chimney, apparently used frequently, a procedure not to be recommended.

The amount of the false air which has to be handled by specially the ESP fan becomes evident, when fan capacity is compared with calculated gas volume under normal operation conditions.

With 1200 t production, 800 Kcal/kg heat consumption and 30% excess air, measured at fan inlet (3.3% O_2) the gas volumes would be 1210 Nm^3/min. The ID fan has a capacity of 1992 Nm^3/min (at 600 rpm, 350°C, 640 mm WG) and ESP fan has a capacity of 2500 Nm^3/min (at 500 rpm, 150°C, 125 mm WG) to allow for mill air. If the fans are working with correct speed they will thus both have capacity for very large deviations from the conditions mentioned.

The cooling tower is not working properly due to troubles with water pump and apparently also the control equipment. A thermocouple could be installed in the dust outlet in the bottom to give alarm when nozzle or water pressure fails.

The ESP is working only 22 hours out of 24 hours kiln operation, and while it works, it does with low efficiency; the problem is partly due to the high gas volume and partly low voltage, but the ESP needs a detailed investigation.

Filter trips frequently because of CO due to the kiln draught limitation. With the constant coal quality and accurate coal feed, a proper combustion control by means of O_2-meter should eliminate such tripping in normal operation.

The cooler is operated very far from optimal conditions. The clinker bed is very thin, only 120-150 mm WG under-grate pressure, where 350 mm WG would be expected. The exhaust air temperature is very high, 350°C.

The kiln hood pressure varies between -1 and -5 mm WG. This should be constant, regulated by the existing control loop. The seal at kiln outlet is also in poor condition.

With all the loops in operation an important improvement of heat recuperation could be obtained.

The clinker has a LSF of 0.82% to 0.86% only with about 1% free CaO. In view of the constant coal and feed it should be possible to maintain a higher level of LSF without excessive free CaO.

The power consumption of the whole plant is very high, 165 kWh/t, upto clinker 121 kWh/t; the power consumption for the kiln system was not available.

SUMMARY:

Summarizing the above comments, following suggestions are made:

1. Install kiln inlet seal

2. Minimize raw mill air and leakages

3. Investigate other leakages in the system

4. Install and operate O_2-meters to control combustion and avoid CO-peaks

5. Check and calibrate all instruments

6. Put in operation all control loops

7. Optimize cooler operation, using control loops

8. Investigate ESP performance and cooling tower problem

9. Use auxiliary chimney only in real emergency

10. Increase LSF to improve quality

11. Strengthen preventive maintenance

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Annex 4

VISIT TO LAKSHMI CEMENT

31 OCTOBER 1986

During the visit mainly present operational problems were discussed and also to some extend kiln productivity. The interested and competent plant staff supplied detailed and well prepared information on the operation.

GENERAL:

The plant operates one kiln 4.6 x 68 m with 4-stage preheater and rated capacity of 1500 t/24 h, commissioned in 1982. The cooler is very large, foreseen for installation of an additional preheater string, but reduced by covering cooler plates at the sides. In view of the very easy burning raw mix a high specific kiln load might be obtained and an output of 1900 t/24 h would be a reasonable expectation with a new kiln-string. A higher kiln speed and possibly bigger kiln motor might be required as the kiln motor now trips frequently. If conditions permit, a precalciner can allow even higher output.

KILN UTILIZATION

The normal output is now 1500 t/24 h, but in a long period in 1985 was 1600 t/24 h obtained. The production in 1985 was 428,000 t and lower in previous years to be compared with a target of 500,000 t. The main reason for the low output in the run-factor, in 1983: 61%, in 1984: 78% and in 1985: 76.5%. With a lining life of 5-6 months the main reason for kiln stops is electrical and mechanical repairs, to large extent repair of cooler plates. Only improved preventive maintenance could improve the run-factor to acceptable level.

KILN FEED

There is only one component in the raw mix and a preblending store is installed but not used at present. The plant manage to keep the kiln feed composition fairly regular but too big variations occur, and it seems essential to operate the preblending store. The feed composition on an average shows LSF=1.15, silica modulus:1.9, alumina-iron ratio 2.0, ground normally to 16-17% residue on 170 mesh.

A weigh feeder was installed about a year ago and seems to give a steady feed when operated. Quite frequently is changed, however, to by-pass feeding system, due to calibrations and repairs. This will lead to irregular feed and may, as discussed later, contribute to the jamming problem. Normally you would expect a weigh feeder to operate continuously.

COAL:

The ash content is normally 26-28%, occasionally up to 35%. The coal has a gross heat value of 4600-5000 Kcal/kg and 0.45% sulphur and is ground to 16% residue. With improved blending of coal the stability in firing would be improved but the coal feeder seem to represent a much bigger problem. A weigh feeder for coal was originally installed but never used and feed is now only controlled with screws hardly designed for this. It would seem essential to have the weigh feeder working.

KILN OPERATION:

The kiln instrumentation including CO and O_2-meters is very well maintained and offers good possibility for stable operation. The ID fan is continuously run at maximum capacity; the control of burning zone condition is performed by changing kiln speed. This way of operation is normally not recommended. It requires constant combustion conditions, specially constant heat input, which is not achieved as mentioned.

The limitation in the kiln is hte ID fan capacity, limited by a large amount of false air drawn by the fan where the gas contains about 60% excess air. The O_2-meter after the preheater shows rather constant 6.5% O_2, whereas the CO-meter in kiln inlet nearly all the time shows CO, with large variation. O_2-meter is planned also for the kiln inlet, but it can be assumed that the O_2 content on average is below 1%. With better sealing it would be possible to increase gas flow through kiln and prehaater with at least 10-20%.

Conditions were apparently better in the period when higher output was obtained. The consequences of the insufficient draught through the kiln are very frequent trippings of the ESP and unstable combustion conditions.

An installation for secondary firing has been made and tested but not used due to refractory failure in the duct. This could of course increase the excess air in the kiln but not increase the output as gas volume through prehaeter remains the same. Successful use of secondary firing would also require constant coal feed.

Cleaning the riser is never performed indicating that circulation of volqtile components is very low as also to be expected from the low burning temperature, e.g. low evaporation. The flame seems to need some adjustment to get a proper shape. The amount of primary air and tip velocity should be measured and adjusted. Also the position of the burner pipe should be adjusted. These measures could lead to reduced tendency to ring formation in kiln outlet, now being a problem.

The clinker shows LSF in the range 0.88 to 0.93, often over 0.92, a fairly high level considering the high ash absorption and resulting in free CaO 1.8% and reflecting kiln feed variation.

JAMMING IN CYCLONE 3:

Lately the kiln has suffered seriously from jamming in the 3rd stage cyclone. In previous years such jammings have occured lesser number of times only, but during the last month it was very frequent, causing many and long kiln stops. A very comprehensive study has been made at the plant comparing present conditions with conditions in periods without troubles. The study was discussed in detail, but did not disclose any change of operational parameters. Tests with reduced content of fines in the feed by discarding ESP dust did not eliminate jammings. Investigation of content of volatile matter in cyclone material shows low concentrations only which could not explain the problem.

The very careful investigation thus has not given any explanation nor a solution to the problem. It is in accordance with general experience that this type of problems are not caused by circulation of volatiles, but caused by operating conditions in the preheater. The temperature profiles in the preheater are normal. The jamming starts with build up of loose material in the cone in the cyclones, the material here always having low flowability.

The cause, known from other kilns is normally that material from 1st stage is falling through to 3rd stage instead of being lifted to 2nd stage. This can happen if the velocity during start-up is too low in the riser after the cyclones or if the feed is surging; even a short period with heavy overload can cause through-fall. The gas velocity in the immersion tube, cyclone 3 is high, about 17 m/sec, but the length of the cylindrical riser is small.

Purges in the feed rate can be caused by defects in the feeding system or moist or agglomerated feed.

The only clue established so far is that in 5 out of 8 cases of jamming has the jamming taken place within half an hour after the feed has been changed from weigh feeder to the by-pass feeding which, of course, easily can give a short overload of material. The feed hopper for the by-pass feeder may also contain moist or agglomerated material. There is no explanation why the jamming problem has increased to present extent lately.

My recommendations to the problem are:

1. Keep weigh feeder working all times and avoid by-pass feeder and hopper for this feeder.

2. Install shock-blasters on the cyclone as already prepared by the plant.

3. Check leaks and deflector plates.

4. Lengthen vortex finder in 3rd stage from present 210 mm below lining to a normal of 2000 mm, aiming at in the long run reduce the risk of throughfall and improve swirl in the cyclone.

5. Pressure gauges to quick detection of jamming or install γ-ray detectors.

SUMMARY:

Apart from the cyclone problem following steps, referring to the above are suggested:

1. Preblending of limestone
2. Investigate false air and close leaks
3. Reinstall coal weigh-feeder
4. Install o_2-analyzer in kiln inlet and maintain complete combustion
5. Measure primary air and adjust conditions
6. Analyse kiln stops and strengthen preventive maintenance

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Annex 5

VISIT TO MADRAS CEMENT-TULUKAPATTI

6 - 7 NOVEMBER 1986

The plant is tidy and clean and is operating efficiently, comparable to most modern plants in the world. An efficient preventive maintenance programme results in very good run-factor for the kiln. Detailed discussions on all kiln subjects took place with an interested and experienced technical staff. The visit was well prepared in a paper, giving information on the plant and questions to be discussed during the visit.

GENERAL:

The plant is equipped with modern facilities and instrumentation, like X-ray analyzer, to facilitate operation, all being well maintained. The plant operates one Dry Process kiln replacing wet kilns, now not being used. The kiln, 4.35 x 64 m with 4-stage preheater and planetary cooler, with a rated capacity of 1200 tpd - the first of its kind in India - was commissioned in 1977.

KILN UTILIZATION

In the last three years, 1984, 1985 and 1986 up to date has a clinker production of 370,000 t/year been obtained, corresponding to expectations. The output per 24 hours operation is slightly below target, 1170 t/24 h, for reasons discussed later, but compensated for by a high run-factor. In each of the three years the run-factor has exceeded 86%. The down-time is mainly due to normal brick-lining repairs; mechanical, electrical and process problems have only contributed little to the down-time. In addition to these there have, however, been long stops for welding of cracks in kiln shell and for one electrical accident. Without such extraordinary stops the run-factor would indeed have been extremely good.

KILN FEED

The limestone is of marginal quality even after rejecting unwanted material and makes the mill feed control very complicated. The raw materials are limestone form 4 quarries, sometimes from various suppliers, a clay/kunkur mixture and bauxite, added in constant amount.

There is no preblending store, but a 40,000 t store with 14 extraction points with vibrators in the bottom.

The possibility of using this store for primitive preblending was discussed, building walls along the store, so that a large stock could be maintained and dividing the store with a wall into a high-grade and low-grade store. But naturally a real prebelnding store would be much better solution with such marginal stone.

The raw mill is equipped with 5 feeders, 2 weigh feeders and 3 chain feeders. Only three are being used, two for high and low stone including sweetener and kukur and one for bauxite. It might facilitate the mill control if the sweetener, a small amount only, was fed separately. A suitable raw mix could be composed in different ways, and it was discussed to make a cost analysis of the various possibilities.

The mill feed is adjusted according to hourly X-ray analysis. The mill product is presently high in LSF for several hours and then low for several hours. Improved kiln feed homogenity could be obtained if the control is operated so that LSF in mill product passes the target frequently.

The kiln feed shows variation in $CaCO_3$ content up to +/- 1.0 and an improvement in homogenity would be beneficial both for kiln operation and cement quality. The kiln feed has a fineness of 16% plus 170 mesh and 2% on 72 mesh, quite acceptable. The chemical composition shows LSF between 1.15 and 1.20, silica modulus

2.18 to 2.5 and alumina modulus 1.2 - 1.3. The level of LSF appears as discussed later to be excessively high, and the variations in silica modulus are large, the raw material available, however, hardly permit control of the silica modulus.

COAL:

Coal are received from 4 fields with large variations in ash content, also within same delivery, from 25 to 45%. About 10-20% imported coal with 16% ash is used. By mixing the coal is achived that the ash content in kiln coal is between 27 and 31%. A coal blending store would facilitate the mixing and possibility of installing a fairly simple store was discussed.

Lignite with 7% ash and 40% moisture is easily obtained. It has been tried to use small amounts, sundried to 14% moisture, but is was experienced to give problems in kiln operation. Lignite after drying has a net calorific value of 4500 Kcal/kg and it would seem possible to use fairly large amount, even considering that the sulphur content is a little higher, about 3%, than the normal coal with 0.8 - 1%. The limitation would be the drying capacity of the coal mill, foreseen for 8% moisture, which is the normal level for the raw coal at present. Use of large amounts of lignite would require a special drier.

The coal is dried in a two compartment mill with drying chamber and one fan only. Even with large amount of air through the mill, corresponding to about 30% primary air, it is not possible to dry the coal sufficiently, only to about 4% moisture, giving problems in feeders.

Heat to coal mill is supplied by a coal fired furnace, giving too low inlet temperature. A heat balance for the coal mill might show means for improving the drying capacity. Also the fineness of ground coal needs further investigation. The residue on 170 mesh, about 16%, is good, but the residue on 72 mesh is very high, up to 3-4% while it never should exceed 2%. The cause is probably changes made in the separator.

The possibility of changing the mill to a two fan system with separate dedusting and changing the mill to one compartment was discussed. There would be evident advantage in the lower primary air and possibility of using a Swirlax-burner. But the need of dedusting requires the use of either bag filter or ESP and both involves an important element of risk.

It will appear that planning of future modifications will require a comprehensive study of mill and furnace.

Coal feed to the kiln shows sonsiderable variations. Even with high excess air peaks of CO occur often, causing tripping of ESP, often 4 to 5 times per day, which should be avoided. One reason could be the high moisture on coal meal.

The weigh feeder for coal to the kiln is not being used because fires in the hopper under the feeder has occured twice. Such fires are usually caused by condensations and should be avoided with better drying, insulation of the hopper and other safety precautions. It seems important to use the weigh feeder. Coal to secondary firing is fed by separate screw-feeder, and it is not known whether this is giving variation. The O_2-meter in kiln inlet would clear up this problem.

KILN OPERATION:

The kiln suffers from a serious defect as the kiln on two supports was cranked during a power cut with heavy rain. Now the kiln is covered to prevent future mishaps and a new kiln section is at site for replacement. But the shell has many cracks and the inlet seal is out of alignment, giving large amounts of false air.

The kiln has an enlarged riser duct with secondary firing, about 20%, which makes it possible to use the false air for combustion, but not without negative effect on exit gas temperature and heat consumption.

The most important observations in the kiln operation is the very hard burning. The burning zone is then close to the outlet and minor variations in the operation can course plugging of the cooler inlets with sticky material. The hard burning also increases formation of coating in the riser.

These two factors actually give a limitation to the output. With a normal burning raw mix it would be expected that an output about 1300 t/24 h could be obtained when also the problem with the seal is solved.

The reason for the hard burning is the high LSF which needs hard burning in order to get the free CaO down; it is varying between 1.5 - 3.0%. The LSF should be adjusted so that 1-2% free CaO is obtained with normal burning. At present is the LSF in clinker 0.92 - 0.94 which would be good with oil firing, but high ash coal with high ash absorbtion will always lead to low LSF, the difference in LSF between feed and clinker being as high as 0.23. Under the given conditions would a LSF of 0.88 be normal, at other plants giving good cement quality.

With a silica modulus 2.3 - 2.4, alumina modulus 1.5 - 1.8 and 2% MgO you would in fact expect an easy burning clinker, as also indicated by the high amount of liquid phase.

In the kiln is often found a ring close to outlet, a result of high liquid and hard burning.

Rings in the middle of the kiln disappeared when secondary firing was introduced.

Coatings in the riser aggraveted by CO require regular cleaning and then it does not cause kiln disturbances. To facilitate the cleaning, now with air lances, could be used high pressure water-jet or shock blasters could be installed in critical areas.

Cyclone 4 has been jammed 16 times this year, always due to coating or bricks fallen down shortly after stops. Jamming is detected quickly both with X-rays and pressure gauge, so that kiln stops are limited to about 1 hour. Feed pipe jamming in C4 is eliminated by cleaning.

The clinker temperature after cooler is high, about 250°C. With normal burning it is expected that the burning zone will move away from the outlet and lower the clinker temperature. The high amount of primary air of course contributes to the high clinker temperature. It is advisable to install water injection in the cooler tubes, the system well known at the plant.

The amount of primary air is as mentioned high, 30% and the velocity in the nozzle about 62 m/sec. Possible change off the size of nozzle should wait until the effect of lowering the burning temperature is seen and the coal mill investigated to see if the amount or air can be reduced.

The granularity of clinker is changing often with big amount of dust, ranging form 17 to 65% minus 3 mm. This is also a result of the high LSF as over-burning can result in dusty clinker.

The temperature profile of the preheater is quite normal indicating good efficiency, but the exit gas temperature is high, 370 - 390°C due to false air in the seal. When secondary firing was introduced a marked improvement in kiln operation and output was obtained but also increase in O_2-content after the preheater. Normally is with secondary firing experienced about 0.2% CO, which cannot be reduced with more excess air.

The O_2-meter at the ID fan normally indicates 5% O_2, and when going down to 3% then CO starts to appear. This might indicate false air in the gas sampling ducts, and this should be investigated.

The O_2-meter in kiln inlet is not in operation due to plugging in the probe. It is suggested to use a sampling system with water spray. The kiln instrumentation is otherwise working well. Two additions were suggested to give the burner additional information in burning zone condition, it is a recorder for kiln torque and a thermocouple on the tip of the burner pipe.

The ESP is working with good efficiency. The lining life over a length of 11 m in the burning zone is 4-6 months and more in other parts of the kiln and in cooler, which appears quite acceptable. The specific brick consumption is as low as 1.45 kg/t clinker. The kiln has this year had an uninterrupted run of 14 days.

The heat consumption of the kiln is not very well known. Figures of 950-1000 Kcal/kg were given, but that is overall figures including coal mill and based on gross calorific value. Based on net calorific value is the actual heat consumption of the kiln in continuous operation below 850 Kcal/kg net.

POWER CONSUMPTION:

For the whole plant is the power consumption over the years 108 kwh/t cement, a very low figure. For the kiln with cooler including ID fan, feed system and ESP the consumption is 28 kwh/t clinker; the ID fan alone consumes 12.8 kwh/t.

SUMMARY:

Summarizing the above comments following suggestions are made:

1. Investigate possibilities for abtaining some blending of limestone in existing store.

2. Improve raw mill control by feeding sweetener separately and aim at short intervals between high and low lime in mill product.

3. Investigate possibilities for installation of simple coal blending store.

4. Investigate coal milling, aiming at improved drying capacity, reduced content of coarse coal particles and reduced amount of primary air.

5. Reintroduce weigh feeder for kiln coal.

6. Reduce LSF in clinker to achive normal burnability.

7. Facilitate cleaning in riser duct by high pressure water jet or shock blasters.

8. Investigate leakage in sampling pipe for O_2-meter.

9. Introduce water spray sampling system for O_2-meter at kiln inlet.

10. Improve evaluation of burning zone conditions with recorder for kiln torque and pyrometer on burner pipe.

11. Reduce clinker temperature with water in cooler.

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Annex 6

VISIT TO CCI, YERRAGUNTLA

12 - 14 NOVEMBER 1986

A paper with description of the plant had been prepared for the visit and detailed discussions of the problems encountered in the kiln section were held with the technical staff and kiln operators. The plant shows rather good general housekeeping, but suffers from excessive dust emission at various points, as coal mill and the ESP often not working at all.

GENERAL:

The plant was commissioned in 1982 and operates one kiln 4.35 x 64 m with 4-stage preheater and rated capacity 1200 t/24 h. A new production line with 3000 t/24 h kiln capacity is under construction to be commissioned in about 2 years.

KILN UTILIZATION:

The kiln output is only about 1000 t/24 h but the rated output has previously been obtained in periods (April

1984 and before). Forthe last three years the clinker production has been 1983/84: 248,000 t, 1984/85: 224,000 t and 1985/86: 220,000 t to be compared with a reasonable target of 350,000 t/year or more. This result is partly caused by low kiln output, in 83/84:1053 t/24 h operation, in 84/85: 996 t/24 h, and 85/86:1053 t/24 h. The poor result is also caused by a low and decreasing run factor, in the three years 65.6%, 61.4% and 57% respectively. When excluding stops caused by want of coal, power and labour the run factor would have been: 69%, 66% and 65%, still unsatisfactory results. Going through the stop list it appears that the down-time mainly is caused by mechanical repairs, the kiln being stopped regularly for general repairs. Single items giving many stops hours is cooler and clinker transport, while stops for lining and operational problems seem to be quite acceptable. The low run factor thus is mainly due to ineffective preventive maintenance.

KILN FEED:

The main component in the raw mix is limestone from circular preblending stone with titration 81-83. Correction is made with a mixture of iron ore and bauxite, mixed in one hopper, the amount of additives varying from 1 to 3%. There are three hoppers before the mill, two with weigh feeders and one, not used now, with table feeder, but foreseen to have weigh feeder. With two components only the result is excessive variations in silica modulus. Daily composite samples of kiln shows S.M.: 1.7 to 2.3 and up to 2.5, A.M.: 1.4 - 1.5 and LSF: 1.05 to 1.10.

Originally was foreseen a three component raw mix, the third being low grade limestone and it would then be possible to keep addition of iron and alumina at constant rate and obtain a constant S.M. of 2.1 to 2.2.

The variations in filn feed titration is somewhat bigger than you would expect with the existing facilities for raw mill control and blending and there are possibilities for improvements.

Average clinker samples show S.M.: 1.8 - 2.3 and LSF: 0.80 to 0.92. Free lime is determined only once a day on a composite sample, showing 0.6 to 1.0%. The average LSF might be kept on the low side in order to cope with coal ash variations. When the burner says that the clinker are hard to burn the titration is lowered, but then of course too late. Intensified laboratory control, preferably by using X-ray analyzer and frequent free lime determinations would be useful for optimizing process and quality.

COAL:

The coal is received from five different collieries and 35 samples taken from the waggons during the last year show ash content from 22% to 35%, average 30%. Blending of the coal is apparently not attempted. Kiln coal is analysed daily on composite samples, but that does not show the variations. There are large variations in LSF in clinker, indicating ash variations. Frequent testing of coal as received and fine coal would give better information on ash variations and would allow a reasonable good coal blending with the crane in the gantry, untill a coal blending store is installed in connection with the extension.

The coal mill appears not to be operated as intended with the design and mill air is continuously leaked to atmosphere, not only a pollution problem but also a loss of coal, estimated to 2%. Heat to the mill is delivered from a coal fired furnace with a temperature about 300o^{C}. A better heat supply with higher temperature might be obtained by using hot air from the first part of the cooler. Air instead of combustion gasses in the primary air mill also improve combustion in the kiln.

Other plants visited have similar problems with coal mills and a few simple calculations might help to explain the problem. The air swept mill require a certain airflow minimum 1.2 kg air/kg coal, in practice may be 1.5 kg. If such amount is taken in as fresh air to the system, it would mean 27% primary air, assuming coal with 4000 Kcal/kg net heat values, unless of course that air is leaking to atmosphere. With high temperature of the fresh air taken into the system, 450°C, the mill inlet temperature should be adjusted with circulating air to cover just the need for drying. With the present high moisture in raw coal, 8%, and 1.5 kg/kg air thorough the mill an inlet temperature of 230°C would be sufficient for drying. That could be obtained with only about 0.7 kg/kg fresh air at 450%.

Such rough calculation shows that leakage to atmosphere not in necessary and that the amount of primary air can be minimized by correct coal mill operation. It is evident of course that large amounts of cold false air to the mill are detrimental to the operation.

A thorough investigation of the coal mill operation, primary air and leakages are required for correct adjustment of the mill operation.

The weigh feeder for fine coal is giving a steady feed rate, which can be seen by the rare peaks of CO in kiln gasses and fan ESP trippings.

KILN DRAUGHT:

The constraint for the kiln output is the draught through the kiln. Both preheater fan and ESP fan are running at maximum capacity and even then there is only draught enough for burning 1000 t clinker. As mentioned has the problem prevailed in 2 1/2 years, previously could output exceeding 1200 t be obtained.

The capacity of the preheater fan has been increased with bigger fan blades and the ESP with bigger motor and higher speed, but that has not led to any improvement apparently only increased the amount of false air. At present with 1000 t production is the under-pressure in 1st-stage cyclone 420 mm WG and after the preheater 580 mm WG, same figures as found previously at 1200 t. This indicates either unchanged amount of kiln gas plus false air through the preheater or some unknown restriction.

The O_2-meter placed after the damper in the downcomer show rather constant 10% O_2 and CO appears when the reading goes down to 9%, indication low O_2 in kiln inlet.

One source for false air in the kiln seal, the springs have lost their tension and big opening i noticable. Considering the low under-pressure at the seal this might not be the only problem and other possibilities should also be investigated. There were found apparent leakage in the duct in top of the preheater.

The under-pressure before the preheater fan was measured to 670-700 mm WG. The pressure drop over the damper is thus as high as 100-130 mm WG. It was found that one of the 5 blades in the damper was closed and further inspection is needed.

When the mill is running +20 mm WG is maintained after preheater fan in order to help the ESP fan. That means that the fan is yielding 720 mm WG pressure and consequently reduced volume. But even then the fan capacity is much bigger than the calculated amount of gas at 1200 t and normal excess air plus false air and air from air lift.

The ESP fan is also a constraint in the gas flow. The capacity of this fan in Nm^3 is 40-50% bigger than the preheater fan, allowing for mill air. The mill is not using hot gasses and the ventilation through the mill should be kept at the very minimum. An important leakage in the cooling tower also gives load on the fan. To solve the problem repaeted and accurate Orsat analysis through the whole system should be made to locate leaks and also calibrate O_2-meters. The gas volumes could then be calculated and compared with fan capacity. Evident leaks of kiln seal, cooling tower and what the investigation might disclose should of course be stopped and mill air minimized.

Under-pressure in the whole system should also be measured and unexpected pressure losses as the damper investigated.

COOLER:

The cooler is operated with a thin clinker bed, 150 mm WG undergrate pressure only, and the same pressure in all compartments, showing unfavourable air distribution. To optimize cooler operation and heat recovery should the partition walls be sealed and the grate speed reduced so that undergrate pressure of say 350 mm WG is obtained in first compartment, decreasing along the cooler to 50-100 mm in 4th compartment. The cooler is equipped with adequate analog control loops, but only loops for air to quench fan and 1st compartment is used. The loo for kiln hood pressure and grate speed should also be put in operation.

KILN OPERATION:

With due consideration to the conditions imposed on the kiln from outside you would expect that a very satisfactory kiln operation can be obtained. Even with the present problems does the operation not give serious problems. There is no real operational constrains as coating, jamming, ring formation etc. A stable coating in the burning zone is obtained, giving a satisfactory lining life, 4-8 months of the alumina bricks.

Control panel and instrumentation is generally in good condition, with exception of the O_2-meter at kiln inlet, out of order for one year now. There are sonsiderable variations in the clinker littre-weight, apparently permissible without loosing control of the kiln. Both operation and quality would benefit from more constant degree of burning.

The kiln torque is recorded but the signal could be amplified to give clear information. A thermocouple on the burner tip would also give valuable information.

The frequency of free lime determination on clinker should be increased. The ESP is out of function for a considerable part of kiln run-hours, not much attention being paid to this problem. Tripping for CO is rare and the main cause is the cooling tower and water pump, needing a thourough investigation. The heat consumption of the kiln is stated to 950-1000 Kcal/kg. This appears excessive, even considering that it is based on gross calorific value (7% too high), that it includes losses in connection with kiln stops and that the low output will increase the specific heat consumption. A true evaluation of the heat consumption can only be obtained by measuring all losses from the system during normal operation.

SUMMARY:

With reference to the above following suggestions for enhancement of kiln utilization have been made:

1. Investigate kiln draught problem and take apporopriate steps for sealing leaks.
2. Strengthen preventive maintenance.
3. Use three component raw mix.
4. Improve raw mill quality control.
5. Introduce systematic raw coal blending.
6. Investigate and correct coal mill operation.
7. Use air from cooler to coal mill.
8. Optimise cooler operation.
9. Reinstall O_2-meter at kiln inlet.
10. Improve burning zone control.
11. Investigate cooling tower problems.
12. Intensify lab control, feed, clinker and coal.

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Annex 7

VISIT TO TEXMACO CEMENT

15 - 16 NOVEMBER 1986

The plant was commissioned in March 1985, the infrastructure not yet finished and starting-up problems in different areas are still dominating the operation. Operation resulting in normal conditions has not yet been obtained. The long commissioning period of 1 1/2 years may partly be explained by labour problems, financial problems and difficulties in recruiting a competent staff. Management and organisation appears to be a seerious problem and the outlooks for the plant are rather dim.

GENERAL:

The plant has one kiln, 4.55 x 68 m with 4-stage preheater and a rated capacity of 1500 t/24 h, foreseen for extension to 3000 t/24 h by installation of precalciner and addtional cyclone tower. The kiln is controlled from a very modern and sophisticated control room with computerised control loops with colour screens and printers and without a conventional back-up system. The control system worked nicely, but will of course require very efficient maintenance. Important items for a central and distant control room a TV supervision of kiln, optical pyrometer and oxygen analyzers were not commissioned or not functioning. Modern laboratory equipment as X-ray analyzer and a coal blending plant as you would expect in a nice modern plant are not installed.

KILN UTILIZATION:

Evaluation of productivity and run-factor of present stage is without interest. In the first 8 1/2 months this years was produced 172,000 t clinker, both run-factor and output per 24 h being far below expectations. The present output is about 1000 t/24 h and only in few hours have been obtained production in the vicinity of the rated capacity of 1500 t/24 h.

In the following are outlined the problems directly related to kiln performance, but the result has been influenced by many other problems.

KILN FEED:

The main component in the raw mix is limestone from a large preblending store with 83-85% total titration. Raw mix adjustment is made with a mixture of iron ore and bauxite, leading to a mix with too low and varying silica ratio. In the original raw mix design was foreseen to use a third component, flagstone, a low titration limestone, in order that the addition of iron and alumina could be maintained constant and it was strongly recommended to adapt this procedure.

Only few analysis of kiln feed are made. Monthly average figures show variation in silica ratio from 1.5 to 2.3, in alumina-iron ratio 1.1 to 1.3 and in LSF from 1.00 to 1.17, and the four samples tested recently show similar variation. By using three components and the three weigh feeders as explained it would be possible to obtain a constant silica ratio above 2.0, the LSF then to be adjusted to give an acceptable LSF in the clinker, including the coal ash.

Clinkers are analysed daily on a composite sample and for one month was seen following variation: Silica ratio: 1.5 to 2.0, iron ratio: 1.0 to 1.7 and LSF: 0.70 to 0.96, variation which of course are not acceptable for kiln operation nor for cement quality. Variation in silica ratio and iron ratio is largely caused by variation in kiln feed, while variation in LSF also is caused by varying ash absorption. A LSF around 0.86 might be a reasonable target with the high ash coal used.

The kiln feed is ground too coarse, due to mill problems, showing 20-22% residue on 170 mesh and 3% on 72 mesh. An inherent feature of the raw meal blending system used is that proper homogenisation is obtained only when the silo is at least half full. This requirement is not being fulfilled and the blending accordingly not efficient.

COAL:

The quality of the coal used is much inferior than anticipated when the plant was planned. High ash coal can, however, be used successfully in Indian cement plants, normally having easy burning raw mix without reducing production capacity, but of course sacrificing cement quality.

A precondition is, however, that the ash content is maintained constant within narrow limits, then an ash content up to 35% is probably permissible. Ash in the coal received varies between 35 and 45% and no blending takes place, the stock being very small. Daily average samples of fine coal last month varies from 32 to 36%, but hourly samples are not being tested and may show higher variations.

In previous periods have as monthly average been found 31.4 to 37.7% in ash and 3480 to 4230 Kcal/kg gross heat value. Coal preblending is thus of imperative importance for obtaining proper kiln utilization.

The coal milling seems to be completely out of control. The output is for mechanical reasons only about 66% of rated capacity and has never reached capacity. Even then is the fine coal not dried sufficiently, the hot air temperature only 250°C, giving 3-8% moisture in fine coal. Hot air is drawn from the cooler and it is claimed that the temperature is limited to 280-300°C due to dust accumulation in the duct. Even with the low output is the residue on 170 mesh as high as 22%. It is evident that the coal mill is not operated according to instructions and a thorough investigation is called for.

The weigh feeder for fine coal to kiln is not being used, the extraction screws being used as feeders. This inadequate feeding is further agravated by moist fine coal.

KILN PERFORMANCE:

The present limit for the output is the capacity of ESP fan while the preheater fan so far appears to be ample. Design figures for both fans indicate ample fan capacity at rated output, and unless there is something wrong in operation of ESP fan, the problem must be extraordinary large amount of false air. The O_2-meters are not working and Orsat tests have not been made, which would give information on the false air.

Many efforts have been made to seal leakages in the ducting by welding, but without effect. The many visible leaks indicate a poor erection. Only a thorough investigation with O_2-analysis will disclose the leaks. The mill of course gives some contribution as foreseen and also the cooling tower could be possible source.

Unfortunately is the ESP fan placed after the ESP, so that this is operated with under-pressure and the design of the filters casing gives suspicion for heavy laekage here. It is not an easy job to change the position of the ESP fan or to improve the filter casing. It is not a solution to increase the capacity of the ESP fan with heavy leakage; it would only give minor improvement in kiln draught.

Coatings in material pipe from 4th cyclone to kiln has given problems and are difficult to clean. The coating over the whole length of the pipe is very hard with high sulphur content. The cause is probably that firing in the kiln is continued also during long kiln stops to keep the kiln warm. The SO_2 from the coal can thus penetrate through the feed pipe and solidify loose coating. If the problem is not solved by cleaning, specially during kiln-stops, the supplier should be consulted and advise wheather a sluice flap could be installed to prevent gas-flow during stops.

The coating in the burning zone is claimed to be very thin and there has been some premature lining repairs. The problem is a result of the large variations in the chemistry explained above.

SUMMARY:

From the above it appears that a number of very fundamental problems will have to be solved before normal kiln operation can be obtained. As first remedy are following procedures suggested:

1. Secure correct and constant kiln feed compositon.

2. Introduce raw coal blending.

3. Investigate coal mill operation and adjust to correct operation.

4. Use weigh feeder for fine coal.

5. Investigate false air in gas ducting system and make appropriate steps to stop leakage.

6. Keep O_2-meter at kiln inlet and after preheater in safe operation.

7. Install TV and optical pyrometer at kiln outlet.

8. Adjust raw meal fineness.

9. Maintain sufficient raw meal stock for efficient homogenisation.

10. Avoid firing in kiln without feed and clean material pipe to kiln.

11. Strengthen laboratory control of kiln feed coal and clinker free CaO.

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Annex 8

VISIT TO SATNA CEMENT

26 - 27 and 29 NOVEMBER 1986

GENERAL:

The plant operates 3 wet kilns and a new separate dry production line, commissioned October 1982. The dry kiln, 4.35 x 64 m with separate line precalciner and 4-stage preheaters has a rated capacity of 2500 t/24 h.

The dry plant is operated efficiently upto a standard comparable to modern plants elsewhere in the world. It appears clean and well maintained, the store for clinker and coal being the only problem area with very dusty conditions.

With the kiln system used a very good clinker quality is obtained, even with the high coal ash and further improvement could be achieved with a uniform coal quality.

All informations requested were given openly after some initial reservations.

KILN UTILIZATION:

The clinker production has been staedily increasing since the commissioning late in 1982, in 1983/84: 512,000 t, in 84/85: 716,000 t and in 85/86: 779,000 t corresponding to a reasonable expectation: 775,000 t (2500 t/d in 0.85 x 365 days).

The run-factor was for the first year after commissioning 74%, in 84/85: 84% and further increased in 85/86 to 87%.

The run-factor has thus reached a satisfactory level, where further improvements hardly are obtainable in practice.

Productivity enhancement are therefore limited to possible increase in production per 24 hours. In 1985/86 was an average obtained 2460 t/24 h but more than 2600 t/24 h has been obtained in some periods with steady operation and still higher output is within reach with the installation, when conditions are optimized as discussed in this report.

The kiln output is influenced by the time it takes to start the precalciner after kiln stops depending on the duration of the kiln stop, the output in this period being only one third of normal. In the present year has the calciner on average been stopped about 2 hours per kiln stop which appears rather high but difficult to evaluate without analysing each stop.

Going through the stop list for 85/86 the stops for lining and for mechanical and electrical repairs appears normal. Power failure did not occur, but has in present year caused 50 hours stop. Operational stops were very small in 85/86, but this year has cyclone jammings, caused by falling down of immersion tube given problems over a period.

KILN FEED:

The raw material are a quite constant limestone from preblending store, 78.2% $CaCO_3$, iron ore and upto 10% sweetener from the quarry. Raw mill control is performed with on-line X-ray analyzer.

Composite samples every 4 hours of kiln feed shows for a month: LSF: average 108.1 (105 to 112.5), MS: average 2.64 (2.5 to 2.9) and AM 1.23 (0.95 to 1.27). Also titration of kiln feed shows rather big variations with a standared deviation of 0.45.

It is not quite clear to which extend these variations are due to changes in set point, but with the control equipment used you would expect better homogenity.

Variations found within a day show similar range. The stock in the CF-silo exceeds 70% according to information on a very good homogenity of the feed could be expected. A detailed study of the problem would be useful.

Clinker analysis for a month shows similar variations, apparently not only caused by ash variation. LSF: average 92.1 (88.2 to 94.7), MS: 2.54 (2.44 to 2.64), FM: 1.23 (0.94 to 1.23), free CaO: 1.1 (0.5 to 1.9) and 2.6% MgO.

Even with the high ash absorbtion causing a decrease in LSF of 14 can high LSF in clinker be obtained, due to 60% of the ash being introduced in the calciner and mixed homogeniously with raw mix. The high ash can thus be permitted without serious deterioration of clinker quality.

COAL:

Variations in coal ash is the dominating problem for kiln utilization and clinker quality but not recognised at the works as a serious problem.

With a monthly average of 29.4% ash in kiln coal vary the daily average samples between 24% and 37% ash. As a test during the visit were hourly samples analysed and within 24 hours was found variation between 28.4% and 34.6% ash.

Coal blending is thus urgently needed and the coal store is designed for blending, however not used for blending. Some modification may be required in order to minimize the dust and of course a minimum stock of coal will have to be maintained. When a stock is established once for all, this should not affect the yearly output of the kiln.

The coal mill with hot air from the cooler is vented to a ESP and thus operated independently of the kiln. The fine coal is dried to 4% moisture with a mill outlet temperature of about 60°C. This temperature should be increased to say 65% for obtaining 1-2% moisture, resulting in increased kiln capacity and uniform feed rate.

The weigh feeders for coal to kiln and calciner have been removed, but it is planned to reinstall them in a different position. Tests have recently been made with high ash coal, 35%, but resulted in clinker balls in the kiln. The reason is apparently over-burning even with decreasing litreweight as typically found with over-burning. The kiln feed has not been adjusted sufficiently. With a reasonable constant coal ash it is no doubt possible to use such high ash coal successfully with good clinker quality.

KILN PERFORMANCE:

Kiln operation offers few problems only. Instrumentation and control loops are all in good condition and the kiln is operated correctly. Ring formations and coatings does not present a problem in the operation, but cleaning during kiln stops is necessary, probably due to Cl in the water for cooling tower. The O_2-meter in kiln inlet shows erratic reachings and cleaning of the probe seems to be a problem. It was discussed to use a sampling system with water-spray which is easier to keep in operation.

The meter after the kiln string shows 6.7% O_2, partly due to insufficient control at kiln inlet and partly due to excessive amount of air from the air lift. It is planned to install cyclone and dedusting for the air lift, resulting in increased capacity of the fans.

A few leakages in the system were identified and needs some modifications.

The tertiary air to the precalciner has a temperature of 680°C to 720°C, where 800°C should be normal and optimal for the calciner. The cooler is operated with a rather low bed depth and optimization of the cooler could improve the air temperature to the calciner.

The ESP is working continuously with good efficiency.

A very good lining life of 6 months is obtained with 70% alumina-bricks, the specific brick consumption being 0.5 kg/t clinker only.

The heat consumption of the kiln has not been established accurately but judging operation will be below 800 Kcal/kg net. For the kiln section, including feeding system is the power consumption 34 kwh/t cement, for the whole dry line 120 kwh/t.

SUMMARY:

Productivity enhancement has not be obtained by operating the kiln with higher output than the rated output.

In order to improve the possibilities for such increase following suggestions have been made:

1. Reduce ash variation by coal blending.

2. Investigate kiln feed homogenity.

3. Improve fine coal drying.

4. Reinstall weigh feeder for coal.

5. Optimize cooler operation.

6. Seal apparent leakages in preheater.

7. Improve gas sampling for O_2-meter.

8. Avoid excessive false air from air lift.

9. Avoid prolonged stops of precalciners.

Some of these proposals are already planned at the works and implementation of all the proposals is within the capability of the plant personnel.

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Annex 9

VISIT TO MAIHAR CEMENT

28 NOVEMBER 1986

GENERAL:

The plant is operating two identical kilns 4.35 x 64 m with 4-stage preheater and rated capacity 1200 t/24 h. The kilns were commissioned in 1979 and 1980.

The limestone has 7% moisture or more, not foreseen at the design of the plant, and it has never been achieved to dry and grind sufficient raw meal for full output at the kilns, and the kilns have since the commissioning been operated with an output about 1000 t/d. Some years ago the raw mills were disconnected from the kilns and are now operated with auxilary furnace and bag filters. That has apparently not, as would be expected, resulted in any increase in the kiln output. Presently is being installed a roller mill for one of the kilns, all kiln gasses going to pass the mill to existing kiln ESP.

The plant gives the impression of poor maintenance and housekeeping and suffers apparently from management problems.

KILN UTILIZATION:

No information could be obtained regarding kiln production, run hours or causes for down-time, and it was claimed that such figures were not recorded.

KILN FEED:

The raw materials are limestone with imbedded soft material, blended in a preblending store, laterite and at times a sweetener. The kiln feed has a titration at 73% only, due to a high content of calcium silicates. Analysis made every two weeks on average samples shows LSF: 0.92 to 1.01, SM: 2.1 to 2.5 and AM: 1.3 to 1.5, but short term variations were not indicated.

Clinker, also two weeks average samples, shows variation in LSF: 0.84 to 0.91, SM: 2.3 to 2.5, AM: 1.4 to 1.7., MgO: 3.8 to 4.4. and free CaO: 1.04 to 2.2. With the high MgO content and the nature of the limestone you would expect a very easy burning clinker with good possibility for high kiln production.

COAL:

Ash content on daily average samples of fine coal varies from 27.5 to 31.5%, short term variations were said to go upto 37% ash, but not substantiated by figures. Coal blending is not attempted. The coal mill is operated with auxiliary furnace; the use of hot air from cooler has been discontinued.

KILN PERFORMANCE:

An evaluation of kiln operation is not possible as log-sheets were not available. It was said that filling-in of log-sheet was abandoned long time ago.

One kiln only was running during the visit and not in normal operation. Going through the instruments it was noticed that the recorder for O_2 could not be seen. It has not been tried to run the kilns at ratedé output, even for shorter periods. It would be advisable before starting of the new mill to make such tests in order to investigate constrains in the system. One constrain could be the ESP fan, placed after the ESP. This fan was apparently running flat out with 1000 t/d output and without any mill air to the ESP. A thorough investigation of pressure profile and false air through the system is an urgent requirement.

Even with the present conditions, the ESP has a very low efficiency due to poor maintenance as indicated by low voltage and current. Discussions with burners and technical staff revealed a need for extensive training.

SUMMARY:

The informations available at the plant did not permit to identify specific areas for productivity enhancement nor to give specific suggestions. The only suggestion made is to investigate restrains in fan capacity due to false air and to make test with full capacity.

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