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Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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August 16. 1989.
English.

FINAL REPORT

UNIDO PROJECT US/CPR/86/130

Vincent SCIASCIA
Industrial engineer
Project manager
RHEO S.A.
BELGIUM

August 16, 1989.
English.

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CONTENTS

I. Chronological account of events

In 1983, a representative of SRRUC, M. Guo Yongkang was a member of an expert team touring Belgium and other countries in order to study their waste recycling experience.

In Belgium the team visited the FN Industry company (the parental company of RHEO S.A.) and "le Centre de Recherches Plastiques (CRIF - LIEGE) which means development center of plastics located in Liege, where they observed a PRH 120 C short-screw-type plastifier invented by Prof. Georges A. Patfoort working at the "Vrije Universiteit in Brussel.

In August 1983, Dr. Herbert MAY, Deputy head of the Division of UNIDC industrial operation visited Shanghai, and inspected the Xinguang Plastics factory.

Two months later the Ministry of Foreign Economical Relations and Trade in China officially requested the UNIDO to set up a project in this matter.

In August 1985, UNIDO experts, Prof. G.A. Patfoort and Dr. A. Buekens visited Shanghai to conduct a feasibility study in Xinguang Factory.

In March 1986, Prof. Patfoort came to Shanghai to hold detailed interviews with the leadership of SRRUC regarding concrete steps to be taken so as to set up a waste plastics recycling pilot plant and support the inserted equipment with all the necessary subsidies.

In April 1986 M. M. Youssef, senior inter-regional adviser from the industrial branch of UNIDO, and Mrs. Oloski, representative of Belgian government in UNIDO for project assessment visited Shanghai

In February 1987, related UNIDO authorities signed an agreement with the project subcontractor i.e. RHEO S.A. from Belgium in order to provide SRRUC with the technology and complete set of equipment intended for plastics waste recycling.

In April 1987, Prof. G.A. Patfoort visited Shanghai, the sequences of the project and operational acts were definitely determined at the plastics recycling department of the SRRUC in the Xinguang plastics factory.

In connection with that, an agreement was reached between Prof. Patfoort and the SRRUC with regard to the training of the Chinese staff in Belgium.

In October 1987, a three-person technical team, headed by Mr. Zhu Kexi, Deputy Manager of SRRUC, went to Belgium for systematic training.

In November 1987, Mr. Georges Micheels, technical adviser from Research and Development Center of F.N. Herstal in Belgium, visited Shanghai as UNIDO expert to investigate on preparation underway for setting up the pilot plant in Xing-Guang Plastics Factory (refer to appendix IV).

In April 1988, Mr. Vassiliev and Mr. Youssef pertaining to UNIDO, Mr. Andersen, programme officer from UNDP/Beijing, and Prof. Patfoort went to Shanghai and held some meetings with representatives of Shanghai Commission for Foreign Economic Relations and Trade together with SRRUC for an interim project examination.

In the end of May 1988, plastics waste recycling equipment arrived in Shanghai.

In June 1988, Mr. Vincenzo Sciascia and Mr. André Noirhomme, respectively Project and Production Managers from RHEO S.A., went to Shanghai as UNIDO experts to install and start-up the recycling line.

In March 1989, a three-person technical team, headed by Mr. Zhu Kexi, Deputy Manager at SRRUC, came in Belgium to prepare the UNIDO workshop on plastics waste recycling technology.

Arrangements as well as a future cooperation and contracts have been carried out between both SRRUC and RHEO companies.

In April 1989, M. Vincenzo Sciascia, Project Manager from RHEO S.A., went to Shanghai as UNIDO expert in economies of plastics recycling (refer to appendix I).

Finally in April 1989, under the combined auspices of the UNIDO and the Ministry of Foreign Economic Relations and Trade (PRC), a workshop on plastics recycling technology was organized in Shanghai at the SRRUC between April 10 and 12, 1989.

II. Introduction.

The final report consists of the different missions that the experts carried out for this project.

The major recycling processes used an important labour i.e. about 10 tons per year multiplied by the number of persons.

The productivity must therefore be improved as follows :

1. To reduce the consumed energy per kg of recycled plastic. Before, a consumption of 4 kw for 1 kilo of platic material could be noted.

   At the present time, it can be obtained +/- 2 kw/kg after having installed the new equipments and integrated their existing equipments in the best conditions.

2. To increase the output per employed person. There was compatibility between the Chinese equipments I observed at the Xinguang Plastics Factory and the equipments used by RHEO S.A. company.

I think that the PRH 120 is particularly well adapted to the recycling operations that are carried out in China. Actually, this machine is simple to use, strongly built and easy to install in such an industrial environment.

The mechanical and electrical workshops I visited are quite capable to assure the industrial maintenance of the equipment supplied by RHEO S.A. Moreover, the personnel has been given a specific training during the different missions performed by UNIDO experts.

It seems to me that the main source of plastic waste will be of film and foil type in the future.

The need of densification in the recycling line will therefore be more and more important.

In the present time most of the energy is consumed by the densification calenders. The next logical step of investment would be to modernize the densification of the plant for the soft PVC and PE.

In this densification step it exists specialized machines more adapted and cheaper than the calenders.

The engineers working at the Xingguang Plastics Factory had the possibility of seeing one machine operating at the RHEO S.A. company in Belgium.

These machines are ready for use and can be supplied by the Engineering Department of RHEO S.A. company.

My first recommendation would then be that UNIDO organization helps the Xingguang Plastics Factory in installing a densification line that would replace the calenders.

III. Workshop on plastic waste recycling technology.

A text of introduction on the workshop was worked out by UNIDO (refer to appendix V). a meeting agenda was prepared by the SRRUC authorities (refer to appendix VI) and approved by the project coordinator (Prof. Georges A. Patfoort).

The proceedings during the workshop had a perfect development and we thank the SRRUC and other organizational authorities for their support and their help.

The relevant persons are the following :

- Deputy director of China International Center for Economical and Technical Exchanges. Ministry of Foreign Economic Relations and Trade.
- Director of Finance and Trade Office of shanghai Municipal People's Government.
- Director of Shanghai Commission for Foreign Economic Relations and trade.
- M. Cha Jia. Chairman. Deputy Director of Shanghai Supply and Marketing Cooperation.
- M. M. Youssef. UNIDO Vienna.
- M. F. Mutton. Conusl-General of Belgium.
- M. jacques Suissaert. Head-development Cooperation section fo the Belgian Embassy in Beijing.
- Prof. Georges A. Patfoort. the Project Coordinator. UNIDO Consultant.

The workshop was honoured with the presence of the Vice-Mayor of Shanghai, Ph. D. Liu Chen-Yuan on April 11, who offered a banquet to all the delegates and representatives attending to the workshop.

M. Zhang Yanging, Deputy Manager at the SRRUC, M.Zhu Kexi, Deputy Manager at the SRRUC and M. Liu Baoping, Deputy Director at the S Xinguang Plastics Factory gave lectures on waste recycling problems in Shanghai, the history and progress of the project at the SRRUC, the specifications of the recycling line at the SRRUC, and the technological details on the working and processing of the new line (refer to appendix VII).

Prof. Georges A. Patfoort, the project coordinator and UNIDO consultant gave the technological features of the RHEC Recycling Machine (refer to appendix VIII).

Apart from the Chinese participants (see appendix IX), delegates from seven countries gave a survey of the situation of the waste problems and the recycling of plastics in their countries (see appendix X).

The relevant countries are the following :

- Bangladesh represented by M. Shahjahan SIKDER.
- India represented by M. Arun ANAND.
- Malaysia represented by M. Joo Fai TUNG.
- Pakistan represented by M. Pervez AHMED.
- Philippines represented by M Adolfo Jesus GOPEZ.
- Sri-Lanka represented by Mrs. Padma Irangani IDDAMALGODA.
- Thailand represented by M. Phietoon TRIVIJITKASEM

IV. Evaluation and results.

With reference to M. Liu Baoping's report in appendix VII and as far as the technology and economy are concerned, the results are positive.

We will mainly mention the following :

- productivity
- labour intensivity
- energy consumption
- working environment
- problems of pollution
- harm caused to workers' health
- quality of material and finished products

V. Recommendations.

Although the successful results that have been obtained with the recycling line and the general satisfaction about the relevant results, we would like to add the following observations :

1. Washing unit.

The washing unit consists of several operations : storage, sorting, washing, drying and packing.

Concerning the sorting, the manual system is very efficient but it should be carried out in better conditions i.e. improving the working conditions for the personnel and in the same time, improving the sorting operation.

If the sorting was performed on a table and if the contaminating materials were put directly in separated boxes, re-contamination would be avoided. This is not the case, now.

Moreover, the metals and non-metals would be recuperated and sold to companies who recycle these materials.

Washing cannot be considered as efficient for the following reasons noted on the spot :

- the plastic films are washed in large size;
- the material is not subject to any mechanical force to be separated from the sand that remains stuck on the films;
- the personnel working in these washing units suffers from a lack of information. This leads to an inappropriate washing procedure i.e. too early wear of crusher knives, extruder screw and feed cylinder as well as cube dicer knives.

Drying is made outside; the pieces of plastic mass are in fact hung on wires. As all washing units are located in the country area, the wind brings dust and sand back on the plastic films that are moreover wet. The area foreseen for the drying operation is the mud floor.

Packing is also carried out outside. This operation could be improved by simply using a small hand-operated press. This will increase the apparent density and reduce the transport charges because the washing units are located at several hours from the recycling factory.

The washing unit I visited can process only a few tons per month at the maximum and sometimes, nothing at all because they depend completely on the atmospheric conditions since all the operations are carried out outside.

In order to take the corrective actions relating to all these problems the managerial staff pertaining to the Xing Guang Plastics Factory is thinking of performing the washing and drying operations in their own buildings.

They also want to improve the mechanization and washing by using for instance, Archimedean screws under water and drilled trommels under heavy water for the rinsing.
A battery intended for hot-air heating can also be used for drying.

This improvement can be rendered possible thanks to the extrusion pilot unit having workers available in their own unit.

I could also note that the percentage of contaminating agents is of about 3 to 8 % instead of 30 % as some told me before.
These values are very important to be able to know the loss as well as the type of washing that is to be foreseen if this operation is mechanized subsequently.

NOTE

Here are some notions of the current prices.
1 yuan = 0.28 US $ corresponding to +/- 10 Belgian Francs.

DESCRIPTION		yuan/kg
dirty plastic waste		1.5
washing (less the loss)		1.0
	Total	
clean plastic waste		2.5
transformation		1.3
	Total	
granules (pellets)		3.8
intact material (soft PVC)		7.5

These prices were given to me by the managerial staff from Xing Guang Plastics factory for the soft PVC.

It can be noted that washing is taking a great part of the selling price of the recycled granules. On the other hand, it is not possible to increase the selling price as long as washing is not efficient.
So, I should like to underline this point for all the improvements to be made.

2. Auxiliary equipments before extrusion.

2.1. Introduction.

I personally consider as auxiliary equipments the following machines :

- the crusher,
- the electromagnet,
- high-speed heating mixer.

As we could note, these equipments give rise to problems and their productivity is not very efficient.

I should like to draw your attention to the following points which have a certain influence on the productivity of the recycling line of plastic masses :

- the density obtained after "*densification*" using the high-speed heating mixer.
  If a real densified material could be obtained, the quantity delivered of the extrusion line would be multiplied by 2 or 3 times depending on the material used.

- if a real electromagnet could be used, the wear of the extruder screw and feed cylinder would be reduced.

Following to these findings all these auxiliary equipments could be replaced by a *densification machine.*

2.2. Densification unit.

2.2.1. The densification will be used for :

- foil shreds,
- foil spoilage,
- waste and spoiling welding and printing,
- waste of trimming and deep drawning,
- used foil packing materials (e.g. : sacks, bags, etc.),
- textile strings out of PA, polyester, waste in band-materials, etc.

2.2.2. The process.

The machine consists of an oval, vertical standing vessel with several anti-rotating knives operating like a pair of scissors.

The rotating knives will be unpelled directly by electric motors (no fault susceptible transmission gearing).

The waste material is brought in the row state on top of the plant. The scissor-like operating knives cut the waste material.

The plant does not require any additional consumption of energy for heating as the frictional heat produced through the cutting process leads immediately to the melting of the material.

With the addition of medium cooling such as water or granulated material, the plastic compound will be quenched and granulated.

The addition of water is automatically regulated by an electromagnetic valve.

The plant is supplied with a suction plant that leads the steam produced after adding the medium cooling i.e. water.

The granulated material is being discharged through a pneumatic operated shutter and bagged or transmitted by an automatic conveyor.

2.2.3. Advantages of the plant.

A profitable investment, working in one shift only, the plant will be paid by itself in just a few months time.

Saw operating costs. Production of the granulated plastics in only one working operation.
For that sort of operation, only a semiskilled worker is required.

Reduced power consumption thanks to ideal arrangement of the cutting devices and the direct-drive maintenancefree through regular lubrication and enclosing of all moving parts.

Easy to manipulate because of smooth inside and no dead spaces, easy cleaning of vessel when material and colour are to be changed.

Crumbling, no caking granulated material with a bulk weight of 0.4 to 0.65 kg/liter.

3. Extruder line.

At the present stage we can say that the extrusion line is operating as follows :

Efficiency.

With the integration of the newly-installed unit in the process, the operations necessary are representing 50 to 60 % in relation to those carried out previously.

However, the efficiency is increased only by 10 % due to the low efficiency produced by the existing auxiliary equipments. For instance, more workers are required for the crushing operation.

Energy.

The consumption of power for the production of PVC is of 0.8 kwh/kg instead of 1 kwh/kg previously.

Quality.

The quality of the plastic masses has increased because the plastifying temperature for each type of material can be now controlled.

In the old process they were using the double-roller.

With this technique they could not controlled the temperature and the material was therefore damaged.

Concerning the PVC, there were emissions of HCl and plasticizer vapours that polluted the working place seriously, caused harm to workers' health, corroded equipments and finally had a bad effect on the quality of the products.

Productivity.

The extrusion line is not used at its optimum productivity. This is due to the density of the plastic masses essentially.

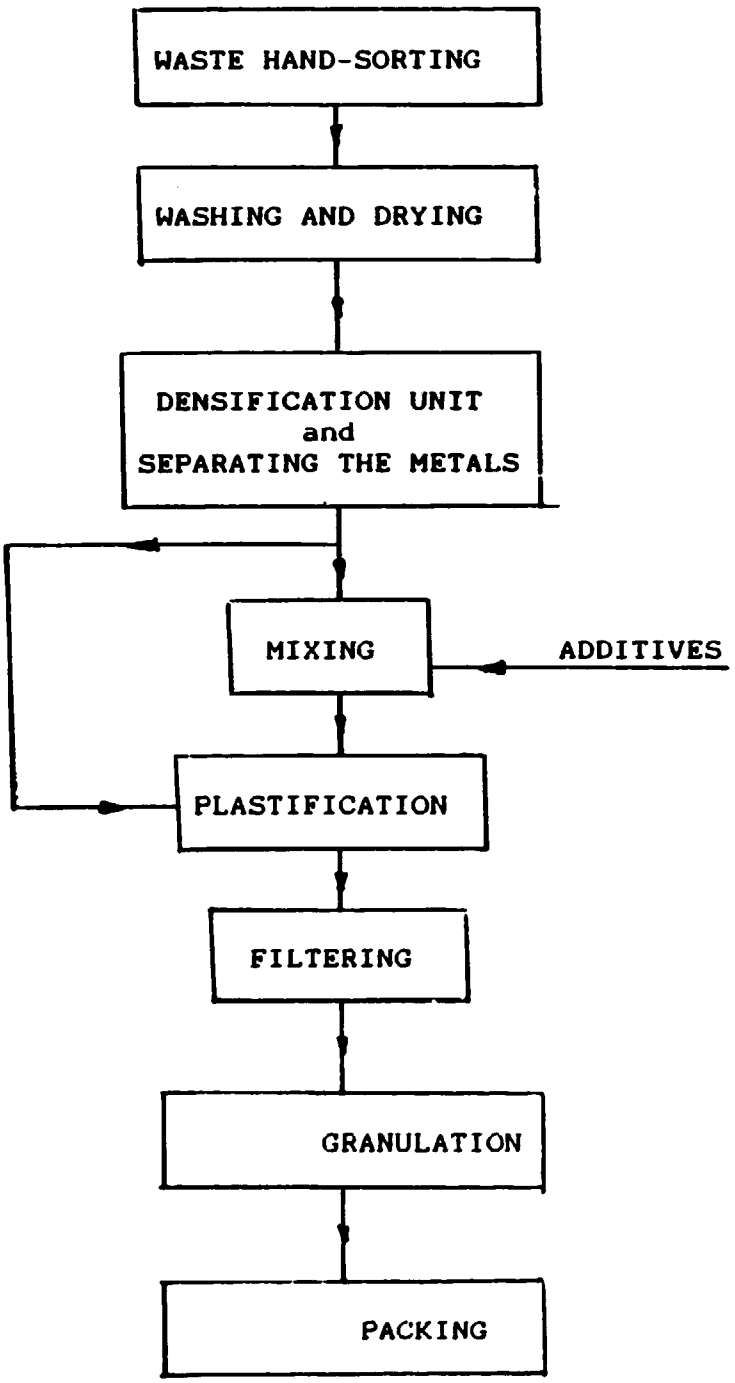
The table herebelow is giving the values that can be reached if a densification line is used.

DESCRIPTION	PVC DENSIFIER		PE DENSIFIER	
	with	without	with	without
Density	0.6/0.65	0.3/0.4	0.3/0.4	0.08/0.1
Average quantity delivered (kg/h)	250/300	145	150/200	73

The productivity could obviously be increased by 2 or 3 times and in the same time the quality could also be improved.

If a densification line was installed at the Xing-Guang Plastics. the flow sheet could be represented as follows :

4. Future flow sheet : soft PVC/PE film.



VI. Economical output and results.

An agreement does exist between SRRUC and RHEO S.A. with the intention of realizing the possibility of making complete lines in Shanghai and builing-up a commercial network in order to sell the line in China and other countries (refer to appendix I, Manufacturing the extrusion line in China).

RHEO S.A. concluded a provisional contract with the SRRUC authorities and a final agreement is to be reached very soon (refer to appendix I, draft between SRRUC and RHEO S.A.).

VII. Acknowledgement.

I personally want to express my gratitude to all the authorities and staff members of the Shanghai SRRUC company and Xinguang Plastics Recycling Factory team for the perfect preparation of the workshop activities and for their efficient cooperation in this project, the hospitality and the kindness during the different missions I performed.

I should like to express special thanks to :

Messrs : Zhu Kexi, Deputy Manager from SRRUC.

Xia Shiming, Engineer from SRRUC.

Liu Baoping, Deputy Director from Xing Guang Plastics.

Zhang Shunrong, Deputy Director from Xing Guang Plastics.

Zhang Dexing, Section Chief.

Zhang Cuoghang, interpreter.

A N N E X E I

FINAL REPORT

EXPERT MISSION AT THE SHANGHAI RESOURCE RECOVERY AND UTILIZATION COMPANY

US/CPR/86/130

PLASTIC RECYCLING DEPARTMENT

SHANGHAI : People's Republic of China

30.03 to 23.04.89
United Nations Industrial
Development Organization

UNIDO

Vincent SCIASCIA
Industrial engineer
Project manager
RHEO S.A.
BELGIUM

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II. Description of the expert mission

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V. Visit to several companies

1. Shanghai Package Instrumentation Plant
2. Shanghai Electric Assemblies Works (SEAW)
3. Shanghai Sixth Automation Instrumentation Factory

VI. Draft between SRRUC and RHEO S.A.

VII. Thanks

I. Chronological account of events

In February 1987, related UNIDO authorities signed an agreement with the project subcontractor RHEO S.A. from Belgium in order to provide SRRUC with the technology and complete set of equipment for plastics waste recycling.

In April of the same year, a decision was reached between Prof. Patfoort and SRRUC with regard to training of Chinese technical staff in Belgium.

In October 1987, a three-person technical team, headed by Mr. Zhu Kexi, Deputy Manager of SRRUC, went to Belgium for systematic training.

In November 1987, Mr. Georges Micheels, technical adviser from Research and Development Center of F.N. Herstal in Belgium, visited Shanghai as UNIDO expert to investigate on preparation underway for setting up the pilot plant in Xing-Guang Plastics Factory.

In April 1988, Mr. Vassiliev and Mr. Youssef pertaining to UNIDO, Mr. Andersen, programme officer from UNDP/Beijing, and Prof. Patfoort went to Shanghai and held some meetings with representatives of Shanghai Commission for Foreign Economic Relations and Trade together with SRRUC for an interim project examination.

In the end of May 1988, plastics waste recycling equipment arrived in Shanghai.

In June 1988, Mr. Vincenzo Sciascia and Mr. Andre Noirhomme, respectively Project and Production Managers from RHEO S.A., went to Shanghai as UNIDO experts to install and start-up the recycling line.

Finally in March 1989, a three-person technical team, headed by Mr. Zhu Kexi, Deputy Manager at SRRUC, came in Belgium to prepare the UNIDO workshop on plastics waste recycling technology.

II. Description of the expert mission

Date of arrival in Shanghai : 1st April 1989.
Date of departure from Shanghai : 22 nd April 1989.

The purpose of the mission was the following :

To realise a recycling system for plastic waste, adapted to the needs of the country and integrated in a general programme of the SRRUC on waste recycling, the expert will be expected to :

1. Survey the operation of the plastics line installed at the SRRUC in Shanghai.

2. Give an appreciation of the efficiency of the operation of each piece of the equipment and of each stage of the operation.

3. Discuss eventual improvements to be made on the working equiment, sequences of operation, collection and separation of the waste, and marketing of the finished products.

4. Discuss possibilities of manufacturing parts of equipment in the PRC and marketing of a recycling line adapted to the local market.

The expert will also be expected to prepare a report setting out the findings of his mission and recommendations to the government on further action which might be taken.

III. Analysis of recycling line and improvements to be brought for a better efficiency.

1. Introduction.

As the plastic waste are coming from different sources, Xing-Guang Plastics Factory is mainly specialized in the processing of soft PVC and PE.

Before the installation of the new extrusion line, the processing of plastics was carried out as follows :

1.1. The former technology for processing soft PVC.

- Waste hand-sorting.

- Washing and drying.

- Tearing, blending and adding with plasticizer, colouring agents, lubricant and stabilizer in double roller. After the plastification of the mixture, bands with a section of 25 x 5 mm were obtained.

- Second plastification using an extruder. The material was filtrated and this produced a band of 20 x 4 mm.

- Third plastification using another extruder to produce a 5 to 6 mm-dia. *spaghetti*.

- Cutting the spaghetti into cylindrical pellets in a cube dicer: the pellets should be 5 to 6 mm thick.
  Weighing and packing.

1.2. The former technology for processing PE.

- Waste hand-sorting.

- Washing and drying.

- Pressing and tearing materials in a double roller for densification to raise the yield.

- Plasticizing the material twice in a *"triple-head"* extruder into a cylindrical band with a diameter of 4 to 5 mm.

NOTE.

The triple-head extruder is used as follows : two extruders for the first plastification and the other is fed by the smelting paste that is discharged from the aforesaid extruders. The last extruder is intended for the second plastification with the purpose of removing oulds completely.

- Cutting the band into cylindrical pellets in a cube dicer: pellets should be 5 to 6 mm thick. Weighing and packing

1.3. The new technology for processing soft PVC/PE.

- Waste hand-sorting.

- Washing and drying.

- Tearing film into pieces with diagonal line of 10 to 20 mm in a crusher.

- Separating the metals.

- Kneading pieces of plastics at a high speed in a heated charging silo, sprinkling the material with water to produce granules while replenishing them with abovementioned additives.

- Inserting granules into the hopper of a PRH-120 extruder to prevent them from bridging.

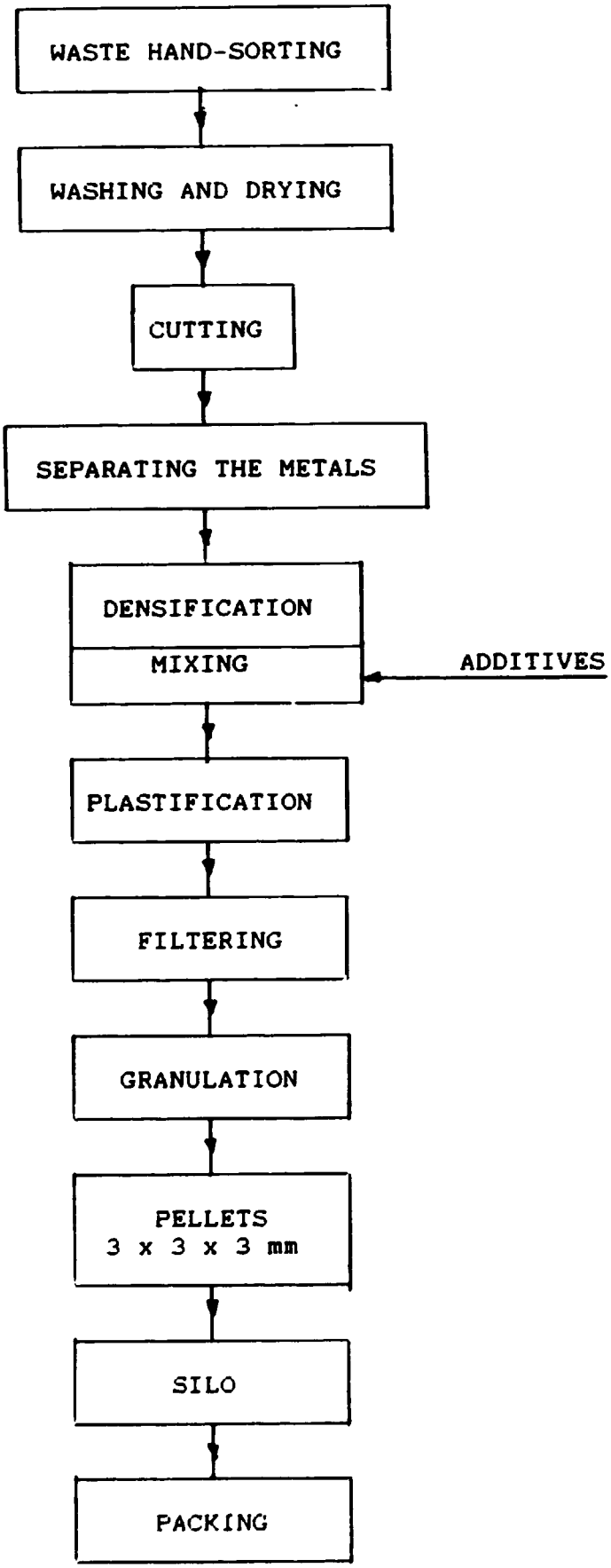
- Filtering the plasticized material through a screen filter.

- Molten plastics being extruded out of a flat mould and pressed into a flat band with a cross-section of 100 x 3 mm in a calender.

- After having been cooled with water and pneumatically dried, the flat band is cut into pellets of 3 x 3 x 3 mm in the GB 125 cube dicer.

- Drying through a cyclone separator; weighing and packing.

1.4. Flow sheet : soft PVC/PE film.



2. Washing and drying unit

Visit carried out with the responsible personnel of Xing-Guang Plastics Factory (subsidiary of the SRRUC) :

- Mr. XIA SHIMING , Engineer at the SRRUC,
- Mr. ZHANG SHUNRONG, Deputy Director at the Xing-Guang Plastics Factory.

2.1. Storage.

Receiving of raw material coming from the selective collection. It is presented in bundle form weighing 10 kilos more or less (refer to figure W1).

2.2. Sorting.

These bundles are taken one at each time and opened on the ground (refer to figure W2).

The workers are performing the following operations :

- separation of PE and soft PVC,
- separation of metallic and non-metallic parts,
- separation of damaged plastic mass;
- opening of plastic bags;
- cutting of plastic films, having a large size, into pieces of 1 m x 1 m (refer to figure W3).

2.3. Washing.

They dip the plastic films into a small tub. These films are not actually washed but are only wet superficially. The sand, located on the surface, is not therefore removed from the material.

2.4. Degreasing.

Following to the first operation the plastic films are dipped during a few minutes into a second tub containing a solution of water and Na2CO3 at a temperature of about 60 degrees centigrade.

This solution permits to remove any trace of oil and fats (refer to figure W4).

2.5. Rinsing.

The plastic films are plunged in the first tub once again and rinsed once more. This neutralizes the effect of the Na2CO3 solution (refer to figure W5).

2.6. Drying.

These long pieces of plastic films are hung on wires, while small pieces are laid on the ground. The drying operation is carried out outside and in the open country (refer to figure W6).

2.7. Packing and storage.

Packing is performed with small 10-kilo bundles and small pieces in bags (refer to figure W7).

Figure W1 : storage of waste films

Figure W2 : hand-sorting

Figure W3 : Hand-sorting

Figure W4 : Washing

Figure W5 : Rinsing

Figure W6 : Drying

Figure W7 : Packing

3. Crushing.

The crushers inspected at the Xing-Guang Plastics Factory are not efficient enough. This can be explained as follows :

- the knives located in the crushing chamber are not often replaced;
- these crushers are not intended for plastic films;
- they are not equipped with a ventilator-extractor used for the evacuation of the cut films from the crushing chamber;
- moreover, the lifetime of the knives is very short due to the presence of foreign bodies such as sand, metal, etc... This is the consequence of a bad washing.

This operation needs 4 workers and 5 crushers.

4. Separating the metals.

The electromagnet used is not efficient since metals are still found in the extruder filter.

The modifications they could bring are the following :

- to buy a real electromagnet;
- to make a vibrating table to let the plastic mass pass under the magnet at 2 to 3 mm;

This operation needs 2 workers.

5. Densification and mixing.

The Xing-Guang Plastics Factory use high-speed heating mixer to carry out the densification.

The results obtained are the following :

DESCRIPTION	PVC	PE
Quantity of material in kg	40	40
Time in minutes	15	40
Quantity delivered in kg/hour	160	60
Apparent density obtained so far	0.3/0.4	0.08/0.10

It can be noted that the results obtained are not satisfactory and above all for the PE. The apparent density obtained is not sufficient in order that the extruder can be used in good conditions of productivity. This operation needs 1 worker.

NOTE.

As the high speed heating mixer cannot densify the PE, they are using now two existing double-rollers to tear and densify materials as a supplementary method to raise the yield. In the other hand, it greatly increases energy consumption and labor cost (2 workers).

6. Extruder line.

I should like to point out that during my inspection I noted that the maintenance department of the Xing-Guang Plastics Factory, managed by Mr. Liu Baoping, did a real good job. After less than one year the extrusion line is in perfect condition of working.

Its production results are the following :

DESCRIPTION	PVC	PE
Density of material at the feeding	0.3/0.4	0.08/0.10
Minimum quantity delivered in kg/hour	126	50
Average quantity delivered in kg/hour	145	73
Maximum quantity delivered in kg/hour	170	77

NOTE

We can see that the quantity delivered is rather normal for the PVC but it is very bad for the PE. These results can be explained by considering the density of each material.

7. Conclusions.

7.1. Washing unit.

The washing unit consists of several operations : storage, sorting, washing, drying and packing.

Concerning the sorting, the manual system is very efficient but it should be carried out in better conditions i.e. improving the working conditions for the personnel and in the same time, improving the sorting operation.

If the sorting was performed on a table and if the contaminating materials were put directly in separated boxes, re-contamination would be avoided. This is not the case, now.

Moreover, the metals and non-metals would be recuperated and sold to companies who recycle these materials.

Washing cannot be considered as efficient for the following reasons noted on the spot :

- the plastic films are washed in large size;
- the material is not subject to any mechanical force to be separated from the sand that remains stuck on the films;
- the personnel working in these washing units suffers from a lack of information. This leads to an inappropriate washing procedure i.e. too early wear of crusher knives, extruder screw and feed cylinder as well as cube dicer knives.

Drying is made outside: the pieces of plastic mass are in fact hung on wires. As all washing units are located in the country area, the wind brings dust and sand back on the plastic films that are moreover wet. The area foreseen for the drying operation is the mud floor.

Packing is also carried out outside. This operation could be improved by simply using a small hand-operated press. This will increase the apparent density and reduce the transport charges because the washing units are located at several hours from the recycling factory.

The washing unit I visited can process only 15 tons per month at the maximum and sometimes, nothing at all because they depend completely on the atmospheric conditions since all the operations are carried out outside.

In order to take the corrective actions relating to all these problems the managerial staff pertaining to the Xing Guang Plastics Factory is thinking of performing the washing and drying operations in their own buildings.

They also want to improve the mechanization and washing by using for instance, Archimedean screws under water and drilled trommels under heavy water for the rinsing.
A battery intended for hot-air heating can also be used for drying.

This improvement can be rendered possible thanks to the extrusion pilot unit having workers available in their own unit.

I could also note that the percentage of contaminating agents is of about 3 to 8 % instead of 30 % as some told me before.
These values are very important to be able to know the loss as well as the type of washing that is to be foreseen if this operation is mechanized subsequently..

NOTE

Here are some notions of the current prices.
1 yuan = 0.28 US $ corresponding to +/- 10 Belgian Francs.

DESCRIPTION	yuan/kg
dirty plastic waste	1.5
washing (less the loss)	1.0
Total	———
clean plastic waste	2.5
transformation	1.3
Total	———
granules (pellets)	3.8
Intact material (soft PVC)	7.5

These prices were given to me by the managerial staff from Xing Guang Plastics factory for the soft PVC.

It can be noted that washing is taking a great part of the selling price of the recycled granules. On the other hand, it is not possible to increase the selling price as long as washing is not efficient.
So, I should like to underline this point for all the abovementioned reasons.

7.2. Auxiliary equipments before extrusion.

7.2.1. Introduction.

I personally consider as auxiliary equipments the following machines :

- the crusher.
- the electromagnet.
- high-speed heating mixer.

As we could note, these equipments give rise to problems and their productivity is not very efficient.

I should like to draw your attention to the following points which have a certain influence on the productivity of the recycling line of plastic masses :

- the density obtained after "*densification*" using the high-speed heating mixer.
  If a real densified material could be obtained, the quantity delivered of the extrusion line would be multiplied by 2 or 3 times depending on the material used.

- if a real electromagnet could be used, the wear of the extruder screw and feed cylinder would be reduced.

Following to these findings all these auxiliary equipments could be replaced by a *densification machine*.

7.2.2. Densification unit.

7.2.2.1. The densification will be used for :

- foil shreds,
- foil spoilage,
- waste and spoiling welding and printing,
- waste of trimming and deep drawning,
- used foil packing materials (e.g. : sacks, bags, etc.),
- textile strings out of PA, polyester, waste in band-materials, etc.

7.2.2.2. The process.

The machine consists of an oval, vertical standing vessel with several anti-rotating knives operating like a pair of scissors.

The rotating knives will be unpelled directly by electric motors (no fault susceptible transmission gearing).

The waste material is brought in the row state on top of the plant. The scissor-like operating knives cut the waste material.

The plant does not require any additional consumption of energy for heating as the frictional heat produced through the cutting process leads immediately to the melting of the material.

With the addition of medium cooling such as water or granulated material, the plastic compound will be quenched and granulated.

The addition of water is automatically regulated by an electromagnetic valve.

The plant is supplied with a suction plant that leads the steam produced after adding the medium cooling i.e. water.

The granulated material is being discharged through a pneumatic operated shutter and bagged or transmitted by an automatic conveyor.

7.2.2.3. Advantages of the plant.

A profitable investment, working in one shift only, the plant will be paid by itself in just a few months time.

Saw operating costs. Production of the granulated plastics in only one working operation.

For that sort of operation, only a semiskilled worker is required.

Reduced power consumption thanks to ideal arrangement of the cutting devices and the direct-drive maintenancefree through regular lubrication and enclosing of all moving parts.

Easy to manipulate because of smooth inside and no dead spaces, easy cleaning of vessel when material and colour are to be changed.

Crumbling, no caking granulated material with a bulk weight of 0.4 to 0.65 kg/liter.

7.3. Extruder line.

At the present stage we can say that the extrusion line is operating as follows :

Efficiency.

With the integration of the newly-installed unit in the process, the operations necessary are representing 50 to 60 % in relation to those carried out previously.

However, the efficiency is increased only by 10 % due to the low efficiency produced by the existing auxiliary equipments. For instance, more workers are required for the crushing operation.

Energy.

The consumption of power for the production of PVC is of 0.8 kwh/kg instead of 1 kwh/kg previously.

Quality.

The quality of the plastic masses has increased because the plastifying temperature for each type of material can be now controlled.

In the old process they were using the double-roller.

With this technique they could not controlled the temperature and the material was therefore damaged.

Concerning the PVC, there were emissions of HCl and plasticizer vapours that polluted the working place seriously, caused harm to workers' health, corroded equipments and finally had a bad effect on the quality of the products.

Productivity.

The extrusion line is not used at its optimum productivity. This is due to the density of the plastic masses essentially.

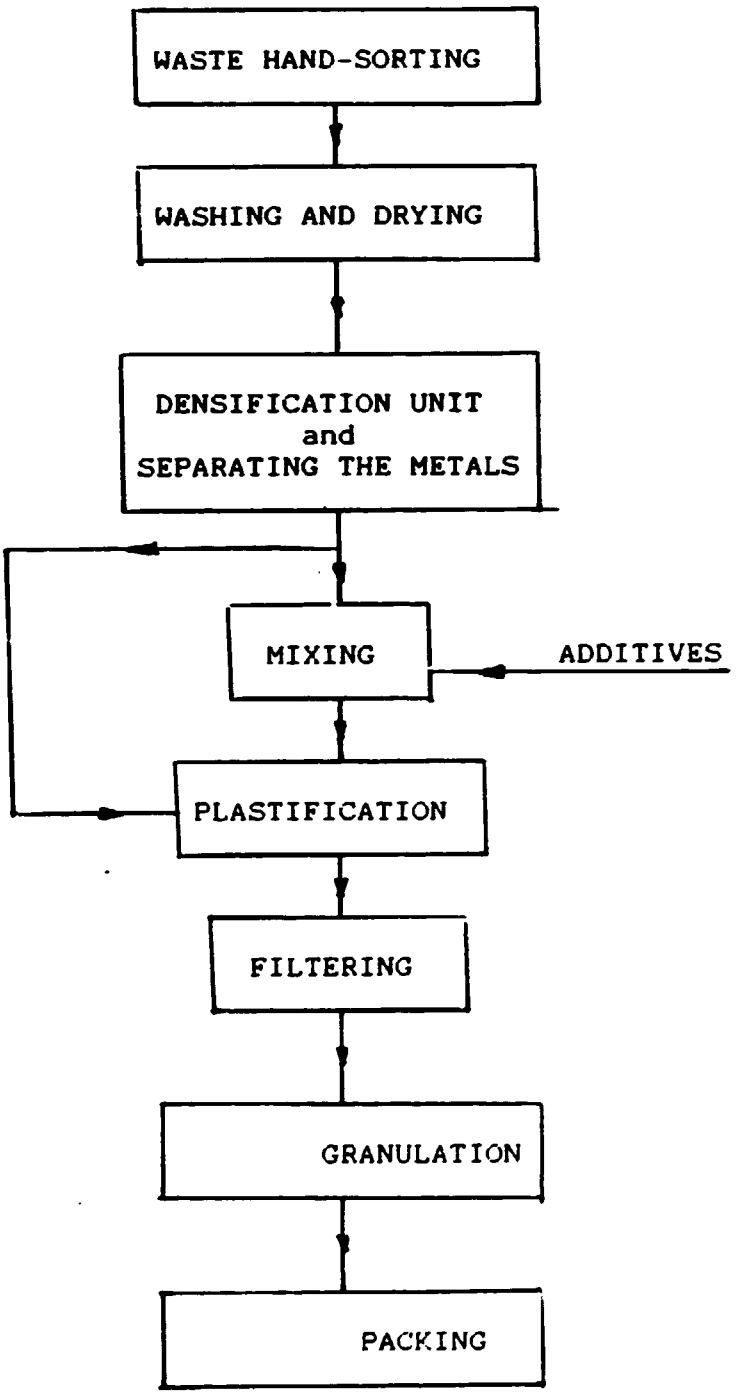
The table herebelow is giving the values that can be reached if a densification line is used.

DESCRIPTION	PVC DENSIFIER		PE DENSIFIER	
	with	without	with	without
Density	0.6/0.65	0.3/0.4	0.3/0.4	0.08/0.1
Average quantity delivered (kg/h)	250/300	145	150/200	73

The productivity could obviously be increased by 2 or 3 times and in the same time the quality could also be improved.

If a densification line was installed at the Xing-Guang Plastics, the flow sheet could be represented as follows :

7.4. Future flow sheet : soft PVC/PE film.



IV. MANUFACTURING THE EXTRUSION LINE IN CHINA

1. Introduction.

In this chapter I am going to subdivide the extrusion line into several assemblies and describe each assembly separately.

The different assemblies are the following :

- D.C. feeder,
- extrusion line control panel,
- main motor of extruder,
- screw and feed cylinder,
- reducer,
- concrete frame,
- chassis and body of extruder,
- granulation.

2. D.C. feeder.

It contains all the power and control components of the extruder motor. It operates with controlled diodes and a fault spotting system is fitted on the panel in case of eventual breakdown of the unit.

This D.C. panel could be supplied by the S.E.A.W company (refer to chapter V, section 1).

3. Extrusion line control panel.

It includes all the power and protective components of the cooling fans, hydraulic units, cube dicer and all temperature control instruments of the extruder and also of the screen changer.

To carry out this assembly, a few modifications are to be brought. Its variation of speed for the calender and cube dicer is made now by using a variation of frequency. This technology is not very well known in China.

It is the reason why we decided, with the agreement of the Chinese persons in charge of this project, to use a variation of speed operating with direct current even for the weak powers.

S.E.A.W are able to supply the relevant control cabinet using the temperature control instruments belonging to the Shanghai Sixth Automation instrumentation Factory (refer to chapter V, sections 1 and 2).

4. Main motor of the extruder.

The Chinese managers, who are in charge of this project, let me know that the motors operating with direct current and manufactured in China, are bigger and larger at the present time.

On the other hand, the PRH 120 extruder manufactured by RHEO S.A. has actually a sufficient available place in the motor emplacement in order to receive it without important modification.

5. Screw and feed cylinder.

The Chinese responsible managers as well as those from RHEO S.A. company have settled an agreement about it (refer to chapter VI, draft).

This assembly will be supplied by the same RHEO S.A.

6. Reducer.

In the present time the reducer is to be supplied by RHEO S.A. company, but afterwards, it could be manufactured in Shanghai.

The reducers made in China now are too voluminous to meet the same technical features and besides, the ball-bearings used to take-up the axial stress cannot be found.

This changement would involve a complete alteration of the extruder (refer to chapter VI, draft).

7. Concrete frame.

At the present time this frame is made from concrete reinforced with metallic fibers according to a process developed at the INIEX institute located in Liège (Belgium).

I personally believe that this sort of material cannot be made in Shanghai. So, this frame can be shaped with founded cast iron. This process is more simple.

8. Chassis and body of the extruder.

I personally see no problem to find a boiler-works for the supply of the different parts according to the working plan.

9. Granulation.

The granulation consists of a screen changer, a central hydraulic station, a cooling tank provided with a calender and a cube dicer.

When the next extrusion line is installed, the cooling tank

will have to be lengthened of 1 meter as cooling water has not a temperature low enough in this area.

As far as the cube dicer is concerned, good machines are existing in the Chinese market. This type of cube dicer could be used efficiently provided that slight modifications would be brought.

V. VISIT TO SEVERAL COMPANIES

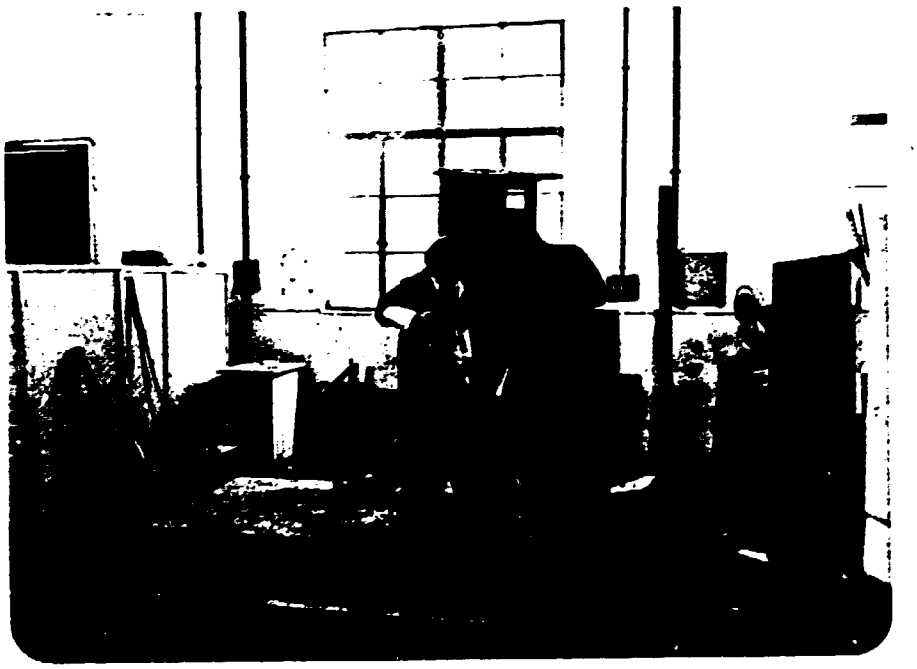
1. Shanghai Package Instrumentation Plant.

   73, CAO BAO road - Shanghai

   Mr. ZHANG EN-CI - Technical Director.

This company is specialized in the manufacturing of control cabinets and panels. They work sheet-iron essentially that is 5 mm thick maximum.

SRRUC company could subcontract the different parts made in sheet-iron that are included in the extrusion line i.e. the water tank, the extruder body and other component parts according to working plan.



2. Shanghai Electric Assemblies Works S.E.A.W.

760, SI PING Road - Shanghai

Mr. ZHOU HE MING - Chief Engineer.

During that visit I was accompanied by the following persons :

- Mr. XIA SHIMING, Engineer, SRRUC.
- Mr. ZHANG SHUNRONG, Deputy Director, Xing Guang Plastics.
- Mr. LIU BAOPING, Deputy Director, Xing Guang Plastics.
- Mr. OU JIN, Xing Guang Plastics Factory

The SEAW factory is specialized in the manufacturing of electric cabinets and direct current panels.

They use material of very good quality and essentially "BBC" components manufactured in China.

The SRRUC company could use this factory as a subcontractor for the manufacturing of the electric cabinets included in the extrusion line.

3. Shanghai Sixth Automation Instrumentation Factory.

Qing Pu - Shanghai - China

Mr. HONG ZHAO JIAN, Vice Director.
Mr. CHEN ZONG HAO, Chief Engineer.

During that visit I was accompanied by the following persons :

- Mr. XIA SHIMING, Engineer, SRRUC.
- Mr. ZHANG SHUNRONG, Deputy Director, Xing Guang Plastics.
- Mr. OU JIN from Xing Guang Plastics Factory.

This company is specialized in the temperature regulation necessary for the granulation.

In the future they could supply all the measuring instruments necessary for the installation of the extrusion line.

VI. DRAFT BETWEEN SRRUC AND RHEO S.A.

Here are the minutes of the meeting and discussions held on April 21, 1989 in Shanghai concerning the follow-up cooperation between the Shanghai Resource Recovery and Utilization Company from China and RHEO S.A. from Belgium.

Participants :

SRRUC

Mr. Zhu Kexi, Deputy Manager, SRRUC,

Mr. Xia Shiming, Engineer, SRRUC,

Mr. Zhang Shunrong, Deputy Director, Xing Guang Plastics Factory,

Mr. Liu Baoping, Deputy Director, Xing Guang Plastics Factory,

Mr. Zhang Guochang, Interpreter, SRRUC.

RHEO S.A.

Mr. Vincenzo Sciascia, Project Manager, RHEO S.A.

An agreement was reached by both parties on the following points :

1. Both parties, SRRUC and RHEO S.A.,expressed satisfaction with the UNIDO Workshop on Waste Plastics Recycling Technology held in Shanghai as scheduled, and especially with its significant influence on the experts and delegates attending the Workshop from different provinces and municipalities in China and those from different South East Asian countries.

2. The Chinese party will immediately submit an official request for follow-ups of the project US/CPR/86/130 to UNIDO authorities through CICETE, the Ministry of Foreigh Economic Relations and Trade.

3. RHEO S.A. expressed confidence and optimism for convincing the Belgian government to provide further financial help for achieving the UNIDO Project US/CPR/86/130 with the whole set of the densification line.

4. After visiting several electric appliances and machinery manufacturers in Shanghai, Mr. V. Sciascia believed that Shanghai is capable of producing all the necessary accessories for the extrusion line except for the short screw, cylinder and reducer but he did not exclude the possibility of manufacturing the reducer in Shanghai some time later.

5. SRRUC expressed willingness to recommend the RHEO 120 type extrusion line to all representatives of resource recovery and utilization companies coming from different provinces to attend the Profession Conference to be held in July, 1989 in Qingdao.

SRRUC would also make the same recommendation to the visiting members from the World Union of Cooperation with the aim of obtaining more purchase orders for the extrusion line.

6. SRRUC wished to be an authorized agent to sell the extrusion lines produced by RHEO S.A. in Belgium.

7. SRRUC had the obligation of not distributing any kind of technical data or drawings concerning the manufacturing and production of the Belgian patented short screw, cylinder and reducer.

The minutes of the Meeting and Discussions are to be prepared in 4 (four) copies and signed by the representaives of both parties, and each party will hold 2 (two) copies.

Signed by :

Mr. Vincenzo SCIASCIA
Project Manager
RHEO S.A.
April 21, 1989
in Shanghai

Mr. Zhu KEXI
Deputy Manager
SRRUC
April 21, 1989
in Shanghai

VII. THANKS

I should personally like to thank very sincerely the SRRUC and the Xing Guang Plastics Recycling Factory team for the kindness and efficiency with which they allowed me to perform my missiom as expert in Shanghai.

Messrs : Zhu Kexi, Deputy Manager from SRRUC.

Xia Shiming, Engineer from SRRUC.

Liu Baoping,Deputy Director from Xing Guang Plastics.

Zhang Shunrong, Deputy Director from Xing Guang Plastics.

A N N E X E II

F I N A L R E P O R T

EXPERT MISSION AT THE SHANGHAI

Resource Recovery and Utilization Company

US/CPR/86/130/11-03/J1340

PLASTIC RECYCLING DEPARTMENT

SHANGHAI : People's Republic of China

03 to 29 June 1988
United Nations Industrial
Development Organization

Vincent SCIASCIA
Industrial Engineer
Project Manager
RHEO. S.A.
BELGIUM

Plan of the report.

I. Description of the expert mission.

II. Installation of equipments.

III. Start-up and operational instructions.

A. Extruder line.

1. Extruder PRH120.
2. Screen changer.
3. Hydraulic unit.
4. Calender and cooling tank.
5. Cube dicer.
6. D.C. power panel.
7. Extrusion line control panel.

B. Microniser line.

C. Note.

IV. Integration of the equipments.

A. Extruder line.

1. Integration of the equipment for P.E.
2. Integration of the equipment for soft PVC.
3. Final flow sheet.

B. Microniser line.

V. Optimization of the recycling line and recommendations.

1. Extruder line.

2. Microniser line.

VI. Conclusions.

VII. Thanks.

I. DESCRIPTION OF THE EXPERT MISSION.

The purpose of the mission was the following :

Date of arrival in Shanghai : 3rd june 1988.

Date of departure from Shanghai : 29th june 1988.

To realise a recycling system for plastics waste adapted to the needs of the country and integrated in a general programme of the SRRUC for waste recycling,the expert will be expected :

1. Survey the installation of delivered machinery, i.e. plasticiser and microniser and other accessories for plastics recycling.
2. Start-up the recycling line.
3. Give the necessary operating instructions to the Chinese technicians.
4. Discuss about the integration of the equipment in a complete recycling line.
5. Integrate existing equipment in the new recycling line.
6. Give instructions on how to use existing and new equipment for technical and economical optimization of the recycling line.

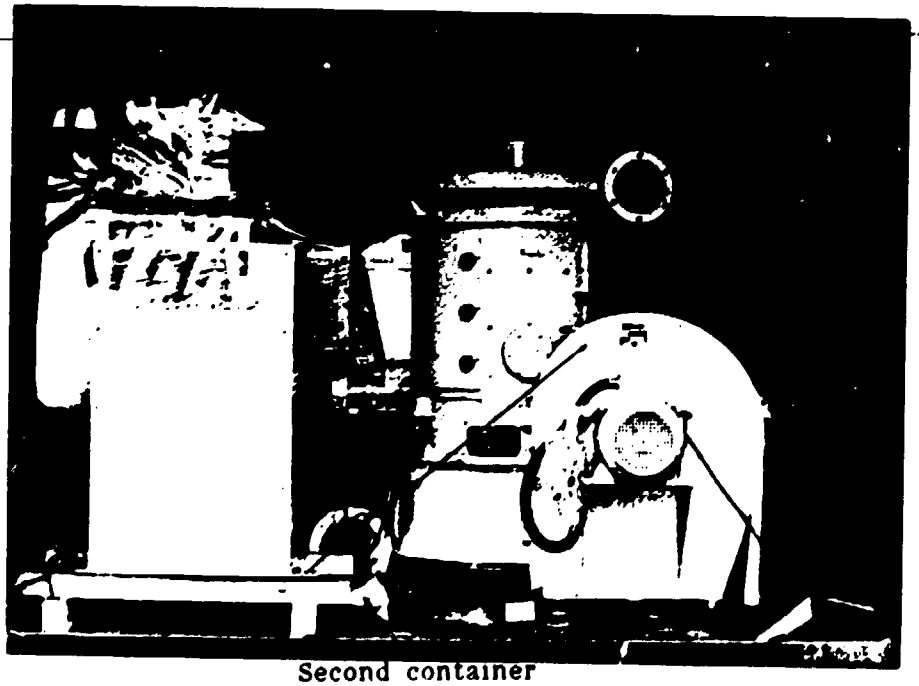
The expert will also be expected to prepare a report setting out the findings of his mission and recommendations to the Government on further action which might be taken.

II. INSTALLATION OF EQUIPMENT.

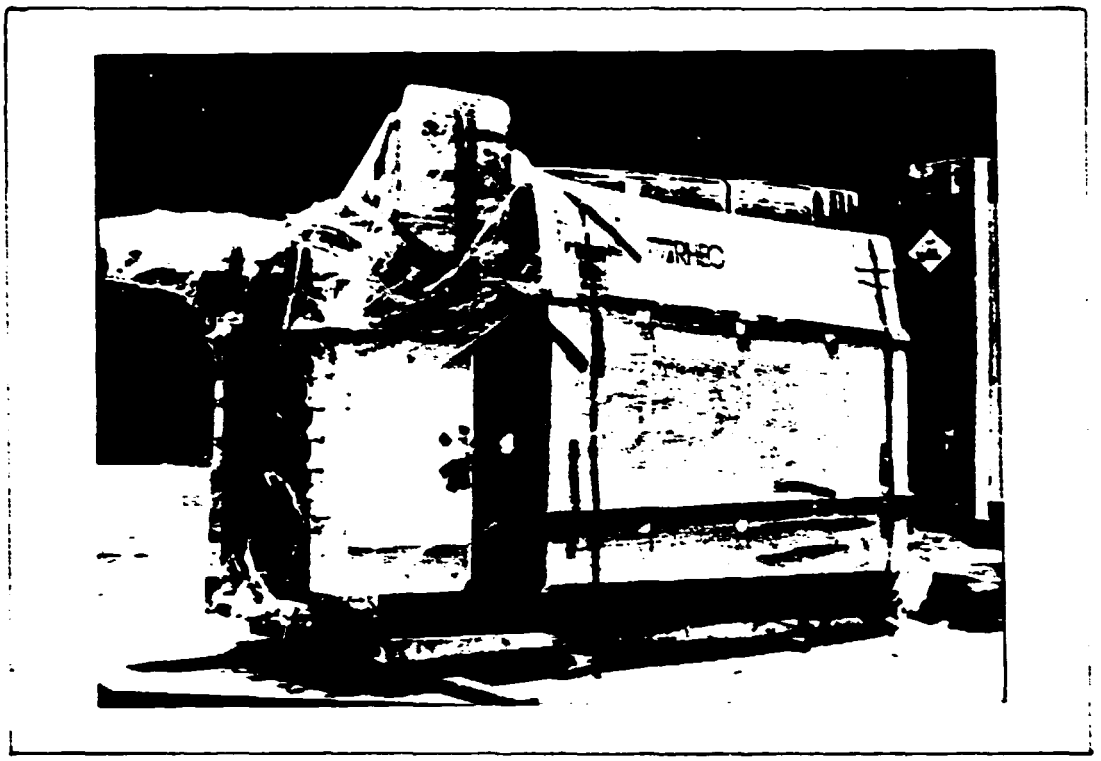
Date : - Sailing of ship : 18th april 1988 (from Antwerp).
- Unloading of ship : 22nd may 1988 (Shanghai).

This material was shipped by RHEO and reached SHANGHAI by sea. The extruder line had been installed inside the first container for shipping while the microniser line was placed inside the second container.
During transportation the shipped equipment was not damaged.

First container



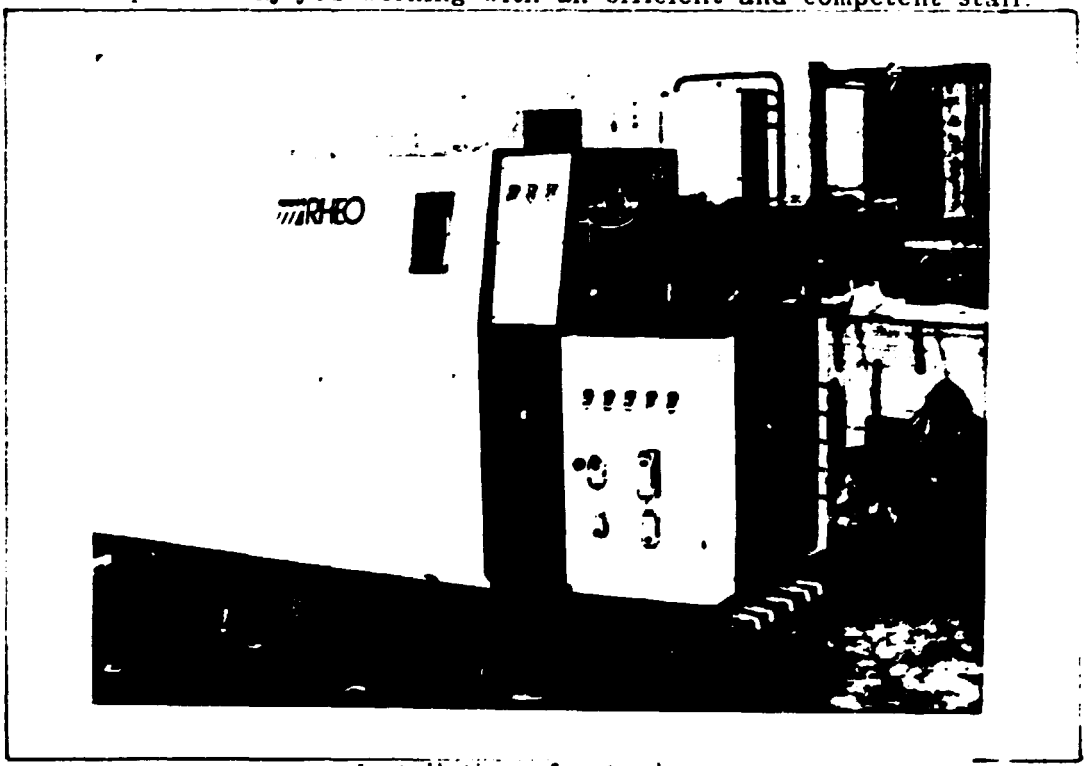
Second container



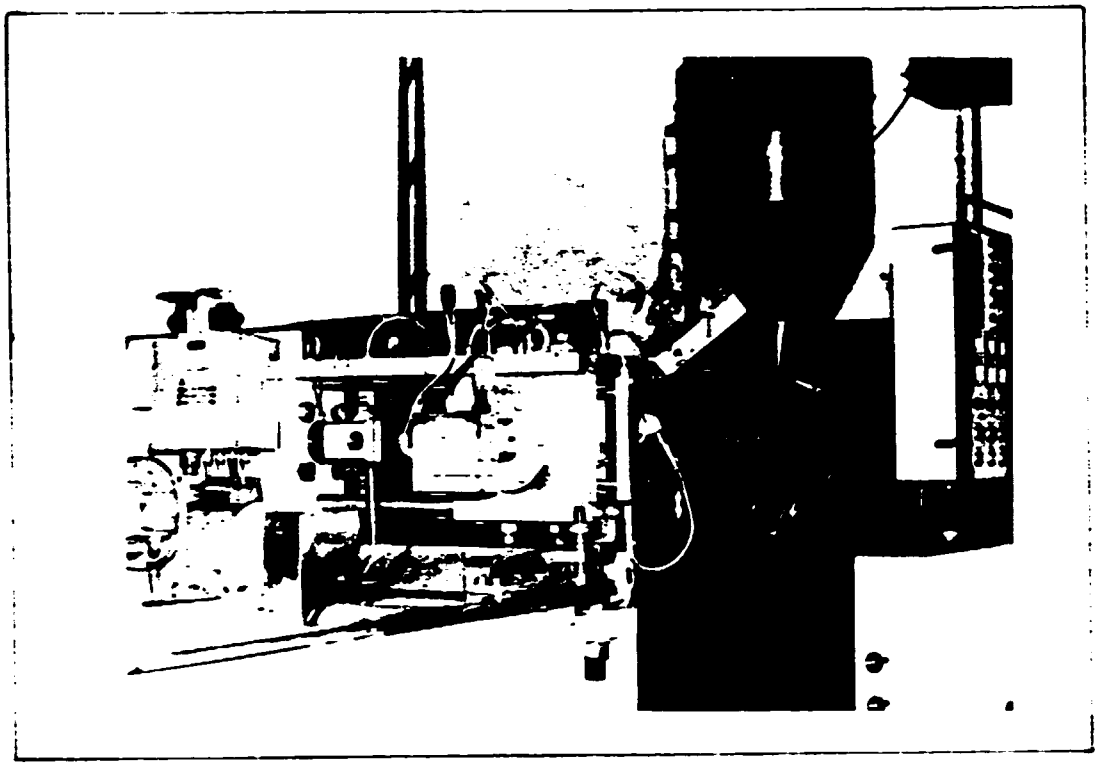
Extruder PRH 120

The assembly and installation of extruder and microniser lines were carried out together with the personnel of XING GUAN Plastics Recycling Company.

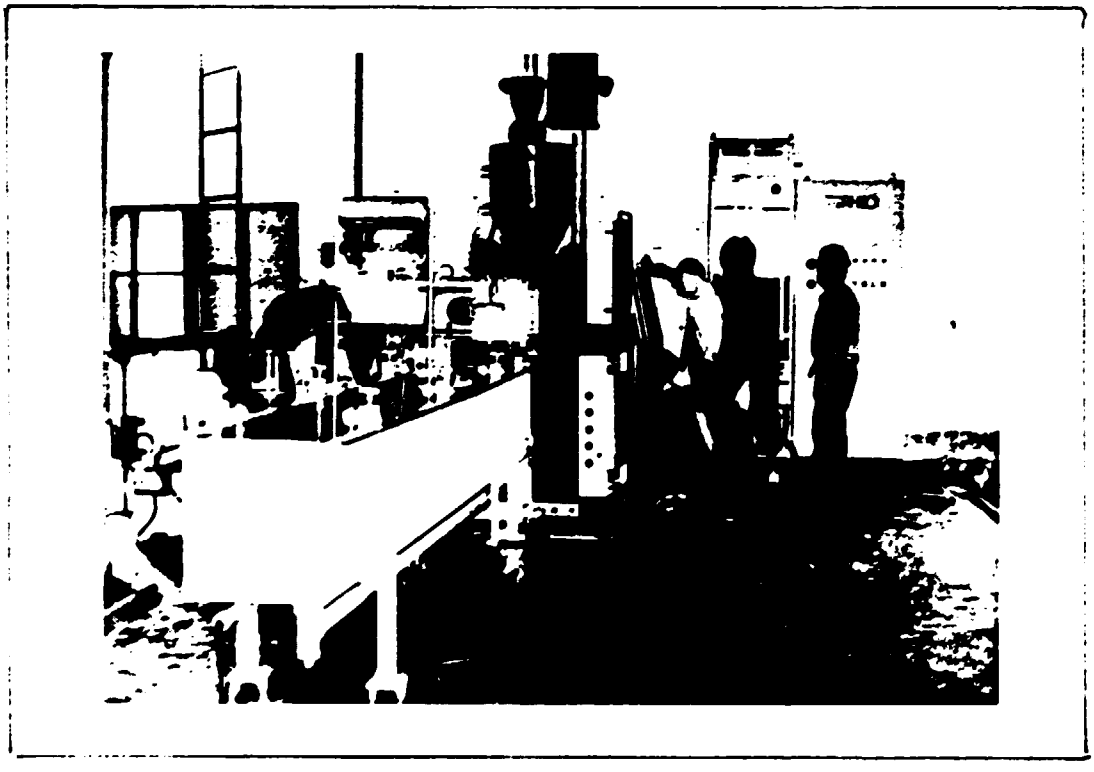
On the spot we enjoyed working with an efficient and competent staff.



Installation of extruder

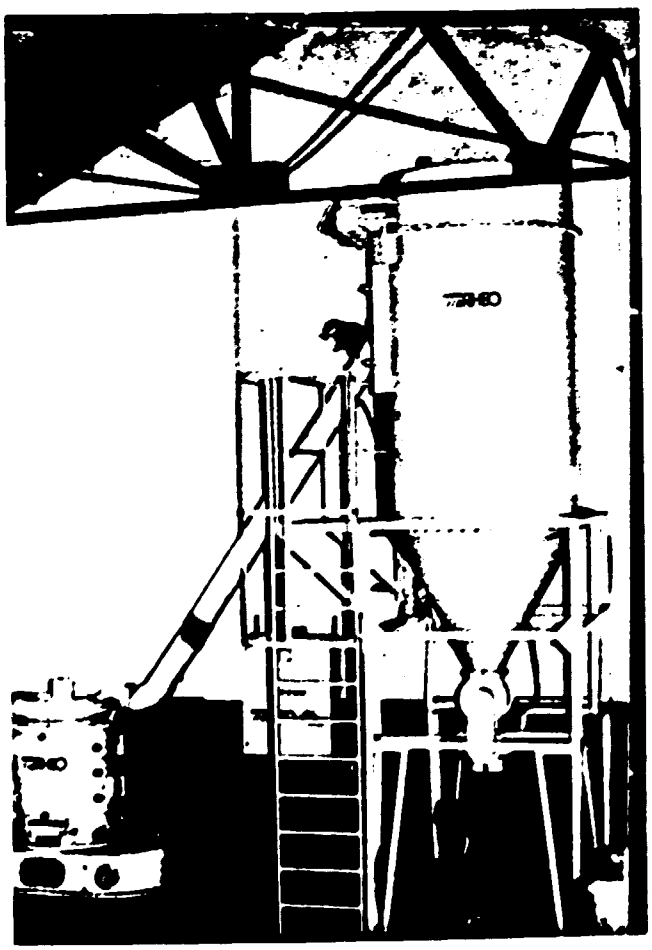


screen changer and calender.



Extruder + screen changer + calender and cooling tank.

Extruder line.



Micronizer line.

III. START-UP AND OPERATIONAL INSTRUCTIONS.

The extruder line and microniser line were put into service with the help of all customer technicians from XYNG GUANG Plastics Company.

For each machine we gave the instructions for the start-up together with the safety instructions.

A. Extruder line (refer to drawing n° 87/59/MK/1057)

1. Extruder PRH 120.

- Checking the rotation direction.
- Starting the main motor (111 kw).
- Checking the cooling system of main motor.
- Checking the various safeties (thermal, ventilation, pressure, ...).
- Rotation direction of mixer located in the feed hopper.
- Instructions for lubrication.
- Checking the cooling circuits for the following parts :
  - . reducer;
  - . screw of the extruder;
  - . feed hopper;
  - . feed cylinder;
  - . plastification cylinder.

2. Screen changer.

It is hydraulically operated and a pressure gauge is fitted into it. The reason is to advise the operator by means of an alarm system connected to the pressure gauge when a filter change is required.

Inspection : . heating resistance;
. temperature regulator;
. pressure gauge.

3. Hydraulic unit.

The screen changer is supplied with a hydraulic unit composed of a welded steel sheet oil tank with external level indicators, filling cap with filter, inspection door for discharging outlet.
The gear pump is mounted coaxially to the valve with manometer on-off pressure switch and hydrogen accumulator.

Inspection : . motor rotation direction;
. overload;
. working pressure.

4. Calender and cooling tank.

The unit consists of a calender that permits to obtain a strip with constant thickness. Moreover, speed is adjustable (frequency converter).

A safety is located at the foot and permits to reverse the rotation direction in case of incident. Finally, a blower permits to dry the strip.

Inspection : . rotation direction;
. overload of each motor;
. adjustment of calender linear speed;
. instructions for adjustment of frequency converter for calender engine;
. adjustment of drying blowers to the obtained width of strip;
. instructions for lubrication.

5. Cube dicer.

This unit permits to obtain cubic pellets (3x3 mm) from a 3 mm thick and maximum 125 mm wide strip.

Inspection : . overload;
. rotation direction;
. instruction for adjustment of frequency converter for driving and cutting engine;
. instructions for lubrication;
. various safeties.

6. D.C. Power Panel.

It contains all the power and control components of the extruder motor located on the panel. A fault spotting system is fitted in case of eventual break-down of the unit.

7. Extrusion line Control Panel.

It includes all the elements of power and protection of the cooling fans, hydraulic units, cube dicer and all the temperature control instruments of the extruder and screen changer.
All the machines are fitted with interblocks for operating mistakes. Each element can be operated separately and an alarm system is operating in case of breakdown and will draw the operator's attention.

B. Microniser line. (refer to drawing n° 87/59/MK/1057).

The microniser consists of :

one vertical rotor with 4 centrifugal plates. Each plate is equipped with 24 adjustable and interchangeable turbine plates. There are 4 intake holes. Three of them are provided with adjustable rack slides for regulating the quantity of the inflowing air. The overflow is

flanged to the fourth intake hole. The overflow is infinitely variable to recirculate oversized particles.

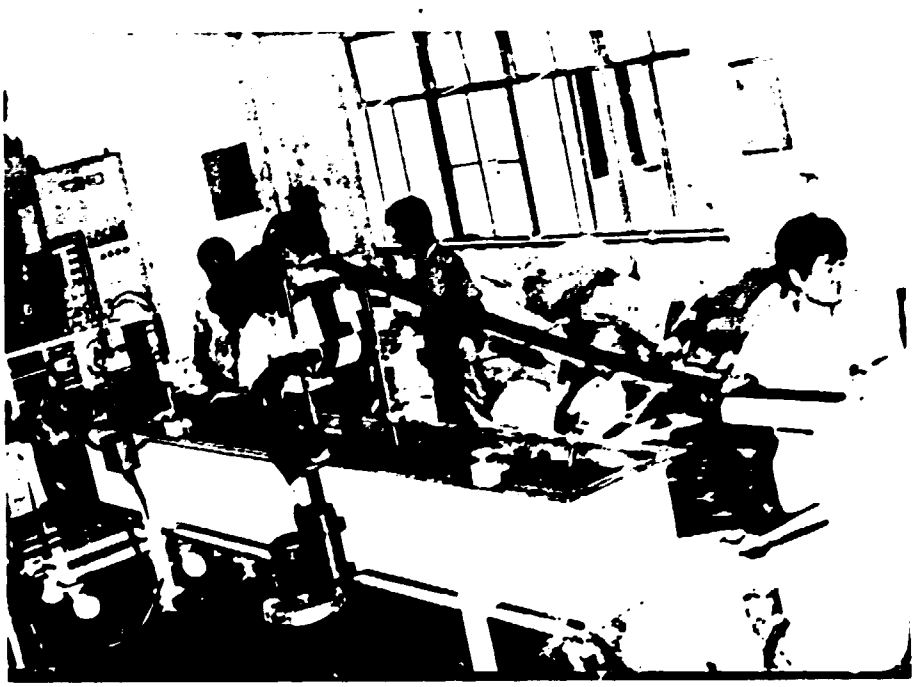
The filter-cyclone has 16 m2 filter area for cleaning 50-200 m3 air per minute. The control of compressed air for cleaning the filter hoses is effected by 5 electromagnetic valves which are installed on top of the filter. The impulsion for these compressed air blasts is given by electronic timer.

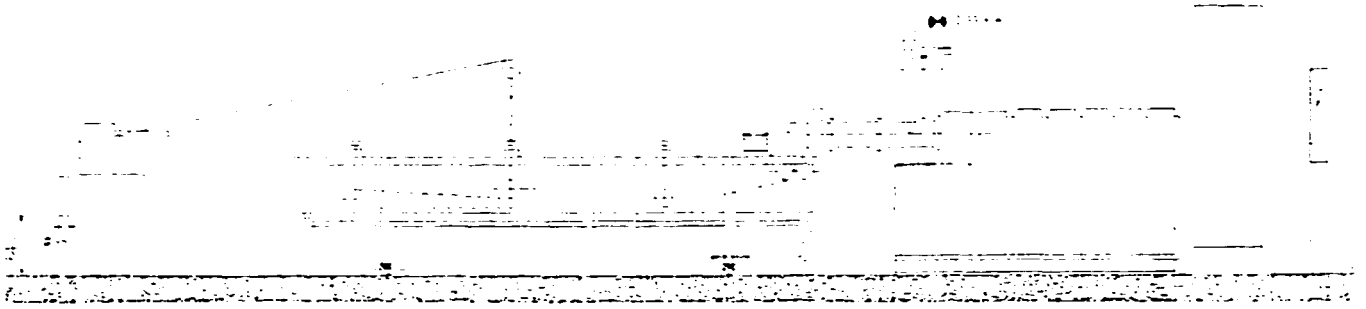
Inspection : . overload for each motor;
. instructions for lubrication;
. direction of rotation;
. line safeties;
. electronic timer control;
. temperature probe;
. depression gauge in the cyclone-filter.

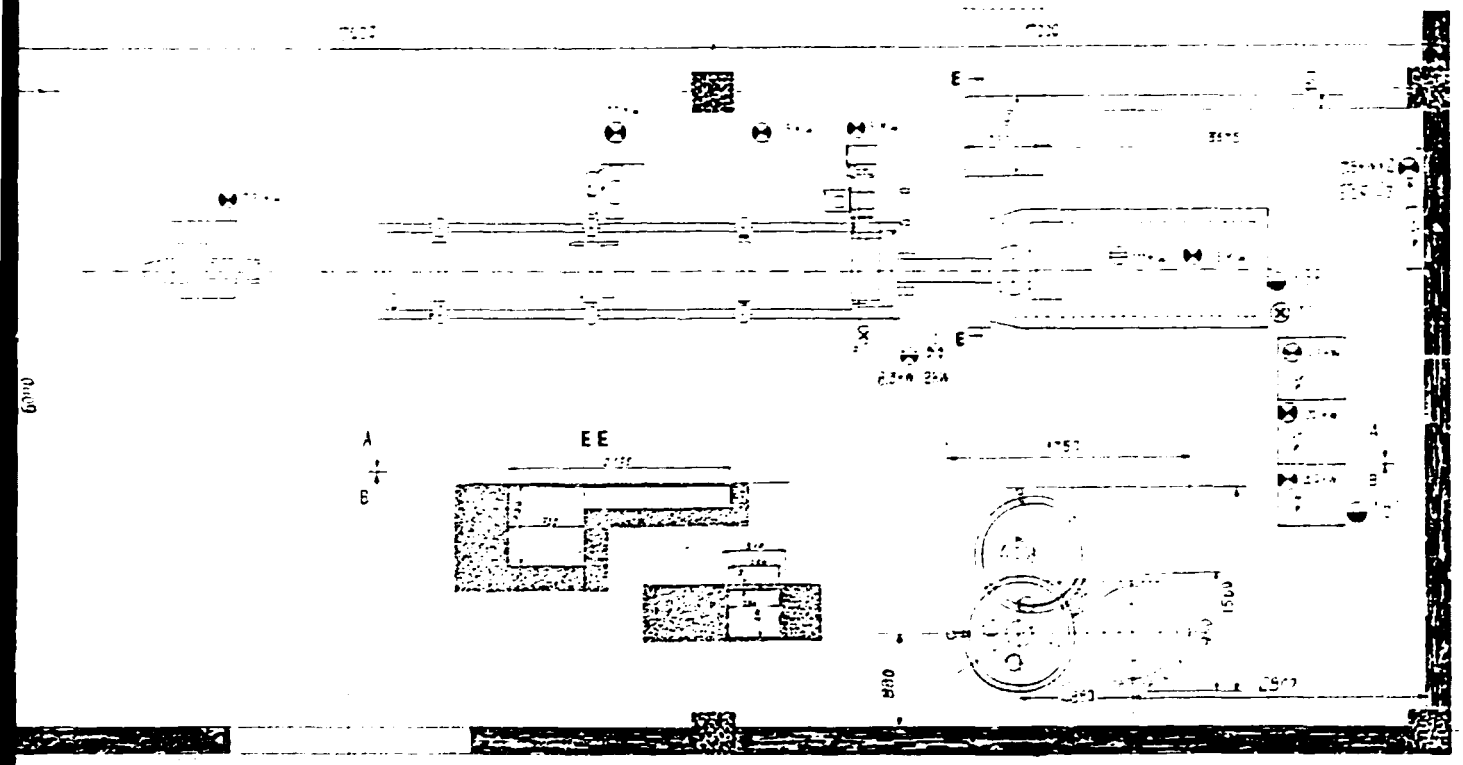
C. Note.

The starting phase with the polymers has been performed with M. Andre NOIRHOMME

(refer to report, chapter 3.5)



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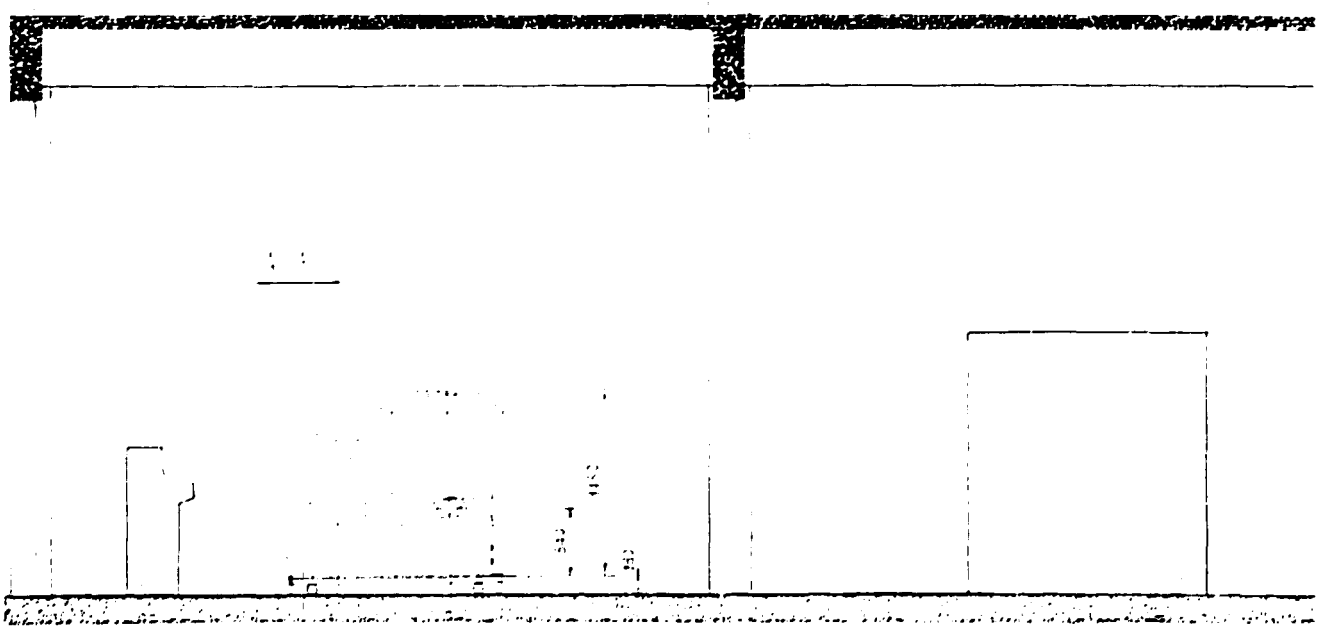


IV. INTEGRATION OF EQUIPMENTS.

A. Extruder line.

1. Integration of equipments for P.E.

During our first discussion with M. Zhang Descing, the latter explained us how Xing Guang Plastics Company would like to integrate the new extruder line manufactured by RHEO S.A. Company.

The flow sheet was the following :

- Washing.
- Cutting.
- 1st. filtration and granulation.
- 2nd filtration and granulation (extruder PRH120)

The first filtration and granulation would permit to perform a pre-densification. But during the first tests, we noted that the material had a too high degree of moisture. This could not be accepted by the next extruder.

The Xing Guang Plastics Company had a mixer operating at high speed and provided with heat while in use.

A test was then carried out in order to know if this high speed mixer could have been used as densification unit.

The principle is the following :

while agitating machine is turning at constant speed, the temperature is increased in the agitating-mixing room until the material is agglomerated.

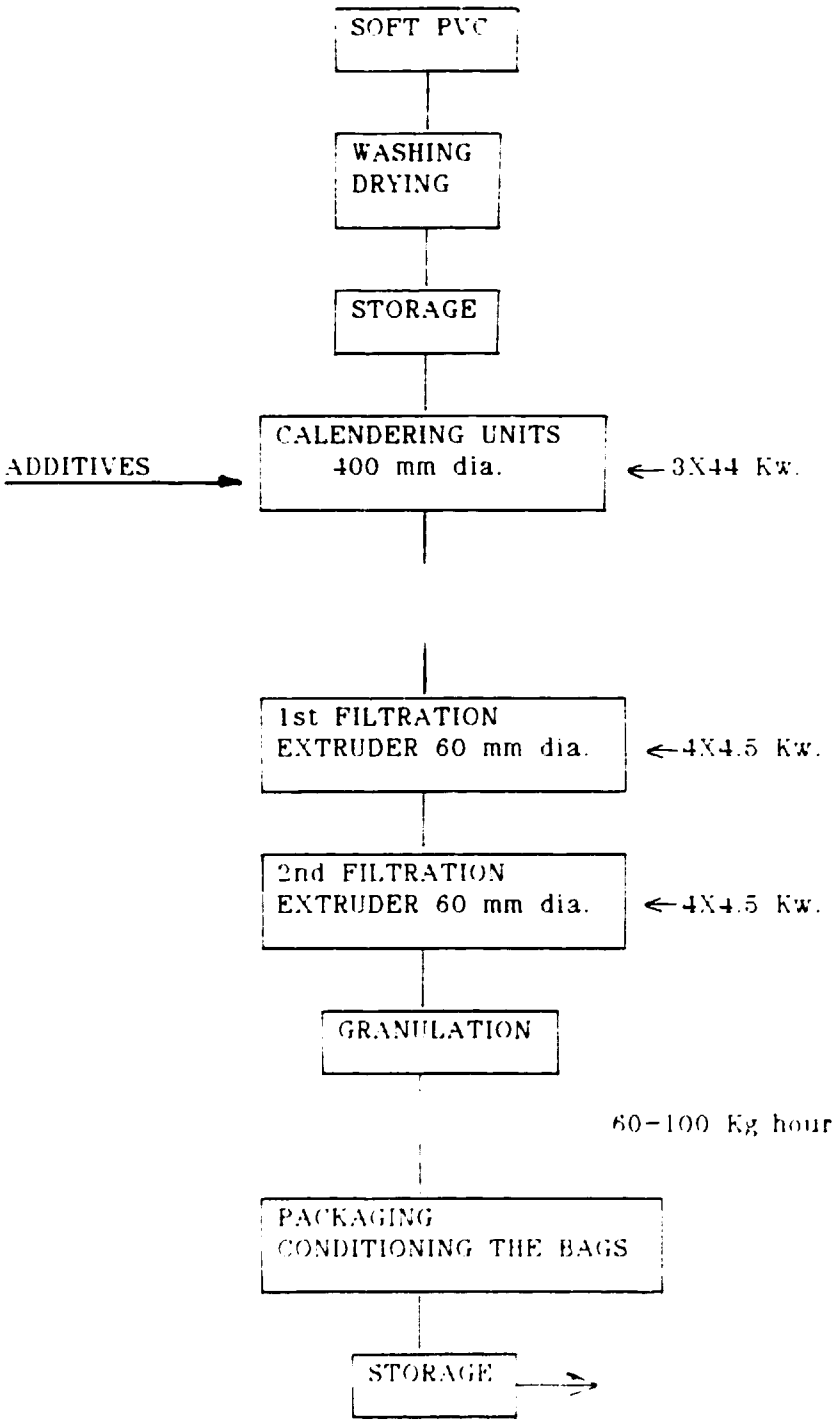
Water is injected to prevent the agglomerates from sticking to one another and also on room walls.

When coming out, the wastes are shaped like densified material.

After several tests, the result obtained was suitable. Densification was acceptable so that the new extruder line could be operated under proper conditions. (Refer to report written by A. Noirhomme for the result obtained in production, chapter 2.5). See final flow sheet, section 3 and sectional drawing of line.

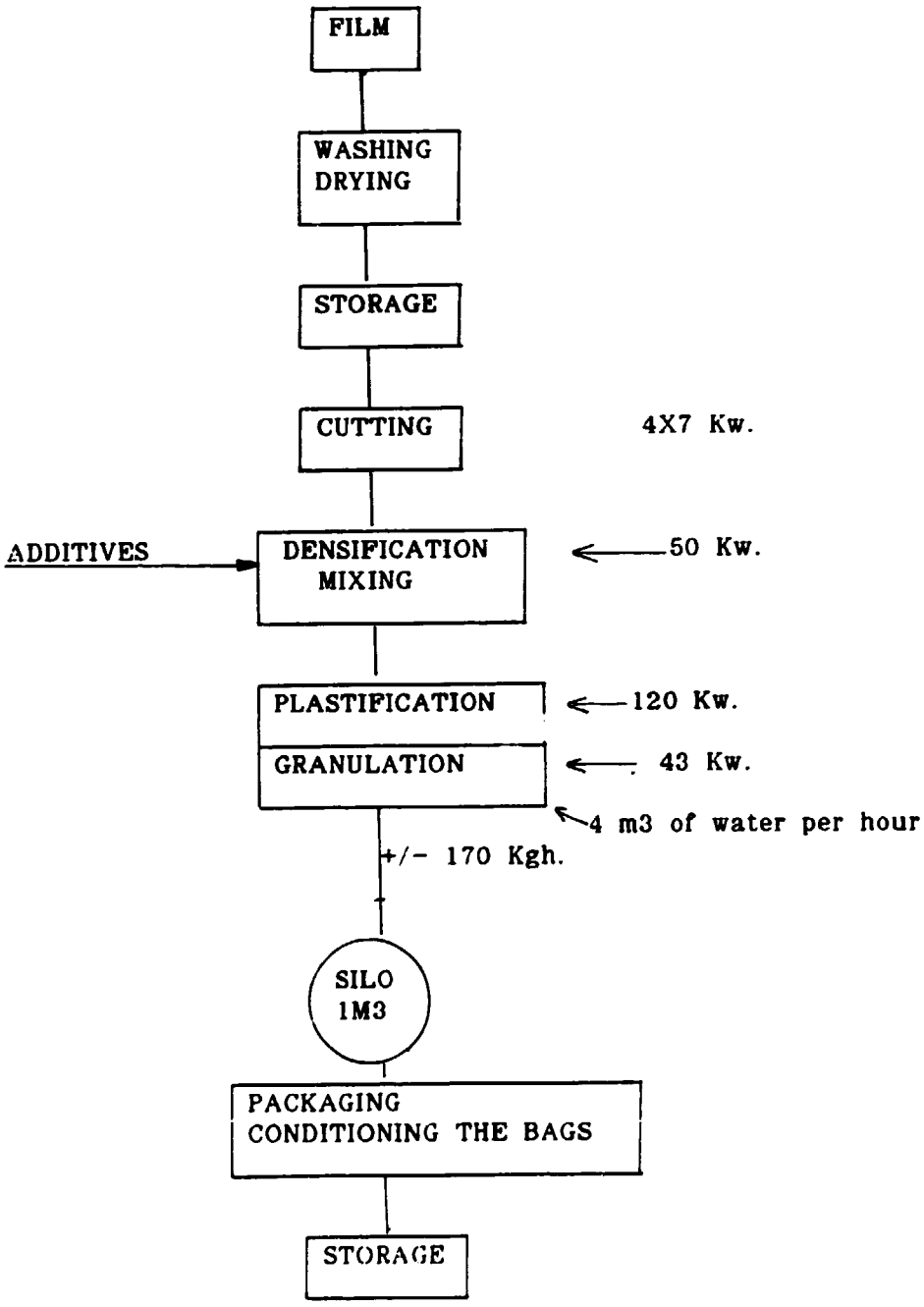
2. Integration of equipment for soft PVC.

The flow sheet was the following :



3. **Final flow sheet : film PVC/PE.**

Situation : end of experts mission



Notes : The Kws represent the installed power.

Following the excellent result obtained on the P.E., the same tests were carried out on the plasticized PVC.
Excellent results had been obtained. (Refer to report from M. André Noirhomme, chapter 5.).

Owing to these results, the Xing Guang Plastics Company decided to remove the 3 calendering units located out of the same room as the new extruder line and installed the high-speed mixer.

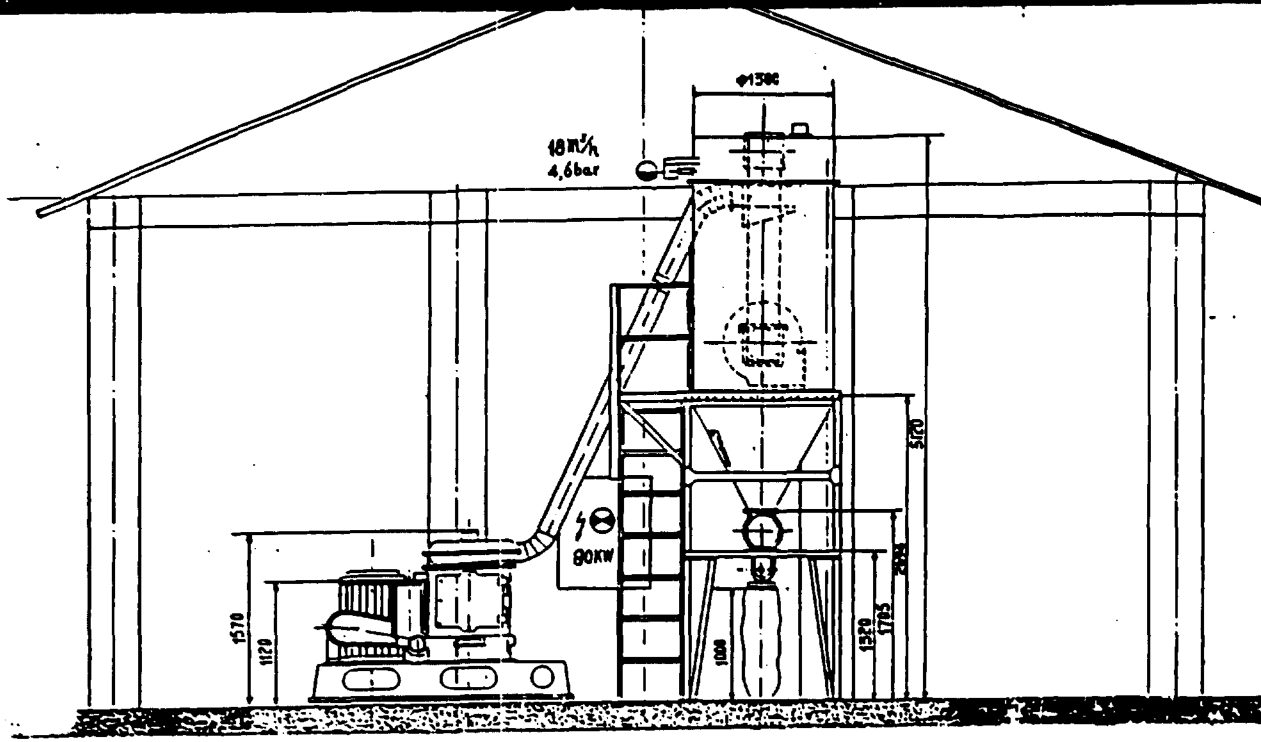
(Refer to final flow sheet, section 3 and sectional drawing of line).

B. Microniser line.

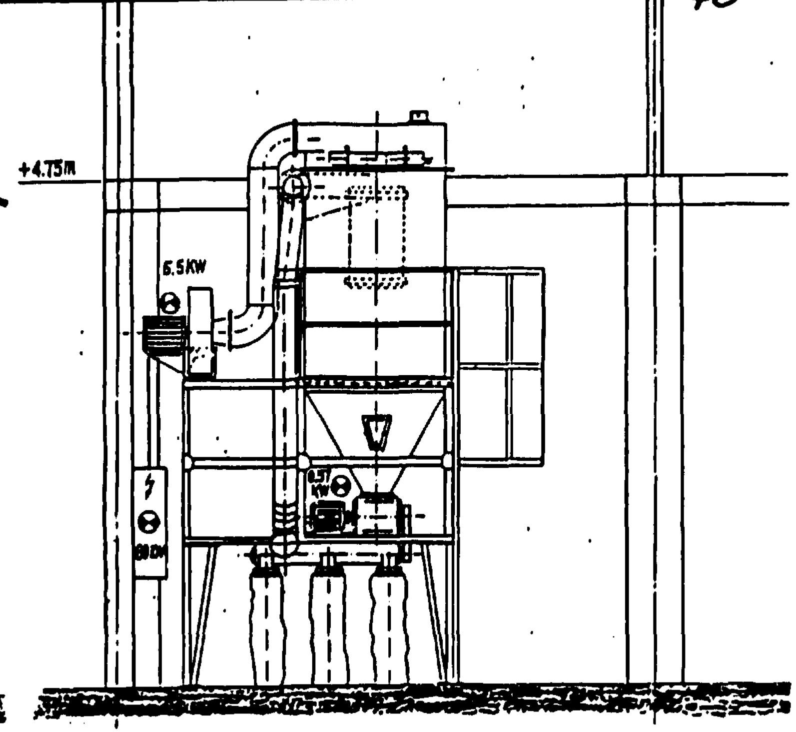
The microniser line was installed in another building than that foreseen for the following reasons :

- noise.
- Height of cyclone-filter.
- Two lines close one from another were separated. (see lay-out of RHEO company, drawing n° 87/59/MK/1057)
- The plastics to be treated were different. (soft and rigid).

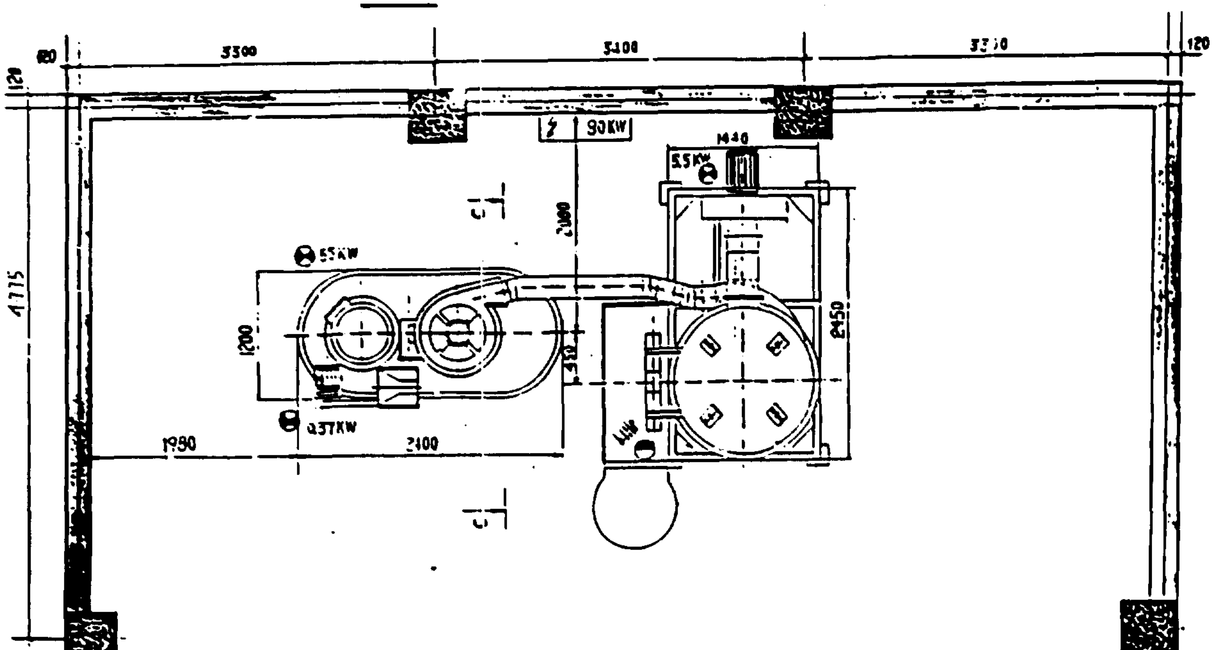
So, it was more reasonable to dispose of two separated places. (refer to drawing).



D 向



C-C 向



微[illegible]机平面图 比例 1:50

设计.制图: 刘[illegible]

70

V. OPTIMIZATION OF THE RECYCLING LINE AND RECOMMENDATIONS.

1. Extruder line.

We recommended to install a feeding screw in order to feed the extruder in the hopper . This avoids that a technician must remain on the extruder cover plate continuously. The technical data had been given to the managers of the company. These told us they would do what was necessary. RHEO S.A. had already foreseen two level indicators on the feed hopper in order to control automatically the feeding screw.

We noted that content of mineral waste (sand) was important in the polymers. It became urgent to solve this problem because the lifetime of wear parts would be reduced very much (extruder screw, cylinder, granulation cutter, etc...). This problem could be solved by improving the cleaning of film. This could be done with appropriate equipment that would perform the following operations :

- Cutting.
- Washing.
- Separation (PE, PVC, minerals, waste particles).
- Drying.

2. Microniser line.

In the present time Xing Guang Plastics Recycling Company is presenting a lack of rigid plastic adapted to the microniser (during our mission in Shanghai we only micronized +/- 100 Kg of plastics).

In the future they would like to be able to extend the use of this line. They do want it anyway.

For instance, they would like to micronize the aluminium wastes (important added value).

This wider diversification and this type of recycling are already used in Europe.

This technique consisting of a line for aluminium is used and mastered by RHEO company.

The following modifications should be brought :

- Cyclone adapted to aluminium.
- Adequate filter.
- Modification of microniser feeding system.
- Extraction fan.
- Modification of electric cabinet.
- A two-stage separating screen.

VI. CONCLUSIONS.

At the end of the mission the microniser and extruder lines were complete and their utilization met the requirements specified in the contract concluded between RHEO and UNIDO.

Four copies of all technical brochures and drawings have been supplied to Xing Guan Plastics Recycling Company i.e.

User's and maintenance manual for microniser and extruder lines.

All the technicians responsible for this project have examined the technical documentation carefully and are able now to use this information efficiently.

Common conclusions.

a) The problem of densification is solved i.e.
two densification units are already installed;
total capacity : 400 Kg/hour and present capacity of plastification : 200 Kg/hour.

b) We deeply recommend what is following :

1. To increase the quantity of spare parts in Shanghai.

The following parts are absolutely necessary :

- grooved feed jacket
- plastification cylinder
- air gap
- screw nose
- extruding screw
- honeycomb or filter holder
- screwing-die
- several sets of cutters for granulator.

2. To use high-capacity crushing-washing machine that can permit :

   - to remove foreign bodies (sand, dust, ...)
   - to increase the quality
   - to increase the crushing capacity
   - to reduce materials handling
   - to reduce moisture

3. To install a second plasticiser parallel to the first. It would be fed with the second densification unit. This machine could be operated with a motor made in China.

4. Owing to the cheerful expectations of installation of additional modules, it is high time that we write down together the preliminaries of a joint-venture agreement.

VII. THANKS.

I should personally like to thank very sincerely the SRRUC and the Xing Guan Plastics Recycling Factory team for the kindness and efficiency with which they allowed me to perform my mission as expert in Shanghai.

Messrs : ZHU KEXI
ZHANG DEXING
XIE SHI MING
WU ZHONGQING
LIU-BAO-PING
LIN XIN ZHONG
ZHANG GUO CHANG.

A N N E X E III

RHEO S.A.
3, rue A. Renard
5210 Seilles
Belgium

F I N A L R E P O R T

EXPERT MISSION AT THE SHANGHAI

Resource Recovery and Utilization Company

US/CPR/86/130/11-04/J1340

PLASTIC RECYCLING DEPARTMENT

SHANGHAI : People's Republic of China

08/06 to 06/07/1988
United Nations Industrial
Development Organization

Noirhomme A.
Product Manager
S.A. RHEO
BELGIUM

PLAN OF REPORT

I. Location and purpose of the mission.

II. Job description.

III. General description of the mission.

3.1. How to survey the installation of delivered machinery, i.e. plasticiser, microniser and accessories for plastics recycling.

3.2. How to give operational instructions to the Chinese technicians.

3.3. How to give detailed instructions for the operation of the machines for different materials.

3.4. How to prepare a user's manual, containing all necessary operations and repair instructions.

3.5. Integration of pilot unit.

3.5.1. Plasticiser.
3.5.2. Microniser.

IV. Special findings.

V. Future Industrial Development between SRRUC and RHEO S.A.
Report on the findings of the mission and recommendations to the Government on further action which might be taken.

VI. Conclusions.

VII. Thanks

I. LOCATION AND PURPOSE OF THE MISSION.

Shanghai is a densely populated industrial city which generates large quantities of waste material in the course of production and daily life, among which the post-consumer waste reaches 8 % and industrial waste 92 % of the total. The Shanghai Resource Recovery and Utilization Company (SRRUC) recovers at present sixteen categories of waste materials.

The company is divided into 12 districts in the city of Shanghai and has 10 suburban divisions, among which the Xing Guan Plastics Recycling Factory where the pilot plant is established. The total annual output is 2000 t. of which +/- 800 tons are recycled in PVC.

The project was to perform a recycling system for plastics waste, adapted to the needs of the country and integrated in the general programme of waste recycling of the Shanghai Resource Recovery and Utilization Company (SRRUC).

Date of arrival in Shanghai : June 8, 1988.

Date of departure from Shanghai : July 6, 1988.

III. DESCRIPTION OF THE MISSION.

3.1. How to survey the installation of delivered machinery i.e. plasticiser and accessories for plastics recycling.

3.1.1. Plasticiser

The machine was mounted according to lay-out established by S.A. RHEO.

Its installation and setting up permitted to work in good conditions.

All the following parameters have been observed :

- dimensions
- water-inlet
- evacuation of water and steam
- compressed air
- power supply
- working safety

One point must however be raised : the tension instability of main circuit.
Using an oscilloscope a deformed sine wave extended by micro-cutting off.
The distributor is not necessarily faulty because the malfunction can result from the proximity of induction machine.
An electronic module was therefore replaced by an equivalent component less sensitive to current fluctuations.

It must also be noticed that at the beginning of the mission the materials had to be supplied and tranferred by hand, while waiting for lifting screw and pneumatic conveyance provided by SRRUC.

This did not disturb the flows but necessitated that two additional workers had to be present continuously.

3.1.2. Micronizer

The micronizer was installed in accordance with S.A. RHEO requirements i.e. according to operating conditions and safety standard.

Its installation and functioning gave full satisfaction.

Moreover, this machine was installed alone in a separated room.

This involved the following advantages :

- facilitating the supply (stock reserve) and storage of finished product.
- avoiding logarithme accumulation of noise and impact of it on the workers.

3.2. How to give operating instructions to the Chinese technicians.

In order that each technician takes great advantage of the operating instructions and after having appreciated the in-house environment during the few days preceding the beginning of the courses, I thought it necessary and efficient to carry out as follows :

1. Generalities on the various plastics and some of mechanical features relating to the functioning of the machines (PE-PP-ABS-PVC-PS).

2. Operation (plastification, filtering, calendering, cooling, drying and granulations). General explanations - theoretic and practical courses in turn.

3. Beginning of the course with more details and supported by each element of the line (theoretic and practical).

4. Special features and handlings - particular precautionary measures.

Disassembly - replacement - adjustment - reassembly - lubrication and preventive maintenance were related in detail.

Most of the special cases occurred since the birth of extruder were explained.

Lines of conduct had been determined in order to solve as quickly as possible eventual problems.

NOTES.

a. The key-points as well as the operating procedures, maintenance and manufacturing procedures had directly been translated into Chinese so as to issue or post copies of them as quickly as possible (see attached example).

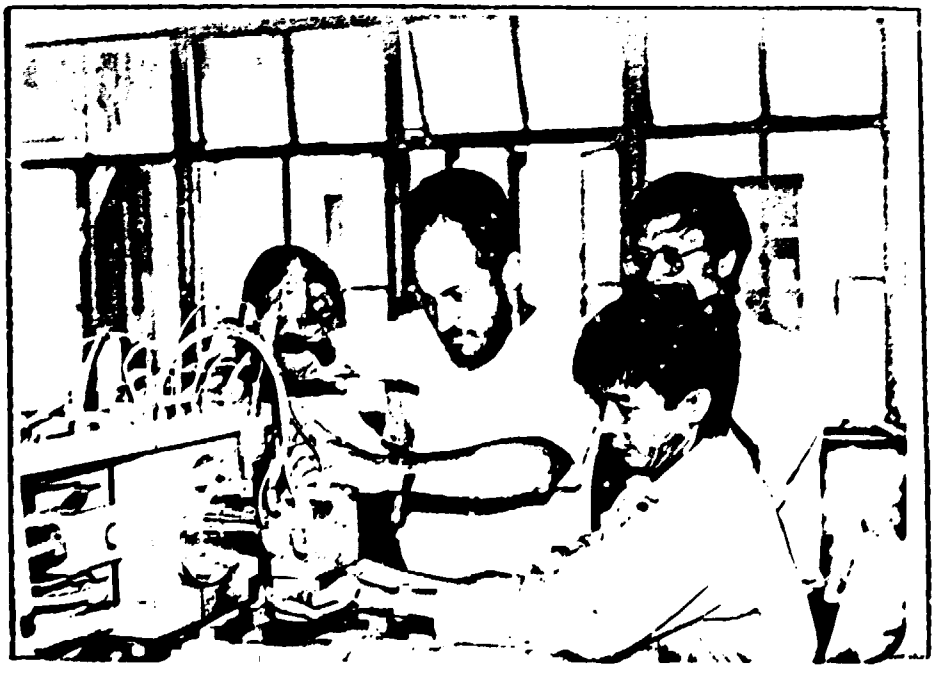
b. Most of the problems involved in the utilization of a new line on a local product and its integration in an existing line had been explained and solved with the close cooperation of the Chinese technicians and their managers.

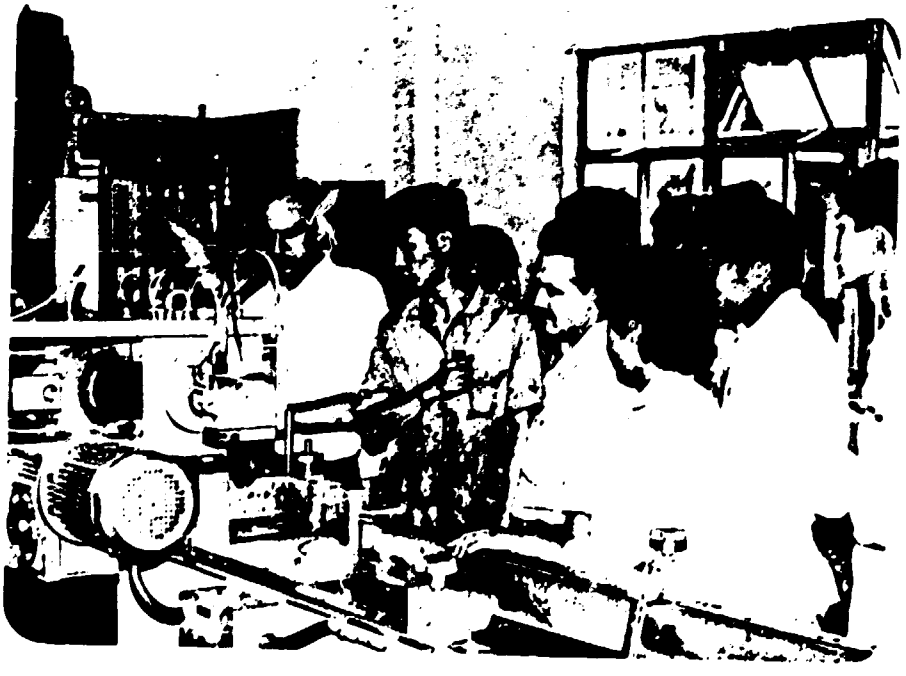
c. I had been able to carry out my mission efficiently thanks to an excellent team spirit and ideal working environment.

After each session we used to speak i.e. questions and answers in order to verify the comprehension and follow-up of the technicians. We also went into more detail for certain point at the technicians' request.

In case of lack of knowledge or comprehension of some peculiar maintenance, the latter was repeated until it was understood by all the technicians.

Example : discussion - design and modification of a screwing-die.





3.3. How to give detailed instructions for the operation of the machines for different materials.

These instructions had been given to all the production workers as well as the maintenance staff.

In turn between lecture room and workshop, the detailed instructions had been given as follows :

1. General description of line and its components.

2. Detailed explanation of each component.

3. How to proceed with start-up and stop operations.

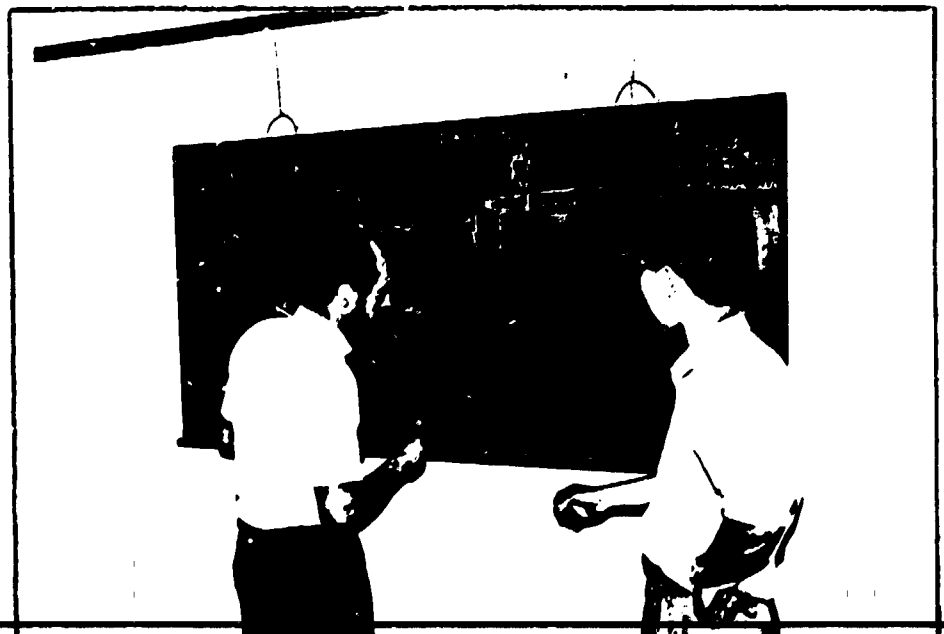
4. Safety instructions.

5. Explanation of each adjustment parameter and eventuals implications.

6. Examination and how to work out the various procedures in relation to the manufactured products as well as internal modifications i.e. replacement of screw nose and air gap, extruder screw, and adjustment of micronizer blades.

7. Optimization of quality and machine capacity according to the worked material.

8. Survey of production procedures. (Refer to example here below).
The operators used repeatedly to start-up, adjust and improve the machine productivity to become independent progressively.



a) **Plasticiser.**

At the end of the educational program the machine could be operated with 2 shifts.

A large number of technicians were able to operate the machine and one only was sufficient to operate it during lunch-time.

Materials used : PE and soft PVC independently.

b) **Micronizer.**

We disposed of two materials only i.e. rigid PVC and PS shock which quantity was reduced.

I had difficulties in showing the obvious performances of this machine.

PVC
Capacity : 200 Kg/hour.
Size grading : < 500 µ.
Man-power (labour) : 1 man.
Consumption of energy : 40 Kw.

PS SHOCK
Capacity : 150 Kg/hour.
Size grading : < 150 µ.
Man-power : 1 man.
Consumption of energy : 40 Kw.

As the micronized material returned frequently in the machine, handling and maintenance of it had been studied thoroughly.

3.6. Integration of pilot unit.

3.6 1. Plasticiser.

During the several tests carried out with production staff, initial program obviously appeared that it was not suitable.

The calendering operation (long, expensive and toxic) had to be followed by crushing.

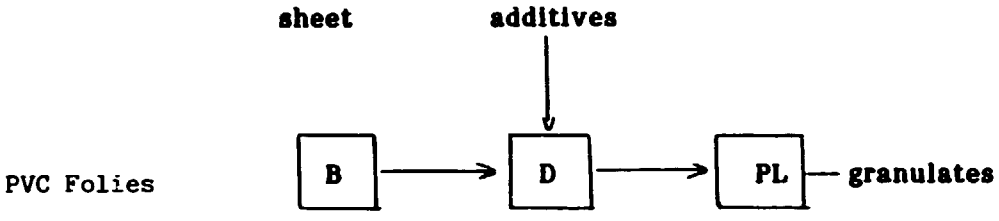
The crushed material obtained could not be compounded on the mixer.

On the other hand the plasticiser only admitted material having a density > 0.3 and very dry.

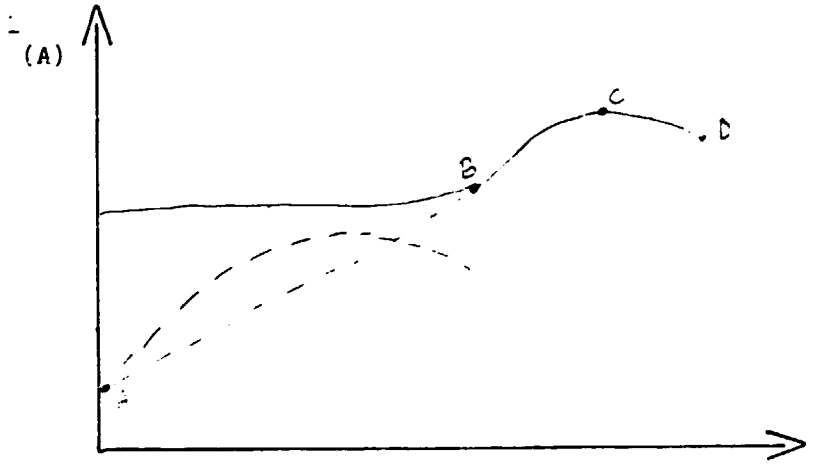
I therefore had to begir a series of tests in order to adapt the different parameters of an internal mixer converted into densification unit-mixer.

Starting from a crushed material (PVC) discharged into high speed mixer, we add the various additives like softeners (plasticizer), oxidation inhibitors, colouring agents in accordance with an established sequence.

B : Broyeur
D : Densificateur
PL : Plastificateur



Sequences



A	Première addition	: PVC Broyé	:	45 kg
		MB Black	:	1
		Plastifiant	:	0,4
		Ti 02	:	1
B	Deuxième addition	: Plastifiant	:	2,8
		Pb S04	:	0,05
C	Troisième Addition	: Water	:	0,
D	Ejection du densifié			

This principle permits to incorporate loads, to homogenize, to densify as well as to dry this mixture (pre-mixed material).

Man-power : 1 man.
Capacity : > 200 Kg/hour.
Power : 25 Kw (motor).
25 Kw (resistor).

Rapidly we could test the finished product in works at the Shanghai Bike Spare parts Manufactury.

This very dynamic company produces parts for bicycles and more particulary handgrips.

Annual distribution : 60 millions of bicycles for Shanghai only.
Moreover, this factory is using the whole production of soft PVC recycled by Xing Guan factory.

The results obtained were more than encouraging. Indeed the produced bicycle handgrips presented a bright surface finish with uniform colour and were free from cavities.

They could be compared to handgrips manufactured with brand new PVC.

Besides, the percentage of plasticizer (softener) was reduced to 50 %. The cost price was then less expensive turning out to Xing factory advantage.

One only black point had to be eliminated : the granulates showed a too high degree of moisture when used in injection ($\geq$ 0.4 % of H_2O).

The accumulated effects of hot bagging and very high degree of moisture due to the dry season in Shanghai gave a too important percentage of H_2O in the bag.

According to the indications the mechanical workshops belonging to X.F. made and mounted a pneumatic transfer equipment.

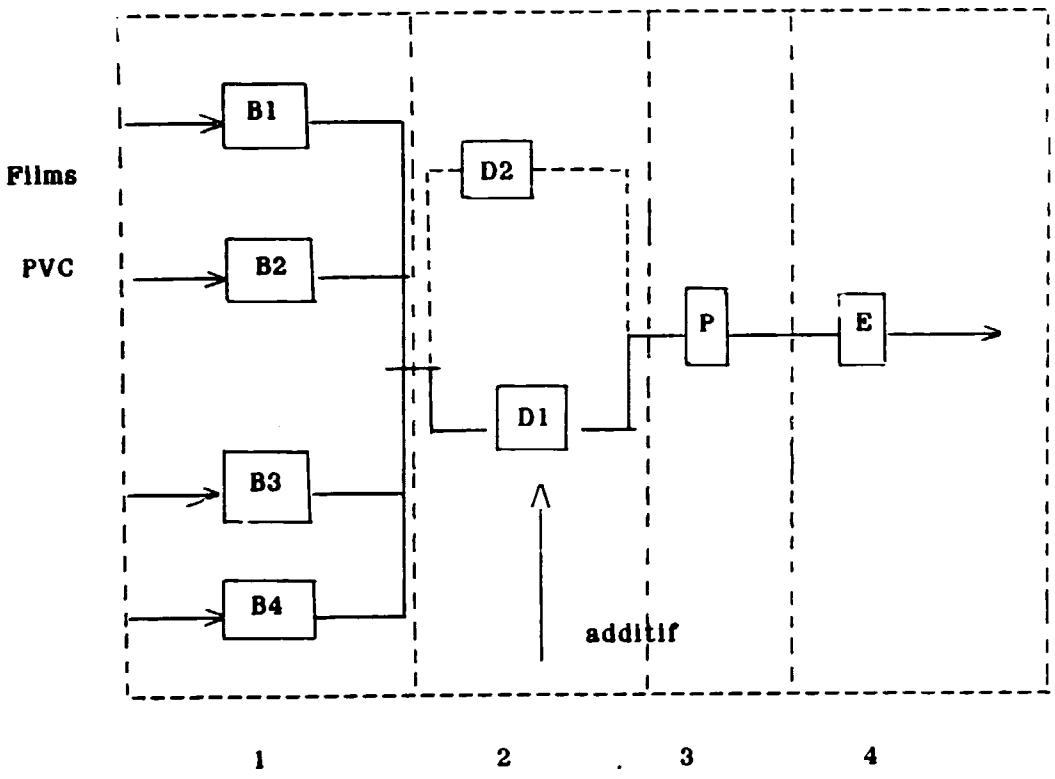
The latter leads the granulates to a bagging silo and liquefy them in ambiant air for cooling down before bagging operation.
The system solved the problem of moisture.

Consequences of these tests.

A. The sales price of soft PVC produced by the plasticizer doubled in comparison with the old price and is equivalent now to 95 % of the price for brand new PVC.

B. Densification - incorporation step is adapted to the lay-out of the line.

Final layout



B = crushers (4)
D = densification units conditioned granulates (2)
P = plasticizers (1)
E = bagging

Non D2 en fait

1. **Crushing room.**

This independent room is housing 4 crushers provided with rotary cutters and fed each with PVC film. The latter is cut to separating size of 15 mm.
Total capacity : +/- 150 Kg/hour.
Staff : 4 men.

2. **Densification units.**

Two units are installed in the granulation room. Both are operational but only one is being used now, owing to their respective quantity delivered. The following 5 additives i.e. DBP Ti O_2, carbon black, $PbSO_4$ and $BaSO_4$ are incorporated in this unit.
Capacity : 200 Kg/hour (1 unit)
Labour : 1 man.

3. **Plastification-granulation.**

Module delivered by S.A. RHEO.
Present capacity : 170 Kg/hour, but the quantity delivered depends on the fouling of the polymers.
Labour : 1 man.

4. **Bagging - Drying - cooling down.**

Module made by SRRUC.
Labour : 1/2 man.

3.5.2. Micronizer.

It is difficult to predict the future installation of the micronizer inside a circuit.

Several possibilities can nevertheless be contemplated :

1. Crushing - micronization of plastics such as ABS - Nylon - PE - PP - PVC - PS in view of their final utilization in powder form.

2. Micronization of PMMA.
   Pretreatment at the stage of " cracking ".

   NOTE. The project is in stand-by now.

3. Micronization and rounding off aluminium pieces.
   The step is completed with a screening.
   The different cuts are commercialized and sent to different fields like metallurgy.

   This treatment obviously involves some physical modifications because of the potential danger resulting from.

   This process is well-known by S.A. RHEO and could rapidly be adapted.

4. Micronisation of loads (limestone, glass, etc...).
   This possibility was also considered.
   It does not actually necessitate technical modifications but a subsequent education.

IV. SPECIAL FINDINGS.

According to the origin of collecting PVC, it appeared that the latter was fouled differently. Indeed, some lots contain a large quantity of sand because they are coming from agricultural lands near the coast.

The sand has bad effects on the following fields :

- Quantity delivered is reduced because filters are fouled and increase head loss
- Life time of the machine is reduced (depreciation is increased)
- The cutting parts are to be replaced oftener (higher maintenance cost)

If a washing - filtration is not carried out rapidly, it is necessary and useful to draw the attention to the following consequence :

- The stock of spare parts at the SRRUC is not enough now and within short term they will face problems of delivery dates.

I only can advise deeply what is following :

1. Installation of a crusher-washer in replacement of the 4 existing crushers and completing the line.
2. Buying additional spare parts.

I am personally sure that RHEO S.A. is able to cope with these requests rapidly.

2. Study of the integration of a crusher-washer.
The integration of a washer or crusher-washer would be necessary and would have the following big advantages :

A. Increasing the quality of the material and therefore its market price.

B. Increasing the lifetime of crusher, densification unit and plasticizer.

Now, the quality of the raw material is quite unacceptable for the machines.
The quality of the finished product is assured only by a PRH filter.
Lifetime of the machines is reduced by three times.
Practically speaking, the cost price is increased obviously.
RHEO S.A. has a good experience and the control of the crusher-washer module and could make a detailed offer in due time.

Long term.

According to a joint-venture properly established between both companies, they would produce, commercialize and integrate recycling modules.
From 100 to 300 modules could be manufactured, installed and be operational according to the following program :

- Market analysis	SRRUC
- Design of the module	RHEO S.A.
Manufacturing	Joint-venture to be determined between both companies.
Installation	
Putting into service	

This program should be studied and worked out in association before the meeting, open to the different countries of ASIA, takes place during the first quarter of 1989.

V. FUTURE INDUSTRIAL DEVELOPMENT BETWEEN SRRUC AND RHEO S.A.

In the present organization the work-load of the plasticizer is the following :

- 95 % of the time in soft PVC
- 6 % of the time in LPDE.

Owing to the SRRUC'S requirements, the following schedule can be considered :

Short term (in-process)

1. To extend the collecting of PVC (film type) in order to feed the PFN (6 days a week in 3 shifts).
2. To sample the granulates produced by the plasticizer within a zone much wider than that of collected material
3. To receive the return of request of quality and price of the reformuled PVC granules.

Middle term.

1. By supposing the commercial successful results of this product i.e. soft PVC pellets and this is very likely due to positive experience in manufacturing bicycle handgrips, a second plasticizer could be installed parallel to the first one.

VII. CONCLUSIONS.

Common conclusions.

a) The problem of densification is solved i.e. two densification units are already installed; total capacity : 400 Kg/hour and present capacity of plastification : 200 Kg/hour.

b) We deeply recommend what is following :

1. To increase the quantity of spare parts in Shanghai.

   The following parts are absolutely necessary :

   - grooved feed jacket
   - plastification cylinder
   - air gap
   - screw nose
   - extruding screw
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   - several sets of cutters for granulator.

2. To use high-capacity crushing-washing machine that can permit :

   - to remove foreign bodies (sand, dust, ...)
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   - to reduce moisture

3. To install a second plasticiser parallel to the first. It would be fed with the second densification unit. This machine could be operated with a motor made in China.

4. Owing to the cheerful expectations of installating of additional modules, it is high time that we write down together the preliminaries of a joint-venture agreement.

VII. THANKS.

Before finishing the present report I should like to thank very sincerely all the persons who played a great part in bringing my expert mission to a successful conclusion.

ZHU KEXI
ZHANG DEXING
XIE SHI MING
WU ZHONG QING
LIU-BAO-PING
LIN XIN ZHONG
ZHANG GUO CHANG

Throughout my mission they prove their team spirit as well as their efficiency, cooperation, devotion and kindness.

So, I am hereby making a point to thank them very much.

RHEO

I, undersigned ..... Zhang Dexing .....

declare that I have received from ....A...SAURHAMME.....

the .....OPERATIONAL....MANUAL.....(2 pieces)

Made in ..... Shanghai ..... Date 5/7/1988

For receipt : (signature)

Zhang Dexing

上海市新光塑料厂

第一足 第三足 日期 6.20 班次 2

Raw material (原料)	PVC	钙						
Time. (记录时间)	4:36	4:46	5:00					
A. Extruder (挤出机) I(A) [电流(A)]	185	190	210					
Speed (RPM) 转速	14	70	70					
Water (O/C) Zone 1 (1区)	✓	✓	✓					
Zone 2 (2区)	✓	✓	✓					
Zone 3 (3区)	✓	✓	✓					
Screw (螺杆)	✓	✓	✓					
Heating (°C) (加热温度 °C)	162 X	162 X	162 X	X	X	X	X	X
Zone 4 (4区)	✓	✓	✓					
B Screen filter (滤网) Heating (°C) (加热°C)	150°C 155°C	149°C 158°C	147°C 154°C					
Mesh (N°) (目数N°)	20	20	20					
C Calender 压延 Speed (m/min) (转速)	12.5	9	12.5					
I(A) [电流(A)]	0.4	0.9	0.5					
Notice (工作状况)								
D Cube Dicer 冷切粒机 Speed (%) (转速)	12	12.5	15					
I(A) [电流(A)]	7	6	5					
Notice (工作状况)								
Output (kg/h) (产量 kg/h)		100	120					
All Output (当班总产量)								

地址：七宝吴宝路 2640 号 电话：380081×129 130 177

流量测试：36秒出料重量×100为准，每小时测定一次。

A N N E X E IV

F.N. HERSTAL

F I N A L R E P O R T

EXPERT MISSION AT THE SHANGHAI RESOURCE RECOVERY AND UTILIZATION COMPANY

PLASTIC RECYCLING DEPARTMENT

SHANGHAI : PEOPLE'S REPUBLIC OF CHINA

Georges MICHEELS
Ingénieur Civil
Chimiste
Conseiller R & D
FABRIQUE NATIONALE SA
BELGIUM.

November 1987.
UNITED NATIONS INDUSTRIAL
DEVELOPMENT ORGANIZATION.

PLAN OF THE REPORT

1. SINCE FIVE YEARS THE SHANGHAI RESOURCE RECOVERY AND UTILIZATION COMPANY IS WELL KNOWED BY THE UNIDO

For memory :

Shanghai Resource Recovery and Utilization Company, founded in 1957, is a group of recycling companies with the qualification of a legal body specially engaged in exploiting secondary resource, and is the largest of its kind in China. It has more then 20.000 staff and workers with an annual waste recovery amount over 1.6 Million tons. SRRUC deals in numerous categories of waste material processing and trade, such as scrap steel and iron, non-ferrous metals, precious metals, plastics, chemical fibers, ill-qualified cloth, cotton and gunny, waste paper, used glass bottles, human hair, poultry feathers, domestic animal bones, old hardware, machinery, electrical appliances, etc ...

The business scope of SRRUC covers two principal parts : trading and production. The former comprises domestic and overseas trade, while waste processing and utilization are incorporated in the later, with an aim of providing industry and market with adequate raw material and useful products.

SRRUC has devoted its sustained effort to the utilization of all recoverable waste generated in society, and no less effort to the development of international economic and technical exchange in this field with an expectation of achieving conservation of resource and protection of environment for the benefit of mankind.

It adopts various flexible business activities, such as direct purchasing of usable rejects and purchasing through agents, direct selling of reclaimed products and selling through agents, processing waste for clients, assigning processing to other related firms, swapping available material to meet different needs, setting up joint enterprises, promoting compensation trade, etc ...

The company holds dozens of processing enterprises capable of recycling different items of waste material. With innovation of mechanical devices, revamping of outdate facilities, and introduction of advanced technology and equipment, most of them have upgraded their processing capacity, and can provide industry with qualified raw material, and supplying market with desirable end-products, which have, largely, undergone, for instance, chemical decomposition and polymerization, melting and forging at high temperature.

Shanghai is a densely populated industrial city which generates large quantities of waste material in the course of production and daily life, among which the post-consumer waste accounts for 8 % and industrial waste 92 % of the total.

The constitution of the collected waste can be briefly summed up as follows : scrap iron and steel takes 42 %, useable formed steel 18 %, non-ferrous and precious metals 1 %, paper 7 %, rags 1.2 %, gunny 1 %, plastics 0.3 %, rubber 0.7 %, cullet and glass bottles 8 %, waste acids 8 %, and other items make up 12.8 %.

All reclaimable waste material and rejected articles should be repeatedly utilized in order to provide markets with cheap raw material and useful articles.

Most subsidiary enterprises of SRRUC have a technical contingent skilled in sorting, classifying, reassembling and reforming all rejected material and articles that still retain certain use value, such as used containers, mechanical parts and tools, and durable commodities. With their special skill all these rejects regain their seviceable vigour.

At present, rejected material and articles consist chiefly of the following items : [illegible] and iron scrap, non-ferrous metals scrap, [illegible], hardware, machine parts and tools, automobile parts, waste tyres, used packaging paper boxes, oil barrels, gunny cloth and sacks, ill-qualified paper stock, waste acids, etc ... After sorting and simple processing, these reclaimed material and articles can increase an annual profit of about 20 million yuan.

Reclaimed product

The wastes which can not be reused directly are to the processed into various reclaimed products, including raw materials, intermediate product and finished product through certain technological treatment.

At present, reclaimed products can be categorized into six varieties with more than 130 kinds:

Reclaimed Iron and Steel Scrap : sheet iron, iron briquettes, conversion pig, casting pig, cast-iron conduits and pots, sewer manhole covers and other castings.

Precious Metals and Chemical Products : gold, silver, platinum, nickelous nitrate, cobaltous chloride, copper oxide and other salts.

Reclaimed Non-ferrous Metals : miscellaneous brass, alloyed casting aluminium, deoxidizer, flocculant, anti-piping compound, etc ...

Reclaimed Plastics : regenerated plastic granules, plastic floor tiles, hard and soft plastic tubes, perspex sheets and buttons, and other cracked monomers.

Reclaimed Rubber : regenerated gum rubber, synthetic rubber and small articles such as ring, plate, gasket, etc ...

Chemical Extracts from Human Hair : various amino acids, such as cystine, histidine, gultamic acid, lysine, proline, etc ...

Other reclaimed products include stainless steel wire, chromel filaments, electric wire for civil use, thermosetting cloth powder, needle felt non-wavens, weaving machine parts and accessories, vacuum packer, electric meter, silicon rectifier, gears, belt pulleys, etc ...

Professional Training

SRRUC has set up a vocational education center, which provides different professional training for its staff and workers, thus giving rise to a technical contingent fully adaptable to their jobs.

With a view to upgrading production quality, developing novel products, so as to maintain market competitiveness for its reclaimed material and articles, the company attaches great importance to applied science research, especially on product design.

In order to guarantee proper production technology and advanced quality standard, strict operational regulations are stipulated, various testing devices are well equipped, and programmed quality control and supervision are put into full play.

Scientific business management is heading up by big strides. Now there are some 30 sets of electronic computers put into service for calculating the merchandize flow, financial performance, personnel administration and payroll accounting, etc ...

2. DESCRIPTION OF THE EXPERT MISSION

The purpose of the mission was :

To establish a complete pilot unit for the recycling of plastics waste in order to upgrade the properties and increase the yields of plastics recycled material.

The Expert will be expected to :

1. Identify any pending matters regarding the design and installment of equipment built in China to complement the equipment imported :

2. Ensure that the equipment which is being built in China will be of the right material and will satisfy the requirements of the equipment suppliers in Belgium ;

3. Ensure that the equipment built locally is adaptable to the equipment imported ;

4. Ensure that the necessary infrastructure required for he installment of the whole plant is available ;

5. Assist RHEO S.A. in making the installation drawings of the plant following his mission.

The Expert will also be expected to prepare a final report on his findings and recommendations to the Government on further action which might be taken.

3. RECYCLING OF PLASTICS BY THE XINGGUAN PLASTICS FACTORY

(Subsidiary of the SRRUC)

3.A. ACTUAL SITUATION

Deputy manager : Mr LIU BAO-PING

- Employed personnel : 257 persons.
- 4 specialized recycling workshops and one administrative building.
- Present capability : 2.000 T/year.
- Selling prices of the recycled products :

. PVC granules	:	3.000 y/TON *
. PE "	:	3.000 y/TON
. PA "	:	4.000 y/TON
. 1st quality white PA granules	:	7.000 y/TON
. PMMA Plates	:	10.000 y/TON

The PMMA recycling has been stopped and is now moving because of environmental protection matters.

Price of the electric energy : 0,11 y/kWh.
Average consumption at the present time : 4 kWh / recyled Kg.

* 1 y = 0,27 US dollar = 10 Belgian Fr.

The factory supplying in material to be recycled seems to happen as follows :

PVC : SOFT PVC only.
- Collection through the SRRUC network
- Agricultural bags waste
- Industrial waste.

PE : (PEHD + PELD)
- Collection through the SRRUC network
- Agricultural FILM waste
- Industrial waste.

PA : Textile industry waste

PMMA : - Collection through the SRRUC network
- Industrial waste.

The SRRUC collection network is composed of ± 270 settled selective collecting stations spread all over the Shanghai town (PURCHASING STATIONS).

The population brings the waste thereto and gets money in return for.

These stations are supplying 12 RECYCLING SHOPS, kind of sorting wholesalers, where the waste are sorted out and prepared for transport to the recycling factories:
- sorting
- washing
- drying
- compacting

These 12 RECYCLING SHOPS are supplied as well by the plastics transformation industries, which bring their industrial waste there.

This plastics waste collection system is remarkable and unique in the world. The Shanghai town as well seems to be the leader and pilot with this system for whole China.

For me it is impossible of course to estimate the precise cost in energy and manpower involved in this collection work. Anyway, the most important conclusion I can present from the study on this collection system is the following :

The Republic of China and the Shanghai town can be the LEADER in the recycling of plastics coming from the urban rubbish. After 17 years experience in the matter of plastics waste in Europe, and after having visited recycling factories in JAPAN and in the USA, for the first time I can meet a population who :

1. Attaches importance to the plastics waste, taking the economical and molecular value of into account.

2. Possess a real will of collecting the secundary raw material contained in the plastics waste.

3. Has got a real and deep skilled knowledge about the rheology and thermo-dynamical problems involved by the recycling of plastics waste.

These three remarks just confirm the impression I had, that the assistance project UNIDO to the XINGGUAN PLASTICS FACTORY gathers all the chances of success, and more than the other developing countries (and even more than most of the developed countries indeed, where plastics waste collection seems to have regressed these last years : decrease of the natural and recycled raw materials prices).

The customers of the XINGGUANPLASTICS FACTORY :

During my mission, I have had the opportunity to visit 2 customerfactories of the XINGGUAN FACTORY.

1) The XINGLIANPLASTICS FACTORY (subsidiary of the SRRUC).

Specialized in the production of :

- buttons
- games tokens
- belt-buckles
- etc ...

This company employs 400 persons.
Managing-Director : Mr JIANG FU QUING.

The production concerned is mainly performed by injection : PA, PS, PE, PP, ABS and by machining in the mass (from PMMA plates).

This factory is presently using 100 T/year of recycled plastics, coming from the XIGGUAN FACTORY, but is able to use more of, without problems any.

2) The SHANGHAI BIKE SPARE PARTS MANUFACTURER

This company produces bicycle parts (production in the neighbourhood of Shanghai : 60 millions bikes per year).

The recycled plastics are mainly used for :

- SOFT PVC : bike handles
- PE : rear reflector support.

This company uses all the PVC SOFT recycled by the XINGGUAN FACTORY and is able to double the supplied quantities without problems any.

These two customers are satisfied by the recycled plastics quality supplied to them, and only wish to consume more of.

3.B. IMPLANTATION OF THE PILOT UNIT WITH RHEO S.A. COMPANY

The present recycling happens according to the following technological steps :

A) SOFT PVC :

- Densification and compounding (additive = coloring agents and softener) on 3 calenderig units of 400 mm diameter.

- 1st filtration : 4 extruders of 60 m diameter (4 x 4.5 kW) : 160°C.

- 2nd filtration and cold granulation on one die. 6 extruders of 60 mm diameter (6 x 4.5 kW) : 160°C.

Filters of 38 MESH/INCH^2.
The extruders have a yield of 15 to 25 kg/hour.
The replacement of the filters involves to stop the extrusion (every 3 minutes).

B) P.E. :

Same process as the SOFT PVC : calendering unit + extruder + cold granulation on one die.

After densification on calendering unit, the apparent density of the product is around 0.32.

C) P.A. :

1. The textile fibers are loaded in a batch and melted discontinuously (300°C).
   The batch basis includes a valve, which supplies the gear pomp by gravity. This pomp is supplying the melted P.A. to a die (25 kg/H) which dives in a water tank (cold granulation on one die only).

2. In some cases, the non-fibrous P.A. waste are extruded directly on a 2 levels extruder (25 kg/hour), with filtration and cold granulation.

D) P.M.M.A. :

The present process, which has been interrupted now, is as follows :

1. Cracking
2. Distillation
3. Repolymerization.

The whole of the recycling processes involves an important manpower : around 10 TON/Year x person. The profitability of the factory is absolutly to improve :

1. By reducing the energy drained per kg of recycled plastics ;
2. By increasing the yield per person employed.

PROPOSED SOLUTIONS FOR THE IMPLANTATION OF THE RHEO UNIT

By common consent with Mr LIU BAO-PING, the implantation solution will be as follows :

For the SOFT PVC and for the PE :

1) The densification operation on the calendering units (3 PVC and 2 PE) remains unchanged, their yield will be increase however thanks to a temperature reduction (120°C) and to a reduction of the sequence concerned (short duration).

2) The products will be led on a high speed internal mixer (500 rpm) - (50 kg/5 min). This mixer already exists at the XINGGUAN FACTORY's. This operation enables a size reduction of the densified pieces and brings them further to an ideal design of ± 7 mm.
This mixer enables also the apportioning of additives, which will be homogenized on the short screw type extruder.

3) Extrusion on the Plastificator PATFOORT Short Screw (PPSS) = PHR 120. This machine will be installed next to the calendering units.

Including the following :

- Plastificator
- Filter with continuous net-changing
- Cooling tank + band air drying unit
- Band cold granulator.

This whole line can replace the existing extruders. It will be able indeed to work at a yield of 150 to 200 kg/hour with the waste type treated.

For the P.A. :

The trial which will be performed in Belgium - RHEO Factory - will determine the precise sequence to use, as the fibres pre-drying problem has to be studied.

For the P.M.M.A. :

The micronisator supplied by the [illegible] company will be used as pre-treatment to the [illegible] step.

This micronisator can also be used to micronize and homogenize all other plastics rigid waste. For instance : recycling of HARD PVC, P.S., A.B.S.

THE LAYOUT PROBLEM

I checked there the building of the LAYOUT project, the building dimensions, and the access to the building for the equipments.

The definitive LAYOUT plan, taking these data into account, will be confirmed beginning 1988 by the RHEO company :

- Space required ;
- Water supply ;
- Electric power supply ;
- Sewerage ;
- Compressed air.

I can confirm there are no obstacle to the realization of the installation in the building concerned.

I can confirm further there is compatibility between the Chinese equipments I have seen at the XINGGUAN PLASTICS FACTORY's and the equipments of the RHEO S.A. Company, I have seen in Belgium.

I think the PPSS (PATFOORT PLASTIFICATOR) is particularly well adapted to the recycling performed in China. This machine is simple, strongly built and easy to implant in such an industrial environment.

The Mechanical and Electrical Workshops I visited in the SRRUC are able to perform the industrial maintenance of the equipment, which will be supplied by RHEO S.A.

On the other hand, I can confirm the excellent technical contacts existing between the SRRUC technicians and the RHEO technicians, the information between both companies happens in the best way.

3.C. RECOMMANDATIONS FOR A NEXT STEP TO INCREASE THE YIELDS OF THE FACTORY.

According to the information from Mr ZHUY KEXI : Deputy Manager of the SRRUC, it appears that the plastic fraction collected by the SRRUC would progress in the years ahead as follows :

SOFT PVC	:	35 % (packing bags and films)
PE	:	30 % --> 45 % (agricultural films)
PP	:	10 %
PS	:	7 %
PMMA	:	6 %
ABS	:	4 %
P.A.	:	3 %
OTHERS	:	4 %

3.C.1) :

It seems that the FILMS AND FOILS type plastics waste will be the main sources in the future.

The densification need within the recycling line will become so more and more important. At the present time, the densification calendars are just draining most of the energy.

The next logical investment step would be to update the densification part of the factory (for the SOFT PVC and the PE).

Specialized machines exist regarding this densification step, which are more adapted and more economical than the calendering machines. The engineers of the XINGGUAN FACTORY have had the opportunity to see one of these running at the RHEO company's in Belgium. These machines are now checked-out and can be supplied by the Engineering Department of the RHEO S.A. company.

My first advice would be, that the UNIDO, in a second step, could help the XINGGUAN PLASTICS FACTORY to get a densification line, replacing the calendering machines.

The factory would then be able to work continuously, without energy waste, and with a reduced manpower, at a yield of at least 200 kg/H, 24 H / 24 H, and 3 shifts.

Anyway, my advice is for the factory to work 24 H on 24 H, as it is uniogical in the extrusion industry to stop (to cool and to reheat) the machines every day.

3.C.2) :

Regarding the P.A. (waste from the textile industry), it would be interesting for the factory to have a dryer adapted to this product.

In the P.A. fibres waste have to be recycled on the PPSS, it will be necessary indeed to have an efficient drying prior to re-extrusion. Trials in Belgium would confirm this view.

4) FUTURE INDUSTRIAL DEVELOPMENT BETWEEN SRRUC AND RHEO S.A.

Messrs ZHU KEXI - Deputy Manager
ZHANG YAN QUING - Deputy Manager
ZHANG DEXING - Deputy Section Chief,

have spoken several times about the transfer of licence for the manufacturing in China of the PPSS (PRH 120) machine. The problem has of course to be discussed between the management of the SRRUC and the RHEO S.A.

After having visited the STATE OPERATED SHANGHAI PEOPLE'S INSTRUMENT FACTORY (Subsidiary of the SRRUC) :

Employed personnel : 200 persons.
Vice Director : Mr YIN SHUN BAO.

This company produces :

A) Voltage meter instrument
B) Packaging vacuum machine (for export).

I think this company is able to perform the electrical assembly and the instrumentation of the PPSS.

The company disposes of the required laboratory and technical staff for this activity.

It can perform machining as well, and assembly of mechanical parts.

I believe however that the EXTRUDER PPSS (PRH 120) is too big and too heavy to be mechanically assembled in this factory.

But it is in fact too soon to think about it at the present time. We have first to get results from the PILOT PLAN running, and during 1989, a negociation will then be possible between the SRRUC and the RHEO S.A., as to equip the other factories in China.

5. THANKS

I personally wish to thank the SRRUC team, for the kindness and the efficiency with which they allowed me to perform my mission of expert in SHANGHAI.

Messrs ZHANG YAN QUING
ZHU KEXI
ZHANG DEXING
XIE SHI MING
LIU BAO PING
YUAN YONGLIN
ZHANG GUOCHANG
CAI JUN FU

Mr JIANG FU QUING from the XINLIAN PLASTIC PRODUCT FACTORY
Mr WANG ZHEN from the SHANGHAI RIVERSIDE POTCH FACTORY
Mr YIN SHUN BAO from the PEOPLE'S INSTRUMENTAL FACTORY

and especially Mr GUO YONG KING from the FOREIGN ECONOMIC AND TRADE DIVISION OT THE SHANGHAI SUPPLYING AND MARKETING COOPERATIVE.

6. REMARKS REGARDING THE SHANGHAI RIVERSIDE POTCH FACTORY

The present report does not speak about the P.A. Pyrolysis Unit of the RIVERSIDE POTCH FACTORY.

As it was planned during my visit, I have first to meet the Professor F. BUEKENS from the "VRIJE UNIVERSITEIT BRUSSEL" in order to discuss the possible improvements to this installation.

Having already visited this installation, he will be able to advise advantageously about the drafting of a report, which will be sent after the Christmas holidays of the University.

Herstal, December 17, 1987.

G. MICHIELS.

ANNEXE V

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

VIENNA INTERNATIONAL CENTRE
P.O. BOX 300, A-1400 VIENNA, AUSTRIA
TELEPHONE: 26 310 TELEGRAPHIC ADDRESS: UNIDO VIENNA TELEX: 135612

REFERENCE

DATE. 29 November 1988

WORKSHOP ON PLASTICS WASTE RECYCLING TECHNOLOGY

Organized under the joint auspices of the United Nations Industrial Development Organization and the Ministry of Foreign Economic Relations and Trade (People's Republic of China)

to be held at the Shanghai Resource Recovery and Utilization Company, Shanghai, People's Republic of China between 10 and 12 April 1989

AIDE-MEMOIRE

1. Background

Since 1971 intensive research has been carried out in Belgium on polymer alloys, which are essentially very finely developed emulsions obtained by intensive and thorough mixing of polymers in the molten state and stabilized by cooling to obtain a high quality mix of a very viscous polymeric liquid. To achieve this it is necessary to have a very short residence time.

When the energy crisis started, concentrated study on the use and fabrication of these polymeric alloys from mixed plastics waste was highly emphasized. In 1977 Fabrique Nationale Herstal S.A., Herstal, Belgium, obtained a licence for the process and developed a complete plastics recycling line with the main piece of equipment being a short-screw plastifier.

In May 1983 a Chinese delegation from the municipality of Shanghai visited Belgium, the Federal Republic of Germany and the United Kingdom to study various plastics recycling systems including the municipal waste recovery plant at Liège, designed to be the EEC Pilot Unit to be copied in other EEC countries, and a factory for industrial waste recovery where all types of plastics waste were recycled using the above system.

In compliance with a request from the Government of the People's Republic of China, two Belgian experts, Prof. G. Patfoort and Mr. A. Buekens were fielded to China in August 1985 under project US/CPR/83/245 'Recycling of Solid Plastics Waste' (financed through a Special Purpose Contribution of Belgium and the preparatory phase of the present project US/CPR/86/130). Their mission was to survey the plastics waste situation in China and the technology used and to discuss with the Chinese counterpart institution, the Shanghai Resource Recovery and Utilization company (hereinafter referred to as the SRRUC), the possibility of establishing a pilot-plant for the recycling and utilization of plastics waste. The SRRUC recovers sixteen categories of waste materials, including more than a thousand subgrades. This includes ferrous metals, non-ferrous metals, rubber, paper, rags, cotton, chemical fibre and animal bones, human hair, broken glass, glass bottles, old machine parts and accessories, chemical residues, waste oil, and of course plastics. The total amount of waste material collected in 1983 was 1,660,000 tons of which industrial wastes accounted for 85% and post consumer waste for 15% with plastics waste being 12,000 tons and rubber waste 8,600 tons.

Following this mission the SRRUC expressed a strong interest in establishing such a pilot plant and in using this plant as a demonstration unit not only for the People's Republic of China but also for other Far East countries. According to the SRRUC there is a potential need in China for the erection of about 200 similar plants.

Based on the recommendations which emerged from the preparatory phase, a project US/CPR/86/130 "Recycling of Plastics Waste" (financed through a Special Purpose Contribution from the Government of Belgium to the UNIDF) was designed to establish a complete Pilot Unit for the recycling of plastics waste adapted to the technological and economic conditions and needs of the People's Republic of China. A pilot plant was built at the Xing Guang Plastics Recycling Factory to upgrade the properties of the plastics waste and increase the yield of the plastics recycled materials. This recycling factory is a suburban division of the SRRUC, covering an area of 10,000 sq m and mainly recycling waste PVC, PMMA and Nylon with a total annual output of 2,000 tons of which approximately 800 tons are recycled PVC.

For the establishment of the pilot plant a subcontract was awarded to RHEO S.A., a subsidy of Fabrique National Herstal producing short-screw plastifiers, the most important item of equipment in the recycling line, and under worldwide patent. This subcontract provided for the supply of the technical know-how, drawings and specifications as well as a plastifier and a micronizer required for the pilot unit. The rest of the recycling line including crushing, compacting, washing equipment etc. has been provided by the Chinese, as this equipment is already available locally and the complete line was assembled by experts from the Subcontractor.

Experiments showed that the extruder is highly efficient in treating pure PE or PVC material of different specifications and is specially adapted for recycling PVC. Experiments on granulating mixed plastics containing 90% PVC

and 10% PE were conducted. The resulting mixed granules demonstrated that production of better quality granules is possible only with minor adjustments of technology parameters. The reclaimed plastics granules produced by the extruder are much better in quality than those produced by ordinary extruders due to its specific design, which ensure sufficient homogenity, short residence time, and no obvious property degradation of the plastics in the granulation process

The patent and know-how, however, remain the property of the subcontractor. This means that, if the People's Republic of China produces this system for sale within China and in the Far East, an agreement has to be reached on the future know-how payments to the subcontractor.

2. Objectives of the Workshop

The project US/CPR/86/130 -"Recycling of Plastics Waste" has both social and economic impacts, and the results and outputs of the programme in the area of existing and new abilities in the technology of recycling plastics waste should therefore be used for maximum profit. Since this technology is also of interest to other developing countries which are facing the problem of utilizing waste materials and reducing environmental pollution, this workshop is considered the best means to demonstrate the applied technologies and the equipment in the field of plastics recycling.

This workshop will thus contribute to upgrading the professional and technical know-how of the participants in the field of plastics waste recycling and to creating possibilities for future co-operation.

3. Programme of the Workshop

The programme of the three-day-workshop will comprise:

1st day: Lectures on methods of waste collection and treatment, the new recycling system, and possibile applications of the recycled materials.

2nd day: Demonstration of the pilot plant and visits to plants using the recycled material.

3rd day: Discussions on possibilities for future co-operation.

4. Expected Outcome of the Workshop

The workshop is meant to demonstrate to participants from invited developing countries in Asia the applied technology and equipment in the field of plastics waste recycling and will also provide an opportunity for professional dialogue among the participants and with the Organizers.

In accordance with an agreement signed between China and RHEO S.A., more such recycling lines will be built for China and also will be exported by the Chinese, under a joint venture with RHEO, to other Asian countries, thus leading to further co-operation in the future with the participants' home countries.

5. Date and Venue

The Workshop will take place in Shanghai, People's Republic of China from 10 to 12 April 1989.

6. Participants

The Governments of: Bangladesh, Burma, India, Indonesia, Malaysia, Pakistan, the Philippines, Sri Lanka and Thailand are invited to nominate three (3) candidates from whom one (1) will be selected to represent the respective country at the Workshop. The participants should be engineers or chemists with a degree or diploma and with practical experience in the plastics industry, especially in waste recycling. They are each expected to present a country paper on the situation of the plastics waste recycling industry in their respective home countries and to discuss and exchange experience in this field. For reproduction purposes two copies of the country paper must reach UNIDO by 10 March 89. The Governments should give consideration to professional qualifications, level of experience and other relevant data when selecting the candidates representing their countries. The selected participants should attend the complete workshop programme according to the schedule prepared by the host authorities and should comply with the Rules and Regulations for the programme.

7. Language Requirements

Since the programme will be conducted in English, candidates must have a good working knowledge of the English language. Applicants from non-English speaking countries or whose academic studies were not in English will have to submit - together with the nomination forms - a satisfactory language certificate, issued by a reputable institution (e.g. British Council or American Cultural Association) before being considered eligible.

8. Financial and Administrative Arrangements for the Workshop

Financial and administrative arrangements for the accepted participants will be made in accordance with UNIDO Rules and Regulations.

UNIDO will provide:

Round-trip economy class (or excursion) air transportation following the officially designated route between the international airport of departure in the home country and Shanghai, China.

The Government of the People's Republic of China will provide for:

A Daily Costing Rate payable in local currency (Yuan) to cover board and lodging. The amount will be determined on the basis of the scheduled arrival and departure dates and will be paid upon arrival in Shanghai.

Local travel

Workshop facilities

Conference services

Material and

Intepreters

The participant's Government or his/her employer will be required to bear the following costs:

(a) All expenses in the home country incidental to travel abroad, including expenditure for passport, visa, medical examinations, vaccinations and other such miscellaneous items as well as internal travel to and from the international airport of departure in the participant's home country;

(b) Salary and other benefits for the participant during the period of the programme.

Neither UNIDO nor the Government of China will assume repsonsibility for the following expenditures in connexion with the participant's attendance at the Workshop:

(a) Costs incurred by the participants with respect to any insurance, medical bills and/or hospitalization fees;

(b) Compensation in the event of death, disability or illness of the participant;

(c) Purchase of personal belongings or compensation for damange caused to them by climatic or other conditions;

9. Visa/Passport

Before leaving the home country, participants should complete all formalities regarding entry and transit visas which they may require for the journey to Shanghai and back.

Before leaving their home countries, they are urged to contact the nearest Chinese diplomatic or consular office to obtain visa and information on customs regulations, as well as health and vaccination requirements in connexion with their visit to China.

10. Time of Arrival

Participants are requested to leave their home countries in time to arrive in Shanghai not later than Sunday, 9 April 1989, or as close to that date as airline schedules permit. UNIDO will not be financially responsible for earlier arrivals for personal reasons. Participants will be met by the Organizers at the airport in Shanghai.

Flight reservations for the homeward journey should be made before departing from the homecountry. Neither the Host Government nor UNIDO will pay additional costs, such as Daily Subsistance, due to failure to make such reservations.

11. Hotel Accomodation

Hotel accomodations for the participants in Shanghai, China will be arranged by the Organizers.

12. The participant's attention is especially drawn to the following:

(a) Participants are strongly advised not to have members of their family accompany them since no accomodation for famil, members will be available. The Organizers of the Workshop will not be liable for any expenses incurred by family members or dependents;

(b) Before departing for Shanghai participants should ensure that their passports are valid for travel to China for the whole period of the Workshop with a clear recent picture as well as an entry visa for China and any other countries the participant has to go through on his way to and from China.

(c) Neither UNIDO nor the Government of China will render assistance in obtaining visas for countries to be visited by the participants for personal reasons or on behalf of his/her company/organization upon completion of the workshop.

(d) Neither UNIDO nor the travel agency will assume financial or other responsibility for any deviations from the foreseen air routing.

(e) Expenses for travel undertaken by a participant during or following his/her stay in China for personal reasons or on behalf of his/her company/organization are the sole responsibility of the participant/company/organization.

(f) Before submitting an application, each candidate should be fully aware of the contents of this Aide-Memoire.

Enquiries and Correspondence

All enquiries and correspondence should be addressed to:

A. Tcheknavorian-Asenbauer, Head
Chemical Industries Branch
Department of Industrial Operations
UNIDO (Officer-in-Charge of Workshop: Mr M.A. Youssef)
Vienna International Centre
P.O. Box 300
A-1400 Vienna, Austria

Telex: 135612
Cable: UNIDO Vienna
Telephone: 0222/2631-3939

directly or through the office of the Resident Representative, United Nations Development Programme (UNDP) in the participant's home country.

A N N E X E VI

UNIDO WORKSHOP ON PLASTICS
WASTE RECYCLING TECHNOLOGY

MEETI..G AGENDA

Monday, April 10

9:30 11:00 Opening session
Opening addresses to the meeting
By: Chairman, Mr. Cha Jie,, Deputy Director, Shanghai Supply and Marketing Cooperative
Mr. M. Youssef, UNIDO
Deputy Director, China International Center for Economic and Technical Exchanges, Ministry of Foreign Economic Relations and Trade
Director, Finance and Trade Office of Shanghai Municipal People's Government
Director, Shanghai Commission for Foreign Economic Relations and Trade

12:00 13:30 Lunch

13:30 16:00 Meeting
SRRUC Reports
1. Resource Recovery and Utilization in Shanghai
Zhang Yanqing, Deputy Manager, SRRUC
2. Establishment and Implementation of UNIDO Project for Waste Plastics Recycling
Zhu Kexi, Deputy Manager, SRRUC

16:00	16:30	Video show: Recycling Activities of SRRUC
16:30	19:00	Open
19:00		Banquet

Tuesday, April 11

9:00	11:00	Site visit to Xinguang Plastics Factory
12:00	13:30	Lunch
13:30	16:00	Meeting
		Report on the Operation of the PRH 120 C Type Waste Plastics Recycling System
		Liu Baoping, Deputy Director, Xinguang Plastics Factory
		Expert presentation
		Prof. Georges A. Patfoort of Belgium
		Presentation of country reports
16:00	17:00	Open
17:00	18:00	Supper
18:00		Performance

Wednesday, April 12

9:00	11:00	Meeting
		Discussion
12:00	13:30	Lunch
13:30	14:30	Closing session
		Closing speeches
		Chairman, Mr. Cha Jie, Deputy Director, Shanghai Supply and Marketing Cooperative
		Mr. M. Youssef, UNIDO
15:00	18:00	Tour of the Jade-Buddha Temple
19:00		Banquet

Thursday, April 13

Participants start to leave Shanghai

(Note: Breakfast at 7:30 to 9:00.)

A N N E X E VII

RESOURCE RECOVERY AND UTILIZATION IN SHANGHAI

Zhang Yanqing
Deputy Manager, SRRUC

Resource recovery and utilization is a task of high significance for conservation of natural wealth, alleviation of environmental contamination, and maintenance of ecological balance, and therefore contributes greatly not only to the welfare of present generation but to the future prosperity of human kinds as well.
Our government has always attached great importance to resource recovery and utilization. The late Premier Zhou Enlai wrote ".....Always bearing in mind the need to utilize waste material, they should purchase all kinds for recycling; expand processing to develop multi-purpose use of wastes; exercise care and practise economy so as to turn the old and worn-out into the brand-new. They should closely cooperate with the people working in industry, agriculture, culture, education, and the army to promote production in an all-round way, and thus to build our country and transform society through diligence and thrift." Premier Li Peng also instructed us with the inscription: "Making great efforts to exploit and use the reclaimed resources, turning wastes into treasures so as to support the construction." Our country has adopted various important measures to press forward recycling activities, which involve establishment of special functional bodies at all administrative levels, and incorporation of resource recovery in the programme of national economic and social development, and in the important policy of boosting material as well as spiritual civilization.
Shanghai is a densely populated and industry-centered city, from which enormous quantity of waste material arises in people' daily life and production. During the 32 years from 1957 when our company was founded up to now, the amount of waste we have recovered reached 34,040,000 tons with a value of 10.48 billion yuan. Of the total recovered resource scrap iron and steel took 13,340,000 tons, scrap miscellaneous copper 89,200 tons, scrap aluminium 55,000 tons, waste paper 3,000,000 tons, and plastics scrap

190,000 tons. Making use of the above material can save a lot of energy, comparable to 13,810,000 tons of standard coal, and 3.57 billion KW/h.

Over the past few years we have developed technical exchanges and business cooperations with more than a dozen countries and regions, and our export commodities have exceeded 20 varieties. In 1987, with the approval of our superior administration, we joined the Bureau International de la Recuperation as an individual member, which enables us to extend business ties with more recycling firms in the world.

Here we briefly recommend our waste reclamation activities as follows:

1. Waste collection

As waste materials are usually small in quantity, widely scattered, and of low value, they are easy to be neglected and thrown away. We, therefore, often make much publicity about the significance of waste recuperation, and encourage the masses to collect and accumulate reclaimable waste while organizing our own efforts to offer timely collecting service, so as to ensure full utilization of the waste materials.

1.1 Dissemination activities:

Persistent and wide dissemination of the significance of resource recovery and utilization aims at inviting public attention. We often take advantage of the street and factory broadcast media or blackboard newspaper to spread information about waste recycling and utilization in our country. Sometimes we put on itinerant shows of related photos and objects, or street performances in coordination with the mass social education such as civilized production, patriotic public health campaign, movement of increasing productions and practising economy, etc. Occasionally, we launch dissemination through newspapers, radio-broadcast, TV programmes, films, and expositions to enable our recycling activities further known to the public.

1.2 Mass participation:

We usually send professional workers to factories to help them form a system for waste collection and management and persuade them to provide part-time staff to take charge of waste management, to set up waste depositary and information card recording

the amount of accumulated wastes. As for the inhabitants' post-consumer wastes we ask them to use receptacles to collect all kinds of reclaimable material.

1.3. Timely collection:

As for industrial wastes from factories we organize collection with variable measures corresponding to the different scales of the factory and different amount of waste material yielded, which usually involve collection at source by resident professional workers, periodical collection at appointed times, and itinerant collection.

As for household postconsumer wastes, besides collection at ramified purchasing stations throughout the city, we send our itinerant working teams to collect wastes from street to street and lane to lane to provide convenience for inhabitants. On occasions like Spring Festival and other big festivals we embark on large-scale collection activities for a definite period of time. As for domestic rejects in the villages we assign small shops to do the purchase on a commission basis.

At present, 16 categories of waste material (including more than a thousand varieties) are recovered by our company. They are ferrous metals, non-ferrous metals, precious metals, rubber, paper, plastics, rags, hemp, chemical fibers, livestock bones, cullet, glass bottles, old electrical appliances, machines and hardwares, chemical residue, waste oil and so on. In 1988 we collected 1,814,000 tons of waste material, among which industrial wastes accounted for 90 per cent and postconsumer wastes 10 per cent.

2. Waste processing

According to the demands of customers and industry departments with regard to the quality and specifications of the reclaimed material and products, different processing methods are applied. Generally, some reclaimable wastes are processed into raw material while others are processed into end products with an aim to maximize utilization. A brief description in this connection is given below.

2.1. Sorting and classifying:

Sorting and classifying are the preliminary stage in the whole

process. After this stage is completed, some material such as usable shaped steel, non-ferrous metals, cullet, glass bottles, cotton, hemp, old hardware, instruments and machines etc. can be directly provided to customers for further utilization, whereas others such as scrap iron and steel, scrap non-ferrous metals, plastics rejects, waste rubber, paper, and rags are subject to further technical processing.

2.2. Repairing and remanufacturing:

The purpose of repairing and remanufacturing is to restore reclimable waste materials to their original use. For example, cartons used by factories and shops, old barrels, old machines, parts, and tools can be used after a series of processing, such as reassembling, refurbishing etc., while odds and ends of cloth can be pieced together and used in children's clothing, making aprons, insoles and the like.

2.3. Mechanical processing:

Some waste materials are bulky, heavy, over-sized, and of enormous quantity, whereas others are light in weight, large, and dust-blended. Thus mechanical processing is required to remove the dust or reduce size and weight. For instance, scrap iron and steel must undergo shearing, oxyacetylene-cutting, forging and pressing before they can be provided to the steelmill as qualified raw material.

2.4. Chemical treatment:

This method is used to extract certain chemical raw material and precious metals from waste solution, residue, and solids bearing various metal elements. Waste plastics, rubber, chemical fibers and other high polymer material are treated with high temperature dissolution and thermo-cracking to recover monomers or to produce granules for related industries.

2.5. Smelting and forging:

Non-ferrous metal residue and chips are usually too contaminated to be directly used in production unless they undergo metallurgical treatment and are cast into ingots as raw material. Seriously eroded and oxidized agglomerated iron chips are to be melted and cast into pig iron, underground water pipes, or iron pots, if they cannot be directly used for pressing.

In 1988 the output value of the processed material and regenerated products topped 128,000,000 yuan. Chief items of reclaimed products are: gold, amounting to 361 kgs, platinum metals, 112 kgs, silver, 28 tons, pig iron castings, 58,500 tons, regenerated rubber, 2,580 tons, numerous chemical products, 400 tons, oil slag binder, 580 tons, iron and steel briquettes, 200,000 tons etc.

3. Scientific research

In keeping with the rapid expansion of processing and production our company has always taken deep concern about scientific research with special stress on applied technology. With an aim at accelerating transformation of science and technology into production capacity to promote comprehensive utilization of reclaimable wastes, we used to combine scientific research with recycling practice. Over the past years we have strengthened cooperative ties with various scientific research institutes and universities. For instance, the "Foundation for Research on Exploiting Secondary Resources" was founded just years before on the united effort of our company and the Shanghai University of Technology. The fruitful results we have achieved can be briefly illustrated as follows:

3.1. The leftover chemical fibers were simply used as fillers in the past. After technological improvement they are now pressed into sheets, or, through expanding, made into non-wovens.

3.2. As for recycling of precious metal-bearing scrap in the past, only silver was recovered from the used photographic fixing solution and broken bits of silver-plated glass, and now new technology has made it possible to extract gold, silver, nickel, cobalt, platinum, palladium, iridium etc. from chemical effluence, residue, and solids bearing traces of precious metals.

3.3. In order to increase recycling efficiency while reducing labor force we have carried out a series of renovation of mechanical devices. Loading, unloading, and transport of cargoes are now basically mechanized since the introduction of self-designed hydraulic pressure crane-trucks, electronic folding cranes, and various kinds of bridge hoists and lifts. Sales

shops are generally provided with small double-case baling machines and warehouses are equipped with mechanical stacking and heaping devices of various specifications.

3.4. For processing purpose our company has built some upright double-head shears, various types of air-driven hammers, screw-driving or hydraulic pressure baling and briquetting machines of different capacities, 25-ton programme-controlled rubber desulphurising machine, dust-removing, sorting, and baling production line for waste paper processing etc.

Although we have made some progress in mechanical processing, we still have a long way to go before we could fully realize mechanization in waste recycling.

4. Oganizational system

To facilitate management and operation of waste recycling in urban and suburban area of Shanghai we set up 3 business departments, 6 direct subordinates, 12 district branches, 26 district waste processing and business centers,272 waste purchasing stations, 60 specialty sales shops, and 138 general retail shops in the city; 10 county branches and 215 waste purchasing agencies in suburban areas. In addition, there are 44 specialized waste recycling factories and plants. All these constitute a network of waste collection, processing, and utilization throughout Shanghai and its outskirts.

The systematic organization greatly facilitates administration and development of our recycling industry.

The UNIDO Workshop on Waste Plastics Recycling Technology held in Shanghai now will surely provide us with opportunity of exchanging technical know-how regarding better utilization of reclaimable plastics waste. With the endeavor of all of us we believe the workshop will be a big success.

Thank you.

ESTABLISHMENT AND IMPLEMENTATION OF UNIDO PROJECT FOR WASTE PLASTICS RECYCLING

Zhu Kexi
Deputy Manager, SRRUC

Introduction

Of all the projects set up for the beanefit of our company with the support of UNDP and UNIDO this project is meant more for us, as it provides effective solution to the technical problem of recycling mixed plastics waste. The project helps us establish a complete new system wholly adapted to the specific circumstances of China. With this new recycling system, upgrading of working efficiency, improvement in product quality, and elimination of environmental pollution have been realized. RHEO S.A. of Belgium, subcontractor of the project, undertakes to supply the Xinguang Plastics Factory of our company with a complete waste plastics processing and production line, which comprises chiefly of the extrusion machine, granulator, and microniser as the main equipment. The contribution of UNIDO and the Belgian government to the project totals USD 429,965 and the government input in kind USD 903,000 (for the workshop, premises, and subsidiary equipment). Implementation of the project starts from 1987 and ends in 1989. And now this waste plastics recycling system has been put into normal production, which proves that what we originally expected to acquire from the project, i.e., upturn of production capacity, improvement in product quality, and elimination of environmental pollution have been successfully achieved. It is envisaged that this recycling system will expand its positive influence to other industrial cities in China, and possibly some other developing countries.

Background

In 3-year span from initiation to the establishment of this project we have noticed such mutual confidence and good cooperation as existed between our government and UNIDO.

Shanghai Resource Recovery and Utilization Company (SRRUC for short) is one of the large-scale State enterprises specializing in waste recycling in China. Plastics waste takes 6.70 per cent of the recyclable waste total our company collects. Apart from a portion of such scrap directly supplied to the market as raw material for industrial production, the remaining part is to be processed and utilized by Xinguang Plastics Factory, a subsidiary of SRRUC.

At present, plastics waste treated by Xinguang Factory comprises chiefly of PVC, PE films and PA6 filaments. Products made of such processed material are regenerated plastics pellets. The original process adopted by Xinguang Factory can be briefly illustrated as follows:

Plastics waste ⟶ sorting and washing ⟶ plastifying in 2-roll mills (adding in plasticizer, stabilizer, colorant) ⟶ extruding ⟶ filtering ⟶ granulating ⟶ quality checking up and packaging

The above process actually resulted from a careful study of the characteristics of the plastics waste allocated to Xinguang Factory and the simple equipment availble on domestic market. For a small factory with limited investment and limited time to achieve production capacity, such a process was considered feasible and rational then. But before long Xinguang Factory faced up to some serious technological problems. Plastifying and densification of the films by 2-roll mills with electric heating in an unsealed state led to disintegration of a portion of PVC with evaporated gaseous hydrochloride pervading the working surroundings, thus gravely affecting the workers' health.

The material repeatedly heated in the course of plastifying, filtering, extrusion, and granulating inevitably resulted in property degradation, thus impairing the quality of the product. Besides, inadequate material pretreatment added disadvantage to the entire process.

All these negative factors cropped up to prevent the growth of production capacity, and even stagnated the normal operation. For our company, the only way out was to turn to technological reform with the introduction of more advanced state-of-the-art facilities.

Thanks to the UNDP/World Bank global project 80/004 for integrated resource recovery and utilization enforced in Shanghai in 1983, in the frame of the project, a representative of our company, Mr. Guo Yongkang, participated in an expert team touring Belgium and other countries to study their waste recycling practices. In Belgium the team visited the FN Industry Company (the parental company of RHEO S.A.) and the Centre de Recherches Plastiques (Liege), where they observed a PRH 120 C type short-screw plastifyer invented by Professor Georges A. Patfoort of VRIJE UNIVERSITEIT BRUSSEL. The creative design and structural novelty of the machine invited deep interests of the study team. In demonstrative operation, the machine displayed its superiority in productivity, product quality, and exclusion of environmental contamination.

With an expectation of remoulding the existing process of plastics scrap recycling in Xinguang Factory our representative together with other experts initiated a discussion with the top officials of UNIDO at its Headquarters in Vienna, during which the study team was told that the Belgian government had an idea of using its special contribution to UNIDO to finance the introduction of the above equipment and technology to our company in Shanghai.

In August of 1983 Dr. Herbert May, Deputy Head of the Division of Industrial Operation, UNIDO, visited Shanghai, and inspected the Xinguang Plastics Factory. Two months after, the Ministry of Foreign Economic Relations and Trade in China officially requested the UNIDO to set up a project in this connection.

In August of 1985 UNIDO experts, Prof. G. A. Patfoort and Dr. A. Buekens visited Shanghai to conduct a feasibility study in Xinguang Factory. Along with their positive mission report, they

submitted a project proposal to UNIDO and our government. In March, 1986 Prof. Patfoort came to Shanghai to hold detailed talks with the leadership of SRRUC regarding concrete steps to be taken to set up a waste plastics recycling pilot plant and to support the introduced equipment with all necessary subsidiaries. In April, Mr. M. Youssef, Senior Interregional Adviser, Chemical Industries Branch of UNIDO, and Mrs. Oloski, Representative of Belgian Government in UNIDO for project assessment visited Shanghai to inquire of our company how to proceed with the proposed project and to hear the work report prepared by Prof. G. A. Patfoort.

Prof. Patfoort as coordinator of the project submitted an official project proposal US/CPR/86/130 to our government and UNIDO for clearance. The project was approved by Mr. Vassiliev, Deputy General Director of UNIDO, and started to be executed in April, 1987.

Implementation of the project

In February, 1987 related UNIDO authorities signed agreement with the project subcontractor RHEO S. A. of Bilgium to provide SRRUC with the technology and the complete set of equipment for plastics waste recycling.

In April, 1987 a decision was reached between Prof. Patfoort and SRRUC with regard to training of Chinese technical personnel in Belgium, delivery of equipment, and mapping out the engineering programme for complementing the imported equipment with necessary subsidiaries.

In October, 1987 a 3-person technical team headed by Mr. Zhu Kexi, Deputy Manager of SRRUC, went to Belgium for systematic training.

In November, 1987 Mr. Georges Micheels, Conseiller of Research and Development Center, and designer of PRH 120 C type extrusion line, visited Shanghai as UNIDO expert to investigate preparations underway for setting up the pilot plant in Xinguang Factory. He expressed satisfaction with our engineering programme for complementing the imported equipment with

necessary subsidiaries.

In April, 1988 Mr. Vassiliev and Mr. Youssef of UNIDO, Mr. Andersen, programme officer of UNDP/Beijing, and Prof. Patfoort visited Shanghai, and held meetings with representatives of Shanghai Commission for Foreign Economic Relations and Trade and our company for an interim project examination. All the parties in concern felt content with the progress made as scheduled.

In the end of May, 1988 waste plastics recycling equipment reached Shanghai, and immediately afterward Mr. Vincenzo Sciascia, Industrial Manager, and Mr. Noirhomme A. Production Manager of RHEO S.A. came to Shanghai to execute their expert mission at SRRUC to guide and supervise the installation of the delivered machinery, and help start-up the recycling line with necessary adjustment for test-running and production operation.

In the course of trial production, the machine line has run well and yielded a good result in processing PVC films. Of course, for the sake of further improvement some work has to to be done to well compact the films first, but,for the present, effective densificator is not available on domestic market.

Far-reaching significance of the project;

Following the rapid development of industry and the growing shortage of natural resources, exploitation and utilization of recyclable waste material is an important policy for extending the function of potential resources, alleviating environmental contamination, and protecting ecological balance as a whole.

The project US/CPR/86/130 manifests a fruitful cooperation among UNIDO, the Belgian government, and our country in the field of waste recycling, and the successful implementation of the project results in such benefit our company now acquires as envisaged in our original plan, which might invite

interests of other Asian Pacific countries having an intention to promote their waste plastics recycling activities. Shanghai as an industry city with a population of more than 12 millions is eager to introduce advanced technology adapted to its local conditions to develop resource recovery and utilization. As such, we are willing enough to share with you any kind of good experience, and sincerely expect technical exchange and cooperation with you especially in the field of waste plastics recycling.

SRRUC as a direct beneficiary of this project would like to take this opportunity to show gratitude to UNDP and UNIDO authorities and their experts for their kind support and assistance, to the Belgian government for its significant contribution, to RHEO S. A. for its good cooperation, and to Prof.G. A. Patfoort for his devoted effort in successful coordination of the project.

Thank you.

A REPORT ON TRIAL OPERATION OF RHEO 120 EXTRUDER LINE

Liu Baoping
Deputy Director, Xinguang Plastics Factory

1. Abstract

According to the implementation schedule of the UNIDO project the RHEO 120 type extruder line, provided by RHEO S.A., arrived in Shanghai by the end of May, 1988, and was installed under the conduct of Belgian experts early in June. Since then, the trial operation of the system has lasted for a period of time, and it has obviously proved most advantageous and qualified in view of design and technology.

2. Technology

As plastics waste originates from various sources with different types, the processing methods are quite different correspondingly. One of the major plastics waste which our factory treats with the technology of plastification is soft PVC film.

2.1. The former technology for processing PVC:

A. Manual sorting, washing and drying of the waste;
B. Tearing, blending and adding in plasticizer, colorant, lubricant and stabilizer in a double-roller. Extruding the mixture into strip with a cross-section of 25 x 5 mm;
C. Plasticizing, filtering and pressing the strip into finer strip with a cross-section of 20 x 4 mm;
D. Plasticizing the strip again into a cylindrical strip with a diameter of 5 to 6 mm in an extruder;
E. Cutting the strip into cylindrical pellets with a thickness of 5 to 6 mm in a granulator; weighing and packing.

2.2. The former technological process has been improved greatly after the new extruder being put into practice. The procedures are as follows:

A. Manual sorting, washing and drying of the waste;
B. Tearing films into pieces with a size of 10 x 20 mm in a crusher;
C. Kneading PVC pieces with high speed in a heated mixer, sprinkling water in due time to make the film pieces granu-

lated, and, meanwhile, replenishing them with aforementioned additives;

D. Feeding granules into the hopper of RHEO 120 extruder to avoid them doming;

E. Filtering the plasticized material through a screen filter;

F. Molten plastics being extruded out of flat die, pressed into a flat strip with a cross-section of 100 x 3 mm in a calender;

G. After being cooled with water and dried with blowing air, the flat strip is cut into pellets of 3 x 3 x 3 mm in a GB 12.5 model cube-dicer; weighing and packing.

The new technology has the advantage of higher mechanization, simpler process, shorter material dwelling period and less plastification time. It has a significant effect on upgrading the product quality and increasing the yield, maximizing the utility of raw material and additives, alleviating the environmental pollution as well as protecting workers' health.

3. Trial production

Till now the accumulated run-time of trial production is 1200 hours, with the average output of PVC granules 150 kg/h. Owing to the disadvantage of using a high-speed mixer available locally as densificator, the density of of the PVC pieces after densification can only reach the level of 0.35 to 0.38 kg/l. In Belgium, however, with a special densificator, the density of the film pieces can be as high as 0.8 to 0.9 kg/l, with the output about 300 kg/h accordingly. Even though the present output of PVC granules given by trial production has already greatly exceeded the previous record set by traditional technology, it can be foreseen that the present output could be doubled if a similar densificator, which RHEO S.A. is now using in Belgium, be allocated to replace the existing mixer. Compared with the original technology we are very much satisfied with the obvious advantages of the new extruder on the following aspects:

3.1. Higher productivity. The output is about 30 per cent higher than that produced by the conventional extruder of same screw diameter.

3.2. The labor intensity has come down and the operaters have been reduced by 20 per cent.

3.3. Lower energy consumption. The electricity consumption has cut down to 0.8 KWH/kg as compared with the former consumption of 1.0 KWH/kg.

3.4. Less raw material and additive consumption, and better working environment.

As for the old PVC processing technology, materials are subject to plastification for three times. Moreover, the double-roller plastificator is an open system with high temperature up to 170 degrees centigrade that makes the material degraded, and the exhausted HCL gas and plasticizer vapour seriously pollute the working space, harm workers' health, and corrode equipment as well as affect the quality of products.

Thanks to closed-type plastification and low temperature densification, which brings about little degradation of material and evaporation of plasticizer, therefore the following advantages of new technology are brought about:

A. The availability of additives has been increased, the product quality upgraded and the yield raised up. Take a bicycle handgrip for instance, its appearance is considered as good as that made from virgin material.

B. The environment pollution has been eliminated to realize labor protection.

Further than that, the integrated extruding line is very well equipped with electrical overload safeties and labor protecting devices. It's running steadily with less hitch, higher automation ane more excellent functional performance. Since we are just starting now with a trial operation of the extruding line, many things remain to be done in the near future, especially we have to supply the line with most adequate auxiliary equipment. But we are fully confident that the project will result in a much bigger profit than what we expected at the beginning.

4. Acknowledgement

On behalf of my factory and my colleagues I would like to take

this opportunity to express deep gratitude for the significant support of UNIDO, the generous financial contribution by the Belgian government, the enthusiastic coordination of the project by backstopping officials and consultants as well as technical assistance for the RħĿO experts.
Thank you.

A N N E X E VIII

"THE RHEO RECYCLING MACHINE "

Prof. G.A. PATFOORT , Belgium
U.N.I.D.O. Consultant .

THE PLASTIFYING UNIT

In 1959 and for the first time Maxwell and Scalora announced the construction of a screwless or plate-extruder. The pumping action of the extruder screw was replaced by the application of the Weissenberg effect. This phenomenon can be easily understood when we think of a plate rotational viscosimeter. Indeed, this device measures not only the viscosimetric behaviour of visco-elastic-liquids, but also their elastic properties by paying attention to the effect of the normal forces which tend to separate the two discs of the viscosimeter when they

are rotating against one another. One of the two discs is bored and the discs maintained at constant distance, the visco-elastic liquid is forced through the hole. At this time the device is working as a pump able to transfer a visco elastic liquid from the periphery of the discs to the center hole and to extrude it.

It appears immediately that such a device has cutstanding advantages compared with screw-extruders of the classical type. First of all it is evident that there is a notable difference of the axial dimensions between a disc construction and a screw cylinder which has become longer and longer in the past years in order to impose the quality of the extrudate. At the same time, the mechanical construction has been simplified. A screw extruder is far from being an ideal instrument for mixing and plastifying molten polymers. Everybody knows that the flow of material remains laminar and that the screw, instead of mixing, only transfers layers of material against one another and from one place to another. If we consider the development work that is being done, at the present time, all over the world, on the geometry and design of screws in order to improve extrudate quality; we understand that there is an immediate need for finding another way to mix and plastify polymer materials. Mixing and plastifying are really two operations by which we aim at the same goal. In the first case we are stressing the mechanical mixing and dispersing of different ingredients, in the second case, we think of a complete homogeneity of the extrudate, both mechanical and thermic. This homogenizing capacity of a plate extruder seems to be equal to that of two 20 D extruders in series.

A further problem is the hold up time of temperature sensitive materials as P.V.C. The longer the screw, the more pressure it gives, the better the mixing, the more energy is needed, and the longer the dwell time of the material in the cylinder. As we see, we are moving in a vicious circle. Yet, we have extruded without any difficulty or degradation, non plastified P.V.C. at 240° in a RHEO plastificator.

However, disc extruders have two major handicaps :

1. they are difficult to feed because of the narrow gap between the discs

2. the pressures produced are commonly lower than in conventional extruders.

Recent research and development made on disc-extruders are to be considered as attempts to eliminate these disadvantages.

Numerous patents taken in different countries show nevertheless the growing interest in this field.

The RHEO plastificator allies the good pressure building and good feeding capacities of a screw to the exeptional mixing and plastifying advantages of the shearing discs. We resolved this difficulty by adding a shearing zone to a short screw giving good feeding and pressure.

The front of the screw is flat and similates the rotating shearing disc. The inside wall of the cylinder is the rotationary disc. The normal force effect builds up a spiral flow of material in the gap between the discs, from the periphery to the central hole. Once built up, this vortex has a sufficient stability in order not to be overwhelmed by the screw pressure.

The screw pressure is almost exclusively exerted on granules and it is easy to determine the output pressure by the geometry, the surface condition of the length of screw and cylinder.

Plastification is nearly exclusively effected by shear action and takes place under pre-pressure of the granule-feeding screw with three entries to provide an equal distribution of material in the shearing gap. The warming up of material regulates the output temperature by pre-heating the granules but not by plastifying them. The stability of the vortex prevents breakdown of the spiral movement which is working as a damper between the screw pressure and the die back-pressure. It is clear that the normal forces do not act as a pressure-building-up device but rather as a brake with a regulating effect on pressure.

The output of the screw has to be higher than the output of the shearing zone. If this is not the case, the screw will be "starving". This shearing zone must control the material output of the screw, taking care not to be overridden.

Comparing with a usual three-zone-screw, we may say that the metering zone has been replaced by the shearing gap. The feeding and compression zone are replaced by the screw. This compression

takes place on granules and degazing is greatly facilitated.
To-day much experimentalwork points out that the granule zone of a screw is of greater importance on the final performance of the extruder than was generally admitted. In the RHEO plastificator the granule zone is much easier to be mastered.
A screw is designed for a rather limited range of materials. The RHEO plastificator is much more versatile and accepts all different polymers and various diemsnions of granules without plant modification.
One of the outstanding properties of the RHEO plastificator is the uniformity of the viscosity of the extrudate. There are three reasons for this.

1. The heating-effect is due to shear or internal friction instead of conduction from the heaters or friction against the srew. This means that the heat is produced internally and uniformely over the mass of material without being influenced by the bad thermic conductivity and the thermic sencitivity of the polymers and their laminar flow in the screw.
2. The material having the exact visco-elastic properties is moving with maximum speed to the centre of the discs. Other materials undergo more centrifugal action and their dwell-time and warming-up time is longer. There is consequently an continious exchange of material of different viscosity on the discs.
3. The friction varies proportionally to viscosity. Therefore materials of higher viscosity will be heated more than those with a lower viscosity and they will become more uniformly homogeneous. One may say that RHEO plastificator is a device with its own auto-viscosity-regulation. This viscosity can be influenced under given circumstances (material properties, screw speed, etc..) by the preheating in the cylinder.
The whole heating system is reduced to one heater and one temperature feeler that gives viscosity measurement of the outcoming melt. The unit seems particularly suited for high molecular weight material as the very low melt index P.E. that is brought into focus nowadays.

A N N E X E IX

(1) MR. GE JIANSHUEI, DIVISION CHIEF
WASTE GOODS & MATERIALS BUREAU, THE MINISTRY OF COMMERCE, PRC

(2) MR. ZHANG FAN, SECTION CHIEF
WASTE GOODS & MATERIALS BUREAU, THE MINISTRY OF COMMERCE, PRC

(3) MR. HE YAQIN, SENIOR ENGINEER
SCIENCE & TECHNOLOGY BUREAU , THE MINISTRY OF COMMERCE, PRC

(4) MR. LIN YONGHAO, DEPUTY DIRECTOR
THE CHINA INTERNATIONAL CENTRE FOR ECONOMIC & TECHNICAL EXCHANGES, MOFERT, PRC

(5) MR. YAO SHENHONG, PROGRAMME OFFICER
THE CHINA INTERNATIONAL CENTRE FOR ECONOMIC & TECHNICAL EXCHANGES, MOFERT, BEIJING

(6) MR. ZHAO GONGYI, DEPUTY SECTION CHIEF
BEIJING WASTES RECYCLING COMPANY, BEIJING

(7) MR. LIN ZONGCHENG, DEPUTY GENERAL MANAGER
NANJING WASTES RECYCLING COMPANY, NANJING, JIANGSU

(8) MR. LU YANGCHENG, ENGINEER
QINGDAO WASTES RECYCLING COMPANY, QINGDAO, SHANDONG

(9) MR. YUAN JIANJIAN, SECTION CHIEF
HANGZHOU WASTES RECYCLING COMPANY, HANGZHOU, ZHEJIANG

(10) MR. MA PEILIN, MANAGER
WUXI WASTES RECYCLING COMPANY, WUXI, JIANGSU

(11) MR. YUAN FUJIN, DEPUTY MANAGER
WUXI WASTES RECYCLING COMPANY, WUXI, JIANGSU

(12) MR. LI KUNCHENG, ENGINEER
TIANJIN WASTES RECYCLING COMPANY, TIANJIN

(13) MR. WANG XIANGDAO, DEPUTY DIRECTOR
FINANCE AND TRADE OFFICE OF SHANGHAI MUNICIPAL PEOPLE'S GOVERNMENT, SHANGHAI

(14) MR. HAN GENGCU, DEPUTY DIVISION CHIEF
FINANE & TRADE OFFICE OF SHANGHAI MUNICIPAL PEOPLE'S GOVERNMENT, SHANGHAI

(15) MR WANG ZUKANG, VICE CHAIRMAN
FOREIGN ECONOMIC RELATIONS & TRADE COMMISSION, SHANGHAI MUNICIPAL PEOPLE'S GOVERNMENT

(16) MR. LI YONGXIAN, DIVISION CHIEF
FOREIGN ECONOMIC RELATIONS AND TRADE COMMISSION, SHANGHAI SHANGHAI MUNICIPAL PEOPLE'S GOVERNMENT , SHANGHAI

(17) MR. ZHANG GENGSHAN, DEPUTY DIVISION CHIEF
FOREIGN ECONOMIC RELATIONS & TRADE COMMISSION , SHANGHAI MUNICIPAL PEOPLE'S GOVERNMENT, SHANGHAI

(18) MR. XIE GUJUN, SECTION CHIEF
FOREIGN ECONOMIC RELATIONS & TRADE COMMISSION , SHANGHAI MUNICIPAL PEOPLE'S GOVERNMENT

(19) MR. CHA JIE, DEPUTY DIRECTOR
SHANGHAI SUPPLY & MARKETING CO-OP, SHANGHAI

(20) MR. XU WEIJIN, DIVISION CHIEF
SCIENCE & TECHNOLOGY DIVISION OF SHANGHAI SUPPLY & MARKETING CO-OP, SHANGHAI

(21) MR. ZHANG YANQING, DEPUTY MANAGER
SHANGHAI RESOURCE RECOVERY & UTILIZATION COMPANY

(22) MR. ZHU KEXI DEPUTY MANAGER
SHANGHAI RESOURCE RECOVERY & UTILIZATION COMPANY

(23) MR. DENG ZIXUN, DEPUTY MANAGER
SHANGHAI RESOURCE RECOVERY & UTILIZATION COMPANY

(24) MR. ZHANG DAFENG, DEPUTY MANAGER
SHANGHAI RESOURCE RECOVERY & UTILIZATION COMPANY

(25) MR. ZHOU WENJUN DEPUTY DIRECTOR
SHANGHAI SUPPLY & MARKETING INFO REVIEW

(26) MR. ZHOU ZHONGDE, ECONOMIST
FINANCE & TRADE OFFICE OF NANSHI DISTRICT, SHANGHAI

(27) MR. CHEN BINGHAI, MANAGER
NANSHI BRANCH OF SRRUC

(28) MR. LIU BAOPING. DEPUTY DIRECTOR
XINGGUANG PLASTICS FACTORY OF SRRUC

(29) MS. WANG YU, ASSOCIATE PROFESSOR
EAST CHINA UNIVERSITY OF CHEMICAL TECHNOLOGY

(30) MR. ZHANG DEXING, DEPUTY SECTION CHIEF
SRRUC, SHANGHAI

(31) MR. ZHAO ZHENLIANG, SECTION CHIEF
SRRUC, SHANGHAI

(32) MR. ZHU JUNJING, SECTION CHIEF
SRRUC, SHANGHAI

(33) MR. XU JINLIANG, DEPUTY SECTION CHIEF
SRRUC, SHANGHAI

(34) MR. ZHANG GUOCHANG, INTERPRETER
SRRUC, SHANGHAI

(35) MS. LIU QUAN, INTERPRETER
SHANGHAI SUPPLY & MARKETING CO-OP, SHANGHAI

(36) MS. CHEN QIUYING, INTERPRETER
SRRUC, SHANGHAI

(37) MR. XIE SHIMING, INTERPRETER
SRRUC, SHANGHAI

(38) MS. SHI WEILI, STAFF MEMBER OF SRRUC

(39) MR. XU RUITIAN, DITTO

(40) MS. MA FENYING, DITTO

(41) MR. ZHOU CHUNHAI, DITTO

(42) MR. ZHOU BAOQING, DITTO

LIST OF PARTICIPANTS AT WORKSHOP ON PLASTICS WASTE RECYCLING TECHNOLOGY, SHANGHAI, 10-12 APRIL 1989

Name and Contact Address

• Mr. Shahjahan SIKDER
Plastics Technology Centre
BITAC Premises
Tejgaon Industrial Area
Dhaka
Bangladesh

• Mr. Pervez AHMED
3-c, 6/5, Nazimabad
Karachi - 18
Pakistan

• Mr. Adolfo Jesus COPEZ
Industrial Technology Development
Institute
P. Gil, Taft Ave. (P.O. Box 774)
Manila
Philippines
Tel: 59-22-75

• Mrs. Padma Irangani IDDAMALGODA
Ceylon Institute of Scientific
and Industrial Research
363 Bauddhaloka Mawatha
Colombo 7
Sri Lanka

• Mr. Phietoon TRIVIJITKASEM
Sunflower Co. Ltd
14-16 Mahesak Rd.
Bangrak Bangkok 10500
Thailand

• Mr. Joo Fai TUNG
SIRIM
P.O. Box 35
40700 Shah Alam, Selangor
MALAYSIA

• Mr. Aroun ANAND
16, Nizamuddin East
New Delhi 110 013
or
74 Sector 7,
Chandigarth (UT)

ANNEXE X

COUNTRY PAPER
ON
PLASTICS WASTE RECYCLING

PREPARED BY:

SHAHJAHAN SIKDER
CHIEF ENGINEER
PLASTICS TECHNOLOGY CENTRE,
BITAC PREMISES, TEJGAON I/A.,
DHAKA-1208,
BANGLADESH

Contents :

1. Definition of Plastics Waste :-

Plastics like other material such as paper, glass, wood, ceramics, once they have fulfilled their function or have become obsolete, brocken, damage, outmoded or no longer desired are discarded and have to be disposed of in one way or another. The undesired plastics items which we throw away, appears as waste collected with the general domestic or urban refuse. This also applies to industrial rejects and discards which if not dealt with on the site of their production can be readily collected and can thus be treated as plastic waste.

2. Basis for Assessing plastics waste.

Main fields of plastics waste are:-

i) Major proportion of plastics waste originates at present from the packaging section.

ii) Almost all plastics packaging is discarded within a comparatively short period of use life, and of this a substantial proportion will appear in the collectable domestic and trade refuse.

iii) A certain amount of plastics other than packaging will become dustbin waste.

iv) The amount of plastics waste from application outside the packaging area and its proportion in relation to the total plastic waste will increase from year to year.

Disposal Process:

Waste once created, has to be removed from man's surroundings and has to be eliminated in some way, because otherwise its acumulation would eventually hinder, if not prevent, all his activities even the creation of new waste. Basically, there are only three possibilities for disposing of unwanted matter, namely :

i) by depositing it on or under the earth surface,
ii) by dispersing it as gaseous matter into the atmosphere,
iii) by sinking it into the seas and oceans.

The Chemical and plastics industry by their formidable progress in the development of plastics materials, converting technology and end-use application, cannot disclaim their share of responsibility in the "Waste" problems, because, once plastic have become waste, their presence in the general refuse will make itself felt all along the various process steps from the dustbin to the final disposal processes, irresptive of whether such waste is dealt with by dumping, controlled tipping, pulvarisation, compositing, compaction or dumping into the sea. However whatever the method of disposal, it must be economically feasible and technically sound and it should not constitute a nuisance nor it should become a source of pollution of water or the atmosphere.

4. Types of plastics used in Bangladesh:

Mostly used plastics in Bangladesh are PVC, Polyethylene (lowdensity and highdensity), Polypropylene (PP), Polystyrene (PS), Polyamide, ABS etc. Small quantity of some other thermoplastic materials are also used in the country. In the thermosetting group - Ureaformaldehyde, Malamin and Bakelites are also used in Bangladesh.

5. Major fields of Application of plastics in Bangladesh:

Major fields of application of plastics in Bangladesh are:

i) Pipes: for transportation of water, conduit and drainage etc.

ii) Cable: Electrical high power cable domestic cable and telephone cable.

iii) Containers: for packaging of eddible oil, petrolium, foods, packaging of medicine etc.

iv) Packaging(film): for packing of domestic items, foods, shoping bag etc.

v) Domestic Item: Bucket, basket, glass, jugs, plates, various house hold utensils etc.

vi) Industrial Components: Bobbin, pickers, shuttle, various industrial spares etc.

vii) Monofilament: Rope, fishing nets, textile etc.

6. Recycling of plastics at the manufacturers levels in Bangladesh:

Generally thermoplastics are reprocessable materials. At the manufacturers stage, all runners, waste products, scraps etc are reprocessed by crushing those with a crusher and used for manufacturing of some or other various products. Thermosetting plastics are not reprocessable, so the wastages of thermosetting plastics are thrown away as garbages.

7. Recycling of waste plastics in Bangladesh:

In Bangladesh generally shopping bag, containers of various types used in pharmachetical packaging, eddible oil, petrolium and waste shoes, waste pipes are collected by a group of low earning people. After collecting those they are generally sorting it in various groups according to type of raw material or product basis and then they clean it and sell to a group of plastic reprocessing industries.

The waste plastics reprocessors are again sorting the product in groups and crushed and make granuels for selling in the market. This type of reprocured plastics are used for manufacturing of poor quality low cost toys, dolls etc.

Presently problems are facing with reprocessing of waste shopping bags (film). Some hawkers and some low earning peoples are also collecting this films from garbages and houses. They try to clean this bags as far as they can and then they pack it in beles and supply to the waste plastics reprocessing industries.

Presently some reprocessors developed locally made high speed crusher by which they crushed the films and convert it into granuels and sold it to the market. This type of reprocessed plastics are used for manufacturing of some very low cost injection moulded product. This type of recovery is still possible due to the low cost of labour in Bangladesh. A group of people is living their lively hood by recovering waste plastics. Though there is a group of people to recollect the waste plastic still a major parts of the waste plastics are thrown away with Garbages by the Municipal cleaning authority. The used plastics which are going with garbages are not collected or reprocessed or no any action is being taken presently in Bangladesh to decompose those waste plastics. The cleaning authority is ignorant about the future problem may arise from those undecomposed plastics.

In the process of collection of garbages, the waste plastic films are creating problem during transportation. It is being scattered esily by wind and making the enviorment dirty. This type of packaging (film) plastics also creating problem is drainage system of the city area. As the plastics are not decomposable by biological action, so they are closing the drainage system fully or partially and it requires frequent cleaning by the drainage authority.

8. Conclusion :

The following conclusions are drawn up from the present recycling system of waste plastics in Bangladesh:-

i) Most of the reprocessed waste plastics (except PE or PP film used for packaging) are used for poor quality plastic product.

ii) A Certain percentage of PE & PP film used for packaging of food, other goods and shopping bags are also collected and reprocessed for the use of poor quality product. Percentage of reprocessed waste films is not known as because there is no study in this line (Approximately it may be 30% to 50%).

iii) Waste packaging films are creating problems in drainage system of the country.

iv) Waste packaging films are also making the enviorment dirty.

v) Municipal authority is not aware about the future problem may arise from the waste plastics which are thrown away by them with other garbages in the dumping area as because plastics are not decomposed by microbial action.

vi) A group of people is involved in recollecting and reprocessing of waste plastics.

vii) The reprocessors and the users of recycled waste plastics are not concerned about the quality of the recycled waste plastics.

9. Recommendation:

The following recommendation are made for the local plastics product manufacturers, users and reprocessors of waste plastics:-

i) The manufacturer of plastics product should take more care to reduce the waste of plastics and plastics product.

ii) The manufacturer should take more care about the quality of the waste plastics and they should be more careful, so that the properties of waste plastic does not decrease much and it should not mix with dust and should not Pollute the enviorment.

iii) The manufacturer or users of recycled waste plastics should be aware of the required properties of their product and the properties of recycled waste plastics.

iv) The group of peoples collecting and recycling waste plastics should have sufficent knowledge in identificatiqn of type of plastics, so that they can separate the mixed waste plastics in different groups.

v) The peoples involved for recycling of waste plastics should take more care to clean the waste plastics properly before crushing it for use and they should also take care that waste plastics do not pollute the enviorment.

vi) Municipal authoritybneeds proper knowledge and care so that waste plastics (mainly packing film, shopping bags) do not make the enviorment dirty during transportation.

vii) Municipal authority needs knowledge in dumping of waste plastics as the plastics are not decomposed by biological or enviormental action.

viii) The Municipal authority (Cleaning authority) need proper knowledge in how to make the waste plastics decomposed, so that in the future the waste plastics will not be a threat to the Polution of enviorment.

PLASTIC WASTE RECYCLING INDUSTRY IN INDIA

by

Arun Anand
B.Com. (Hons), FCA (Eng. & Wales), FCA, ACS
Vice Chairman & Managing Director
SHIVALIK AGRO-POLY PRODUCTS LIMITED
302, Sector 9-D, Chandigarh
(INDIA)

Presented at

WORKSHOP ON PLASTICS WASTE RECYCLING AT SHANGHAI (CHINA)
(April 10 - 12, 1989)

Organized by

UNIDO, VIENNA

Hon'ble Chairman of the Conference, Esteemed Fellow Delegates, Ladies & Gentlemen,

It gives me great pleasure to be here to share our experience with you for which my thanks are due to the Organizers of this workshop and most of all to UNIDO for extending this opportunity towards presenting our experience in India. Also to my colleagues for their assistance in assembling this paper and my Company in allowing me the time to come all this way to this magnificent country and be amongst you.

This paper is in two sections - one that refers to General Comments/Contemporary End-Use Application Examples and the other on the Scenario in India.

SECTION - I

General Comments & Contemporary End Use Applications

The subject of Plastic Recycling is of utmost importance on account of two basic factors - first and foremost being environment preservation and protection, and secondly the very important aspect of cost benefit economics particularly with the high cost of plastics (owing to high base price or high fiscal levies or both) and the human endeavour to attain maximum advantage out of it.

As to the matter of environmental protection, plastics being non-biodegradable in general, require handling with careful selectivity in their application so as to ease the subsequent retrieval for recycling and reuse to achieve maximum advantage from its technological use and further to negate any ill effects to the environment.

As to the cost benefit economics, the maximum beneficial

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use must be achieved so as to mitigate its high cost over multiple stage applications for which appropriate R & D in industry must be encouraged.

For long time, recycling of plastic waste has aroused world wide curiosity and interest. It is time to talk of promoting plastics recycling keeping in view a number of reasons why a more efficient recycling industry would make sense both in industry terms and for the whole economy. Plastics recycling generally takes one of the three forms (i) in-house process waste recycling (ii) specialist plastics waste recycling and (iii) mixed plastics recycling. High Density/Low Density Polyethylene (which constitutes half of plastics packaging by weight) is the most common type of material recycled, others being PVC, Polyproplene, Polymides etc.

To sustain ecological balance and to take advantage of the thermoplastics' polymeric life, efforts to develop economical and beneficial technology of recycling plastic wastes and products therefrom must be encouraged to utilize the product which is generated from (i) factories (ii) collectors of industrial aste from large generators/ extruders and (iii) packaging from commercial and agricultural sectors etc. etc. This step imparts efficiency and economy to the use of recycled plastics from the point of view of environmental poilution control, energy conservation, and overall economy, besides maximising material utilisation efficiency.

A very high proportion of virgin material comes under recycling for use in various areas including non-critical applications for different end users in the shape of sheets, utensils, toys, temporary civil structures, auto parts, electric gadgets and so on. But the foremost

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point which sometimes remain unnoticed that standardised consumer products often also open the door to introduction of recycled plastic which must be approached with caution. Indiscriminate use of recycled plastic invariably will bring a product application into disrepute. It is therefore, necessary to resort to maintaining standards and quality control of products which incorporate the use of such recycled thermoplastics. We therefore, must put thrust on end use specifications, economic usefulness coupled with employment orientation. Necessary technology and development must be taken up to usher in specialised processing of low cost yet acceptable products from recycled materials.

Generally, common purpose consumer articles are aimed for. However, effort must be to use the recycled materials for products aimed at industrial applications so that they can contribute meaningfully in overall industrial development.

Various end applications can be conceived and engineered for effective introduction. Two major examples that have been developed are -

(I) Pallets for dunnage in storage/material handling; and

(II) Boxes/cases for fruit/vegetables, soft drinks and general packages made from waste LDPE/HDPE and rice husk combinations.

A unique example which has recently been introduced after development in our country is pallets from recycled HDPE/LDPE, for use as dunnage in storage and material handling, in substitution to wooden pallets.

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This development replaces the use of wood which otherwise is scarce and thus needs to be preserved more particularly for environmental protection reasons.

For sourcing the recycled plastic for this application, the development has been dovetailed to the CAP (Cover and Plinth) storage concept and programme in our country.

The scientific CAP storage requires extensive use of poly covers made from virgin LDPE/HDPE film/sheets for protection of foodgrains during storage from acclamatic conditions and rodent wastage. This is used in an extensive scale in India in the Foodgrain Storage and Protection Programme. This in turn generates substantial volume of obsolete poly scrap which has good polymeric life but is otherwise of limited value. On the other hand, wood becoming increasingly scarce day by day, the development of substitute pallets and need to use this waste was taken up with foresight. Research on non-exploitative ways of using obsolete scrap was taken up which led to development of poly pallets manufactured out of the low value scrap. LDPE/HDPE scrap, otherwise of good polymerics life but low value, thus could be recycled for a second generation application of economic value and contributes to environment preservation through conservation of wood, as also, yet on the other hand, consumption of plastic waste.

Thus plastic scrap is brought into profitable use in the shape of poly pallets which serves the multipurpose applications in storage as dunnage, having quality and acceptable standard of product, specially designed and fabricated for its long life. These pallets can be used with fork lifts for industrial use, and ordinary poly

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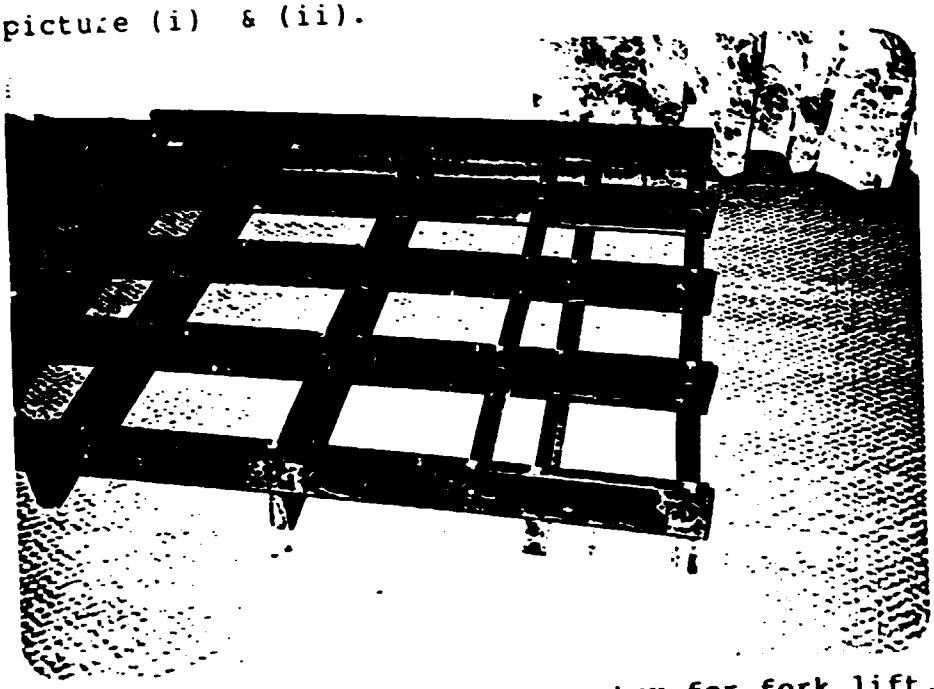
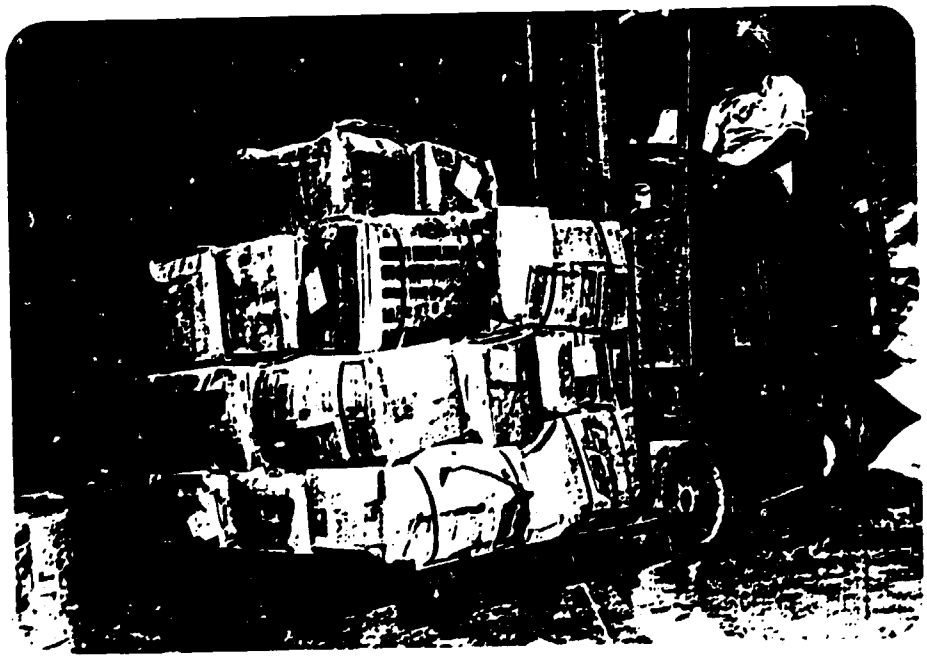
pallets for dunnage for storage applications. Refer picture (i) & (ii).



(i) **Poly Pallet with two way entry for fork lift.**



(ii) **Loaded Polypallet on fork lift - Capacity one tonne**

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The particular characteristics of plastic pallets are, they -

i. need no fumigation;

ii. need no specialised handling being able to withstand rough and tough handling;

iii. need hardly any repairs although of light weight;

iv. do not damage lower layer of gunny bags in a stack;

v. chemically inert;

vi. odourless, physicologically harmless;

vii. help in containing pollution, and

viii advance ecological balance by conserving precious wood for other uses.

Each wooden pallet when substituted by a poly pallet saves 2 cu. ft (0.056 cu. mtr.) of wood.

With the vast number of pallets in use the potential saving of wood can be immeasurable. This in turn carries an immeasurable value in terms of its environmental contribution in ecological balance preservation.

Another application viz boxes for fruit/vegetable handling/packaging have been developed from LDPE/HDPE and rice husk compounded material where a thick sheet of 2 mm is made and then cut and assembled into containers of convenient sizes.

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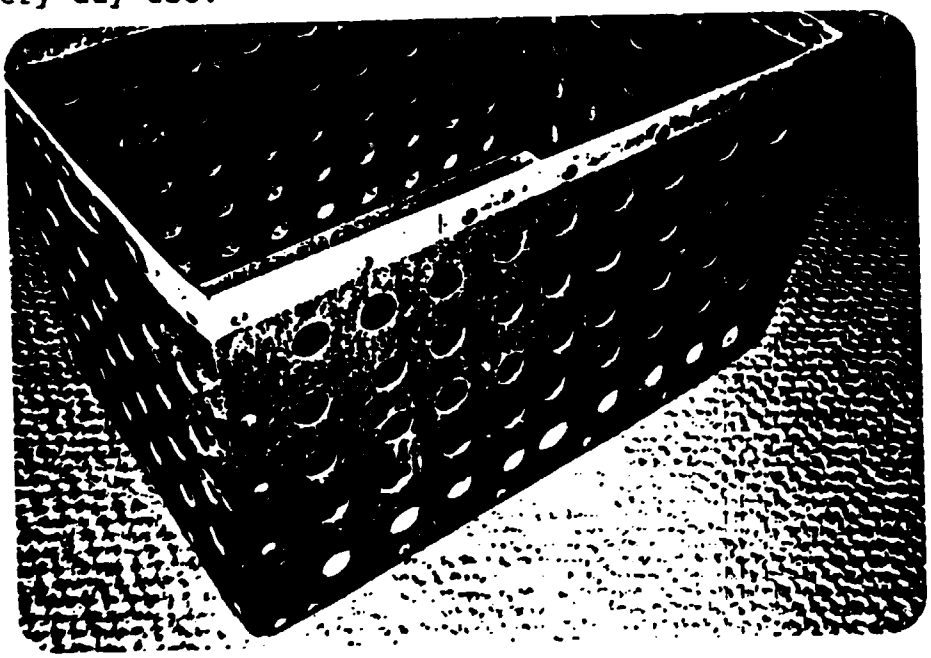
The photographs attached give as an illustration:-

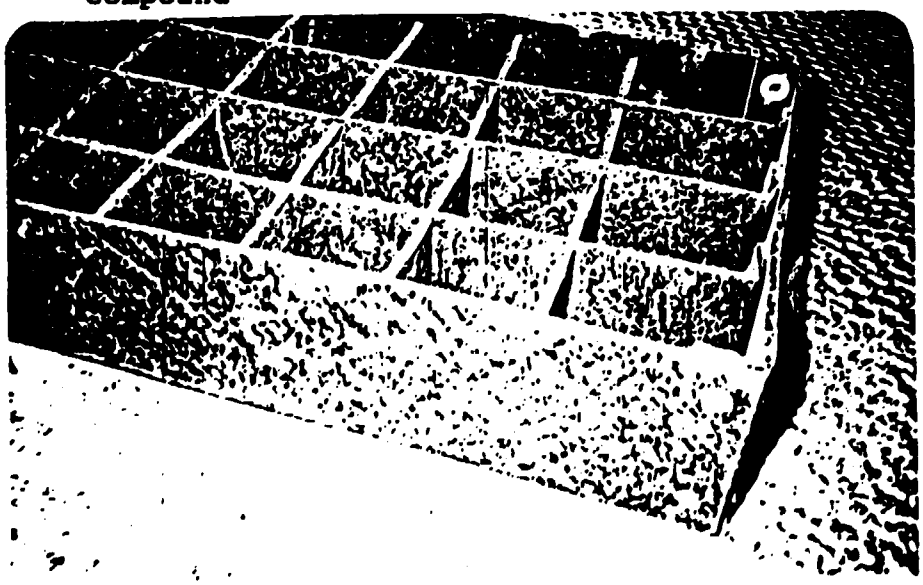
a. Photograph of fruit/vegetable box

b. Box for soft drinks

These applications use both waste plastic and waste byproduct - rice husk and is converted into useful items of every day use.



(iii) **Fruit/Vegetable box from plastic waste/rice husk compound**



(iv) **Box for stacking of Soft drinks bottles or carriage of fragile goods**

SECTION II

Situation on Plastic Waste Recycling Industry in India

Polymers in commercial parlance primarily comprise of thermoplastics, thermo-sets, synthetic rubbers and engineering plastics. The major thermoplastics are L.D.P.E. (Low Density Polythylene); P.V.C. (Polyvinyl Chloride); P.S. (Polyestyrene). Other thermo plastics viz., Acrlylonitrile Butadine-Styrene (A.B.S.), Styrene Acrylonitrite (S.A.N.) and Poly Mythyl Metha Acrylate (P.M.M.A.), though not engineering plastics in the true sense of the term, have been included in this category of plastics. We shall call these as general commodity plastics and shall deal with the scenario in India.

Before we go into the subject of the Reprocessing Industry of Plastics, it would be pertinent to understand the size of the polymer market in the country for virgin material and consequent developments to augment further capacities, as the size of the R.P. Industry amongst other factors also depends on the virgin material availability in the market.

In this context it would be important to understand the past consumption and growth trends in plastics, the polymer availability scenario and demand projections for commodity plastics. The details pertaining to the above have been reflected in Annexures.

The figures reflect considerable growth over the past few years. This growth was 12.5 per cent on the basis of compound annual rate of growth upto the year 1984-85. At the same time polymer availability scenario, though shows considerable improvement, is still far below the

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demand projections, as reflected in table-3 of Annexure. This reflects the demand potential to the extent of 796,000 M.T. per annum for commodity plastics with per capita consumption of 1 kg which is likely to increase to 1.6 kg towards end of the VIII Plan to 2.16 kg by the end of the IX Plan or by the turn of the century.

The annexure also reflects the pattern of consumption. However, another very vital factor which is taking predominance is cost of polymers which has been rising steadily either owing to high base cost or fiscal levies/taxes by Govt. This aspect has been discussed later, in the paper as, this aspect also determines the pace and growth of the industry to undertake reprocessing of polymers.

The indigenous availability of virgin commodity plastics has been significantly lagging behind demand for most of the time. The demand for commodity plastics is dependent on the number of factors like price, supply, consumption characteristics etc. The degree of influence of each of these factors are again governed by the product/market characteristics. In Indian context, the demand for plastics is observed to be more influenced by the supply and to a relatively lesser degree, by real price of the product! The reason for such an over-dependence on the supply factor is owing to the nascent status of the industry which is growing at a very fast pace. The untapped potential is high and the future scope, quite substantial. The influence of supply therefore predominates the consumption overshadowing the marginal changes in the price.

Currently as the production of commodity plastics in the country does not even meet 50 per cent of the total demand,

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the domestic requirement therefore, has to be put most of the polymers under OGL scheme envisaging liberalised imports whereby actual users can meet their requirement through imports. There was relative lull in between as the global price of the plastics had shot up considerably during the year 1986-87. However, despite the above, the demand has bounced back. Another factor which otherwise restricts imports is the high level of import duty on all the polymers, imposed by the Indian Government which can vary between 100% to 340% for different polymers. The import duty structure has given the domestic manufacturers leverage to jack up the price in consonance to landed prices of imports. Therefore the polymer prices in India, are amongst the highest in the world today.

Reprocessing Industry - The scenario:

By the very nature, thermo plastics can be shaped and reshaped many times by the application of heat/pressure/ shear. However, at each processing step, the polymer undergoes degradation due to breakage of molecular chain. The extent of degradation increases in geometric progression at each processing step. Therefore, the upper limit of useful reprocessed goods is not more than three times for all practical purposes.

The scenario with high polymer price with substantial increase in consumption, has brought lot of consciousness to the reprocessed polymer trade.

The reprocessed industry in India during early 60's was confined to relatively small operations - at tiny cottage industry levels - The convertor was relatively ignorant about various properties of different polymers and would

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ultimately mix different polymers having different characteristics. These reprocessed plastics found applications where appearance and properties were of no consequence viz., cheap toy industries, tarpaulins for shelters etc. It was estimated that in the year 1984-85 industry had grown to a position where 23% of total virgin polymer consumption went back into reprocessed sector, currently this has approached 50%.

Trade Practices in the Reprocessed Industry:

The reprocessing industry began in the early 60's and over the years attained reasonable status. The major aspects that influence this particular trade are:

(a) The Reprocessing industry is located closer to the scrap generating industry and consumption markets. This is because the industry has to thrive on economical access to the availability of the discarded virgin processed goods and it was observed that over 85% of the reprocessors are located in the metropolis and large towns.

(b) The major reprocessing activities are carried out against cash transactions. The major quantity of inputs to the reprocessing sector come from the household which sells packaging films and damaged/broken housewares to scrap buyers. Some inputs also come from garbage sources where discarded plastic products are thrown. The other significant source of inputs is auction/tender disposal of packaging materials by the industrial sector.

(c) The output of reprocessing sector is also predominantly sold in the retail markets on cash.

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(d) The reprocessed plastic goods, under normal situation of steady virgin raw material prices and supplies find specific outlets based on their price and functional requirement of end use. The textile industry is reported to be a large user of reprocessed packaging films as well as moulded bobbins cones etc. The agricultural sector also is a large user of reprocessed goods in the form of black films and pallets. Presence of reprocessed injection and blow moulded housewares and toys is quite conspicuous in the rural markets as well as urban markets directed at the low income groups. Reprocessed packaging films are extensively used by retailers for protective packaging of industrial and consumer products.

(e) From mere appearance of reprocessed goods, the trade is in a position to classify these goods into:

i. Once reprocessed goods
ii. Twice reprocessed goods
iii. Goods reprocessed more than twice

(f) Wholesale price of virgin and reprocessed goods depends on various factors viz., once reprocessed, twice reprocessed and more than twice reprocessed. Once reprocessed polymer may cost upto 60% to 65% of the virgin material; twice reprocessed may cost between 45% to 50% of the virgin material and more than twice reprocessed material may cost upto 40%.

This therefore shows the wide scope of the reprocessed industry. In the context and average costs of thermo plastics in India can be taken as Rs. 35/- per kg (US $ 2/- per kg).

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(g) Some products in the household as well as industrial sector have good reuse potential. such products become available for reprocessing to a small extent after the purpose of reuse has been served. Typical products in the household are vanaspati, containers carrier bags etc, heavy duty plastic sacks and HDPE woven sacks also find extensive reuse amongst farmers and industrial users.

It would now be pertinent to evaluate prime application of various virgin commodity plastics which form the source point for the reprocessing industry.

These are:

L.D.P.E.

Food packaging:	This includes liquid milk packaging, cereals, salts and processed foods.
Non-food packaging:	Fertiliser and bitumen laminate, textiles, detergents, industrial products and consumer products including toys and garments.
Non-packaging applications of : film	CAP covers, nursery bags, carrier bags.
Extrusion coatings:	Fertiliser and industrial packaging.
Wires and cables:	For telecommunication sheathing compound.

Contd.....

Injection mouldings: This includes rotational moulding, blow mouldings of various consumer products and profiles.

H.D.P.E.

The prime application for use of HDPE - woven sacks, monofilaments, HM HDPE for packaging, pipes, injection mouldings, blow mouldings, extrusion and others.

Polypropylene:

TQ film, BOPP film, Woven sacks, Monofilaments and ropes sheets and pipes, strapping/sutli, injection moulding, blow moulding, fibre/filaments.

PVC (rigid):

Pipes, conduits, fittings, film and foils, bottles and profiles

PVC (Flexible):

Wires and cables, calendered sheets, leather cloth by spread coating, footwear, garden and discharge hose etc.,

Scrap collection:

The prime factor that determines the scrap value is the grade, quality and condition of the scrap. Thereafter, the next important factor is the colour. If the scrap is of virgin material and in natural colour, it demands the highest value followed by scraps in different colours and last being scrap in black colour. The prime reason being that natural colour scrap can be coloured by the

Contd.....

consumer according to his requirements. Plus the addition of colour gives fresh look to the material; whereas other colours have to be used as such with only minor modifications. Earlier the scrap industry was predominantly in the unorganised sector, but with increased consumption and also the rising prices of polymers, this scenario is now gradually changing, with the emergence of large consumers who have consequently larger scrap generations, a different kind of activity that has emerged whereby scrap collection is now more organised. The scrap is disposed through either tenders or through annual rate contract. Considering that total consumption of commodity plastics of 1989-90, is in the order of 9,55,000 tonnes, it can safely be estimated that the market for reprocessed industry would be in the region of 400,000 tonnes estimating first time reprocessed, second time reprocessed and third time reprocessed material.

It would now be pertinent to identify sectors which utilise reprocessed material and also applications to the extent to which it could possibly be utilised. We shall take the case example of L.D.P.E. The estimated consumption of virgin LDPE during the year 1985-86 was of the order of 1,44,000 tonnes, a detailed end use analysis is available bifurcating each end use.

Based on this analysis possible segments of each virgin processed goods became available to the reprocessing sector during 1985-86, have been estimated.

i. **Canal/reservoir lining:**

By the very nature of this application, there is no possibility of lined film becoming available for reprocessing.

Contd.....

ii. **CAP covers:**

CAP covers are auctioned by FCI and State government agencies after two to three seasons of use. About 5 to 10% of these CAP covers are retained for reuse as dunnage. There is a time lag of 1 1/2 to 2 years when the material becomes available through auction for reprocessing. The consumption of LDPE in this sector was in the region of about 30,000 tonnes out of which approximately 20,000 tonnes were available for reprocessing. The prime application for this material, as the film is black in colour was suited to make black LDPE pipes for farm and water distribution, black tarpaulins and film for shelter and protection and poly pallets for dunnage. (This application is relatively new but is gaining acceptance as an alternative to the existing pallets made of wood, a measure that government wants to encourage to conserve use of wood).

Milk packaging:

This is one area where there is maximum demand for reprocessing. Bulk of the milk packaging are in natural colour or white colour both of which are in high demand. The total consumption of this segment is estimated to be around 20,000 tonnes out of which about 75% is expected to be used for reprocessing. As milk pouches have some fat adherence, this film has to be washed with detergents to remove the fat. Prime application of this film are tarpaulins and shopping bags, nursery bags and grocery bags, which are in good demand in India.

Contd.....

Pertiliser packaging:

LDPE film is laminated with jute or extrusion coated on LDPE/PP ruffia. As such it is not possible to extract the film from the discarded sacks.

Wires & Cables:

LDPE film/compound is used for insulation and sheathing of power cables and communication cables. This sector is gradually emerging as a large source of LDPE scrap. This sector consumes appxly. 25000 tonnes of sheathing compound annually. This material has superior mechanical properties, there is fairly good demand for scrap generated from this industry and thus demands high premium. The scrap from this application, as bulk of it is in black colour, is used for plastic containers, films and sheets and blends for other plastic injection moulded materials.

Carrier bags:

These bags are extensively used in the household and only after damage they are discarded. Very small segment may get salvaged from the garbage stream for reprocessing.

Industrial Packaging:

This segment consumes large quantity of LDPE film for packaging of industrial intermediates; in the year 1985-86 this segment was expected to consume 33,000 to 34,000 tonnes of material and about 20% of this quantity is estimated to have entered for reprocessing through auctioning/tender disposal. Only large sized liners sheets etc., are disposed where small bags and rolls find either reuse or get discarded in the garbage.

Contd.....

Packaging of consumer products:

The consumer of LDPE in this sector is estimated to be in the order of 40,000 MTs annually. Ultimately, LDPE bags and pouches reach household as bags for cereals, salt sugar and retail bags for snack food, processed food and consumer products. Bags of different sizes and printed overlaps are also used in this sector. As such, discarded packaging material from the household does not reach the reprocessed sector to the extent as mentioned for milk pouches. A large quantity is discarded in the waste stream and the quantity salvages for reprocessing is only 20%.

Miscellaneous applications:

In this segment, the immediate application of LDPE are injection moulded housewares, shopping baskets, ropes, half wound canes, roto-moulded containers, colour concentrates, etc. Out of the estimated 35,000 tonnes, input available to reprocessed sector is to the order of 6,000 tonnes appxly through waste collection channels from the household.

In addition, there are some significant sectors where reprocessing is reported several times. This is possible only when the user keeps returning damaged reprocessed goods directly to the reprocesssor. This practice is known to be prevalent on products such as tarpaulins, sheets, films and agricultural pipes and hoses. Some virgin LDPE may be used at each reprocessing stage to marginally improve the product quality. The estimated outlet for such goods is to the order of 20,000 tonnes for tarpaulins sheets and about 10,000 to 12,000 tonnes for black agricultural pipes, hoses and tubings.

Contd.....

The availability of reprocessed goods at prices much lower than virgin goods find market in the economically lower segment of our society. After the urban market, these goods will necessarily go to the rural market. Thereafter collection becomes uneconomic to bring the goods back to the reprocessing sector. Only in cases of specific products discussed earlier, where there is close link between the users of reprocessed goods and reprocessors, it is possible to achieve more cycles of reprocessing. In this sector again, some virgin consumption will always exist due to drastic deterioration in the quality of reprocessed goods and the need to arrest the deterioration to some extent by using vergin material at appropriate level.

The aspect of LDPE was taken up only as an example. Similar demands exist for HDPE, PP and PVC. These four polymers alone account for 80% of the reprocessing trade in the country. It is also estimated that the pace at which demand for polymers is growing (also considering that India has amongst lowest per capita consumption) of plastics, we do expect emergence of much more organised sector to undertake reprocessing to cater to the second level of demand which is highly price-sensitive.

Note: Most of the information of this report has been obtained based on the Report of the Committee for Prospective Planning of Petrochemicals Industry, published by the Government of India, Ministry of Industry, Department of Chemicals and Petrochemicals, for the year 1986-2000 A.D.)

Contd.....

Table-1 Annexure

Commodity Plast Consumption & Growth Trends

Polymer	1975-76	1979-80	1984-85	*CARG (%) in VI Plan	CARG (%) in V + VI plan
Polyolefins					
LDPE	35	70.6	134	13	15
HDPE	21.5	62.8	90	8	15
PP	0.6	15.5	36	18	18
Sub-total	57.1	148.9	260	12	17
PVC	44.2	82	156	14	12.5
PS/HIPS	9.6	12.4	19.6	10	7
Total	110.9	234.3	435.6	12.5	14.5

*CARG: Compound Annual Rate of Growth

Contd.....

Table-2

Polymers: Availability Scenario

'000 tonnes

	1985-86	1986-87	1987-88	1988-89	1989-90
Expected Production plus imports					
L.D.P.E.	140	145	160	170	180
Linear L.D.P.E.	4	12	20	30	45
H.D.P.E.	115	125	140	165	190
P.P.	40	47	56	66	77
P.V.C.	165	165	202	232	267
P.S.	26	29	32	35	38
Total	490	523	610	698	797

Contd.....

Table-3

'000 tonne

Polymer	Terminal Yr.VI plan 1984-85 (Actual)	VII Plan 85-86	86-87	89-90* Terminal year	VIII Plan CARG %	Terminal year	IX Plan CARG%	Termina year 2000 A
LDPE/LLDPE	134	144	157 (165)	225 (2) (245)	11	(413)	8	(607)
HDPE	90	115	125	190	13	350	8	514
PP	36	40	47	77	18	176	8	259
PVC	156	165	165 (3)	267	11	450	8	661
PS	19.6	26	29	38	10	61	8	90
Total	435.6	490	523 (531)	797 (817)	12	1450	8	2131
Percapita %	0.64			1.0		1.6		2.16

Contd.....

Notes to table 3

1. The demand figures for 1989-90 are based on estimates of domestic production plugs imports as shown in table-1 on this basis of availability, the CARG% during VII Plan works out to:

LDPE/LLDPE (as eg, LDPE)	:	14%
HDPE	:	16%
PP	:	18%
PVC	:	11.5%
PS	:	12.5%

2. The figures in the brackets are for equivalent LDPE markets based on LDPE plus LLDPE tonnage. The satisfaction of the demand in future would depend on the tonnage break-up between LDPE & LLDPE.

3. PVC consumption during 1986-87 is expected to be stagnant because of continued non-availability of material from preferred sources. This position is expected to improve from the following year.

Contd.....

End use Analysis

End use analysis is an important and a reliable method where demand is a derived demand. In this major end-uses are studied for their current usage and assessment made for forseeable future based on intimate knowledge of end-use sector. Using this approach the demand estimates for 1989-90 are arrived at for major applications for Thermoplastics. The total demand estimates so arrived are used as the base for 1989-90 and growth rates are applied for projecting the figures for the 1994-95 and the year 2000 A.D.

Table-4

	Kilo tonnes
Product	Demand 1989-90*
LDPE/LLDPE	290
HDPE	200
PP	125
PVC	290
PS	50

* Figures are rounded to nearest ten.

Acknowledgments may be recorded to Mr. G.K. Dang, General Manager (Marketing), Shivalik Agro-Poly Products Ltd., for assistance in collection of statistical data and other relevant materials for this paper.

STATUS OF PLASTICS WASTE RECYCLING INDUSTRY IN MALAYSIA

BY

JOO FAI TUNG

PLASTICS TECHNOLOGY CENTRE

STRIM, MALAYSIA

Country Paper Presented at International Workshop on "Plastics Waste Recycling"

10 - 12 April, 1989, Shanghai

People's Republic of China

STATUS OF PLASTICS WASTE RECYCLING INDUSTRY IN MALAYSIA

PLASTICS INDUSTRY PROFILE

There are about 600 plastics processing factories in Malaysia involved with various types of production techniques such as injection moulding, blow moulding, film extrusion, lamination, thermoforming, pipe and profile extrusions, calendering, rotational moulding and glass-reinforced plastics. The plastics end products are mainly used in the areas of engineering, building and construction, packing, electrical/ electronics, automobiles, furniture, agriculture, toys, leisure items, houseware, footwear, adhesives and coatings.

The major types of plastics raw materials consumed are polyvinyl chloride (PVC), polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyester resins. Other plastics resins used are the whole range of general purpose and engineering grades of thermoplastics and thermosets. Total consumption of plastics raw materials was estimated to be about 150,000 tonne for 1988. Polymerisation plants are available in Malaysia for the production of PS, PVC, polyester and phenol formaldehyde (PF) resins. The other plastics raw materials are all imported. Per capital consumption of plastics is estimated to be about 9.8 kg which is low as compared with industrialised countries such as U.S.A (78 kg), Japan (63 kg) and Netherlands (60 kg).

80 kg.

SOLID WASTE DISPOSALS

Disposal of solid waste in Malaysia is the responsibility of the Ministry of Local Government and Housing, Malaysia. For the year 1988, statistics showed that a total of some 1.2 million tonne of solid waste were collected. The constituents of the solid waste are wood, metal, paper, glass, rubber and leather, ceramics, plastics and a range of other organic waste. There is no official data on the breakdown of the solid waste components but sample analysis of some solid waste obtained in the state of Penang is listed in Table 1.

Type Composition	Domestic Waste	Commercial Waste	Industrial Waste
Paper	25 %	28 %	36 %
Plastics	12 %	10 %	15 %
Rubber/Leather	3 %	3 %	4 %
Wood	3 %	11 %	11 %
Metal	2 %	9 %	2 %
Glass	2 %	9 %	4 %
Garbage (Organic Waste)	49 %	15 %	18 %
Others	4 %	15 %	10 %

Table 1 : Composition Ratios of Solid Waste Sample

Source : Ministry of Local Government and Housing, Malaysia February 1988, Survey, report.

The municipal solid waste collected were dumped in some 236 designated open-air dumping sites all over Malaysia. Of late, disposal of solid waste by land-fill method has also been introduced in the state of Selangor.

CLASSIFICATION OF PLASTICS WASTE IN MALAYSIA

Plastic waste in Malaysia can generally be classified into five different groups. They are :-

i. Primary Industrial Waste
ii. Mixed Consumer Waste
iii. Well Defined Agricultural and Industrial Waste
iv. Long Life Building and Automotive Waste
v. Short Life Applications Waste

Primary Industrial Waste

The sources of raw materials for this plastics waste are :

a) resin production of PS and PVC which supplies mainly reactor sludges and crusts, discarded products contaminated because of container breakages and laboratory test waste.

b) granulated and primary processing, which supplies plastics raw materials coming from processing machinery cleaning operations or from certain processing phases (such as resin or colour changes) as well as plastics that cannot be recycled during processing.

This happens because the processor does not have any recycling machinery or due to the fact that the product being processed does not permit even the recovery of clean scraps.

c) secondary processing - scraps from mouldings, lamination, thermoforming and trimming processes are generated in this stage mainly from processing factories with no upward intergration with a film or sheet extrusion line.

The plastics waste obtained from the above sources have a medium to good quality and a relatively homogeneous composition. The recovery of plastics from this category of industrial scraps is regarded as always economical viable. There are at present about 10 -15 companies in Malaysia involved with these recycling activities and the materials concerned are PE, PP and PVC.

Mixed Consumer Waste

These are plastics scraps from old and scarded consumer items such as housewares, appliances, toys, furniture, PVC sheets, diapers, packaging items, shoes etc. These plastics scraps are always contaminated and in order to recover and reclaim them, it is necessary to use more complex recycling machines and plants which feature a longer sequence of washing, separation and rinsing phases in combination with the drying and granulating operations.

these operations are therefore considered to be time and energy consuming and non-economical in terms of operation procedures, waste collection and separation problems. In Malaysia today, these is no factory involves in this category of plastics waste recycling business.

Well Defined Industrial and Agricultural Waste

Plastics waste in this category composes of the following main groups :-

a) Industry - sacks and drums from the chemical industry (mainly HDPE, PP, PVC); plastics containers and synthetic fibres scraps from the textile industry (polyamide and polyester) packaging boxes for bottle handling and transport ; shrink film form the industrial and food industry ; cable insulation sheaths (PVC and PE).

b) Agriculture - mulch film in plantations and farm areas, fertiliser sacks, nets and boxes.

All the abovementioned scraps represent at present an important resource for recycling business. In fact, in Malaysia today, there are not less than 6 companies involved with the recycling of PVC cable insulation sheaths, plastics crates and containers and packaging films for conversion into recycled materials. These materials are then used for the processing of lower value added products such as shoe soles, knee-pads, sandals, agricultural nursery and rubbish trash bags. However, it is important to note that these sources of plastics waste are sometimes highly polluted and mixed which therefore require more complex operations such as washing, cutting, densification etc for their appropriate reclaimation. Sometimes incorporation of virgin resins and additives during the regranulation phase is necessary in order to obtain a reusable product in granular form.

Long Life Building and Automotive Waste

Sources of plastics waste from Malaysian buildings are mainly water tanks (glass-reinforced polyester resins) pipes and fittings (PVC), electrical switches (thermosetting resins), water cisterns (PS,PP), light diffuses (PS) and wall papers (PVC). Hitheto no sizeable reclaimed plastics are obtained from this source of plastics waste possibly due to the small quantities of materials available at present.

Various types of thermoplastics and thermosets are used as components in automotives. However most of these plastics parts are long-life and replaced once only after a period of few years.

There are about 1.1 million vehicles (passenger cars, truck, vans, buses etc) in Malaysia. Assuming the life time of an average vehicle to be 10 years and each has approximately 50 kg of plastics-made components, then we can expect about 5,000 tonne of plastics waste from the automotive sectors per year. Nevertheless, most of these plastics waste are not reclaim. One noticeable exception is the battery casing which is made from polypropylene. In Malaysia today, there are 3 - 5 companies dealing exclusively with the recycling of these battery cases. Statistics showed that some 1,500 tonne of virgin PP materials are consumed every year for the manufacture of new battery casings for automobiles. Therefore, it can be estimated that possibly about 1,500 - 2,000 tonne of PP are recycled from old and used battery cases annually. The recycled PP granules are used for other lower value added injection products such as housewares, hangers, boxes and containers.

Short-Life Application Waste

Plastics product classified under this category include consumer packaging items and disposables such as shopping bags, food box wrappers, bottles and containers (PET and PVC), disposable food trays and drinking cups (EPS, PVC, PP) egg cartons (PVC, EPS) etc. Hitheto, no appreciable level of plastics reclaim activities have embarked on this source of plastic waste in Malaysia.

It is predicted that between 40 % - 60 % of the plastics waste component from municipal solid waste are derived from the abovementioned products.

In Malaysia today Polyethylene Terephthlate (PET) packaging for cooking oil and beverages is a new industry. Annual consumption of PET resin is about 1,300 tonne. There is still no PET recycling in Malaysia although reclaimed PET is already being used all over the world to produce a wide range of injection moulding items.

Recovery and Recycling of Plastics from Municipal Solid Waste (MSW)

As mentioned earlier, the total amount of MSW in Malaysia is about 1.2 million tonne per annum. It is estimated that on the average plastics waste constitute about 3 % - 5 % of the MSW throughout the country. Since the use of plastics is on the increase, this composition ratio is predicted to rise appreciably in the near future to about 7 %. So far, no attemps have been made both from the public and private sectors for the recovery and reclaimation of the recyclable plastics included in the MSW. In order to reduce the amount of plastics waste, it is essential that the plastics must be separated (possibly before their collection) from the stream of organic and wet waste, in order to prevent any kind of unnecessary polution from degradables and thence their further separation into homogeneous and recyclable groups.

Proposals and Action Plan

The following programme activities are proposed for effecting a more efficient means of collection and separation of plastics waste so that the amount of plastics in MSW can be reduced appreciably.

i. the advertising of the reclaimation project by means of posters, press-releases and pamphlets in order to make the public aware of the social outcome of the recovery ;

ii. the positioning of containers in selected areas for effective and separate collection of used plastics items and packaging in residential areas ;

iii. the distribution of large bags or bins to particular end users who produce large amount of plastics waste such as supermarkers, markets, shops and selected industries ;

iv. stricter enforcement of laws banning littering.

The plastics materials obtained in the containers and from the large volume end-users will then be collected and brought to specially equipped pre-processing areas where the various components will be separated. The collection and transportation operations of the separated plastics waste will be carried out by the municipality waste collection service or possibly by a private service.

Finally, the sorting out of the various plastics types can be performed by companies appointed by the municipality. The segregated materials will then be recycled by specialised firms to be sold to individual plastics processors who are able to use them. As for the non reclaimable plastics waste, they will be incinerated so as to recover the high combustion (caloric) value which for example, the polyolefins have the value at the same level as oil products. It is hope that by the operation of this proposed programme of plastics waste collection together with the positive response and cooperation of both the public and industrial sectors, we can effectively reduce the amount of plastics waste in the MSW and thereby ensuring a cleaner and healthier Malaysian environment.

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APPENDIX A

GEOGRAPHICAL BACKGROUND ON MALAYSIA

Malaysia has a population of 16.7 million and covers an area of about 330,000 sq. km, occupying the Malay Peninsular and the states of Sabah and Sarawak in the north-western coastal area of Borneo island. The two regions are separated by about 530 km of the South China Sea. Peninsular Malaysia, covering 130,000 sq. km has its frontiers with Thailand while Sabah dan Sarawak has about 200,000 sq. km border the territory of Indonesia's Kalimantan.

The federation of Malaysia consists of the following states : Perlis, Kedah, Penang, Perak Darul Ridzuan, Selangor Darul Ehsan, Negeri Sembilan , Melaka, Johor Darul Ta'azim, Kelantan, Terengganu, Pahang Darul Makmur, Wilayah Persekutuan, Sabah and Sarawak.

Malaysia lies near the equator between latitudes 1^{o} and 7^{o} North and longitudes 100^{o} and 119^{o} East. Malaysia is subject to maritime influence and the interplay of wind systems which originates in the Indian Ocean and the South China Sea. The year is commonly divided into the South West and North East Monsoon seasons. The average daily temperature throughout Malaysia varies from $21^{o}C$ to $32^{o}C$. Humiduty is high about 80 % - 90 %.

C O U N T R Y R E P O R T

O N

PLASTIC WASTE RECYCLING TECHNOLOGY

W R I T T E N B Y

PERVEZ AHMED
NATIONAL FIBRES LTD.
KARACHI - PAKISTAN

APRIL,1989

Recycling is now-a-days a much discussed subject and recycling of plastics in particular receives much attention. Consumption of plastics in the world around us is still growing, so as in Pakistan, and with it the flow of plastic products discarded after use. The short term used items such as shopping bags, wrapping and packing materials, containers and bottles, as well as the plastics used in cars produces an ever growing flow plastic waste materials. The basic problem remain the same, the mountain of discarded plastics grows.

Seeking to get the answer to this problem small investors and few industrialist have started recycling the plastic waste. There are many small and scattered cottage industries in the country. The exact number is not available, however, an estimated figure of plastic waste recycling units are around 500 in the country. The plastic processing industry either have its own in house unit for recycling plastic waste or waste sold to other recyclers which are processing only plastic waste. The industries recycling mainly poly-ethylene (LDPE and HDPE), polypropylene and polyvinyl - chloride.

In Pakistan, government is importing plastic granuls 1,00,000 tons to 1,20,000 tons per year. The industrial waste and rejects generated is about 10-12% out of which around 8 to10% gets recycled. The plastic waste generated can be classified in two types.

1 - The industrial waste.- waste generated while processing and the rejects.

2 - The consumer waste.- all plastic consumers items eg. shopping bags, toys, bottles, buckets, other house hold items .

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For successful recycling three basic conditions have to be fulfilled.

A - Feedstock

This should be available in sufficient concentration and uniformity at logistically accessible places.

B - Recycling process

A technically and economically feasible recycling process should be avaialable.

C - Market

For the recycled plastics a market should exist or has to be developed.

Collection of plastic waste is a big problem one major reason is of its bulkiness (plastic waste by volume is about three times than by weight). Even in the industry waste collected is not clean and uniform. It mainly gets contaminated with sand and with other materials used in the industry. Domestic waste is a nuisance especially the shopping bags being light in weight can be seen flying all over. These consumer waste usually collected by self employed workers from everywhere and supplied to cottage industries, where it gets recycled in a crude way. A flow diagram can be seen on page 5 . An estimated figure shows that around 80% of the domestic waste gets recycled in cottage industries. The items made from this is of very low quality items sold in the local market.

There are only two industries in Pakistan which are recycling plastic waste in an organised manner. They have the technology and using mainly their own industrial waste, rejects also using imported plastic waste . About 6,000 tons of waste gets recycled per year in these two organised industries. The

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production will increase to about 10,000 tons/year by mid 1990 after an expansion in one of the industry. The waste recycling line diagram can be seen on page 7 . Many plastic industries have its own recycling units, after making granuls from waste they mix with virgin plastic granuls and make different items according to the market. In case of PVC the conduit pipes and other commonly used pipes gets extruded from recycled materials.

The plastic waste recycling technology has lot of room for development and a market search is also needed. If there is a better system of collecting waste which can give clean plastic waste then recycling waste industries can be organised and improved. There are lots of small investors who can not depend on the imported plastic waste thus can not improve their industry.

There is a plastic technology centre in Pakistan established in 1988 with the aid of UNIDO. This centre is helping in advancement of plastic technology but very little services are there in case of plastic waste recycling technology.

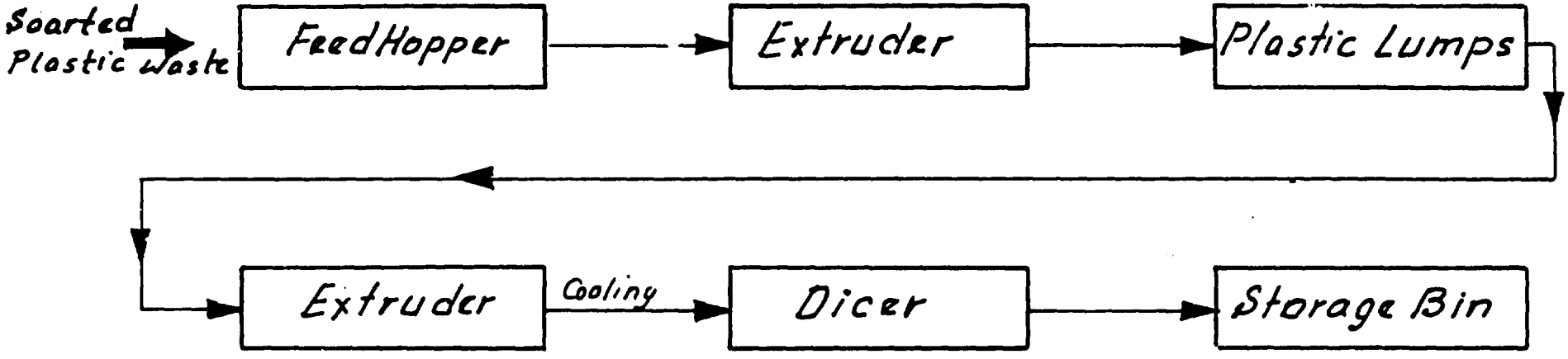
POLYESTER WASTE RECYCLING TECHNOLOGY

The country is processing about 100,000 Ton/year of polyester in about nine different industries this consumption will increase to 150,000 ton/year by the mid 1990.

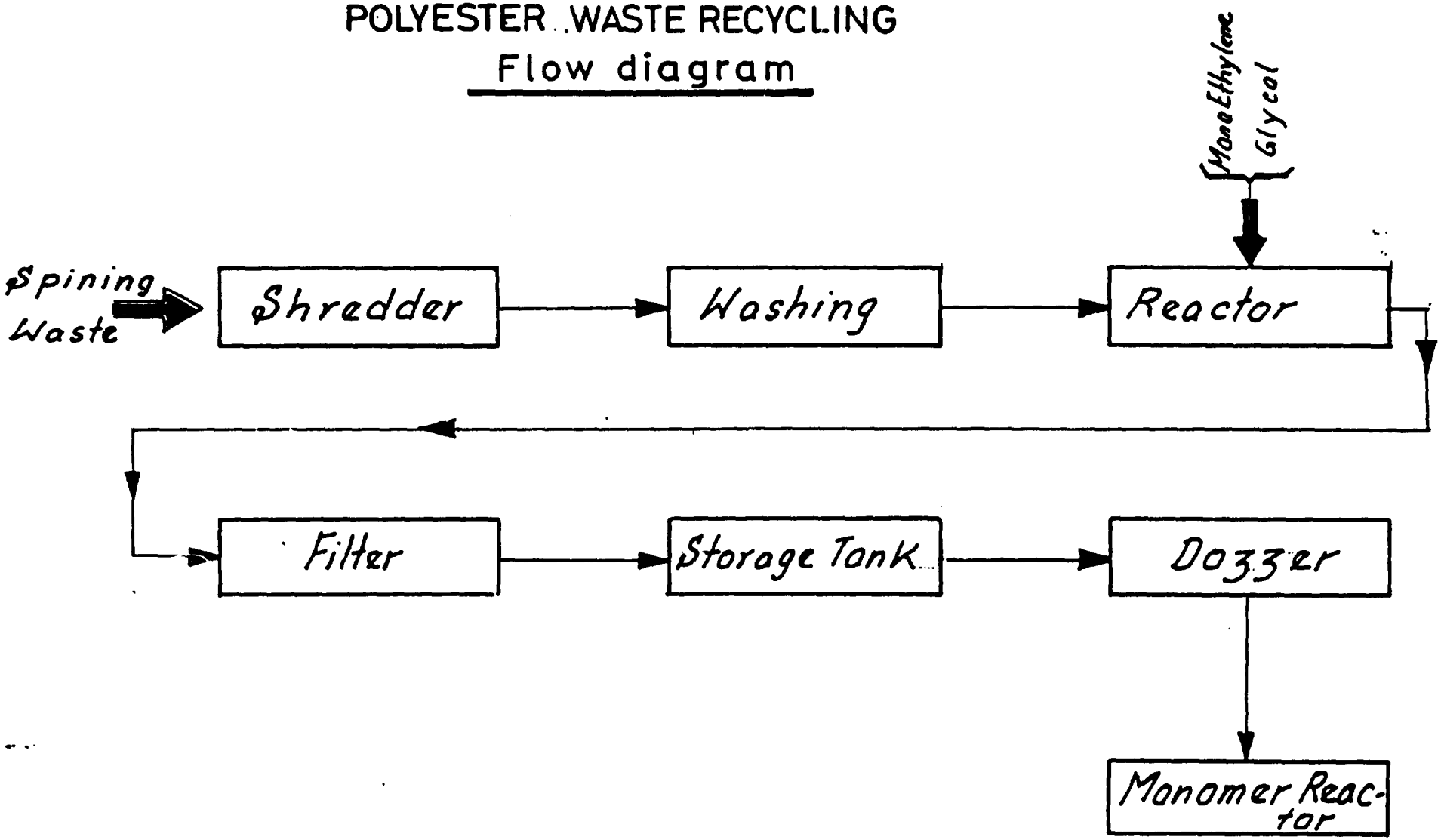
The polyester waste generated in these industries are about 3 to 4 % which is sold in the market at low price latter it is exported.

There is no waste recycling technology available in the country except one industry. This available technology is based on reverse reaction (Glycolysis of polyester). The waste (mainly spinning waste) is kept in a clean bags then shredded, washed with water, air dired and fed manually to the reactor. This cleaned waste then heated with mono-ethylene glycol to take out water left while washing and to form monomer. When the polyester is glycolysed properly it is passed through a filter and stored in a heated storage tank where it is fed in on line first stage monomer reactor in small pre-calculated quantity. This technology has its own defects and also not recommended for production of fine denier fibre. The block diagram of the process can be seen on page 6 .

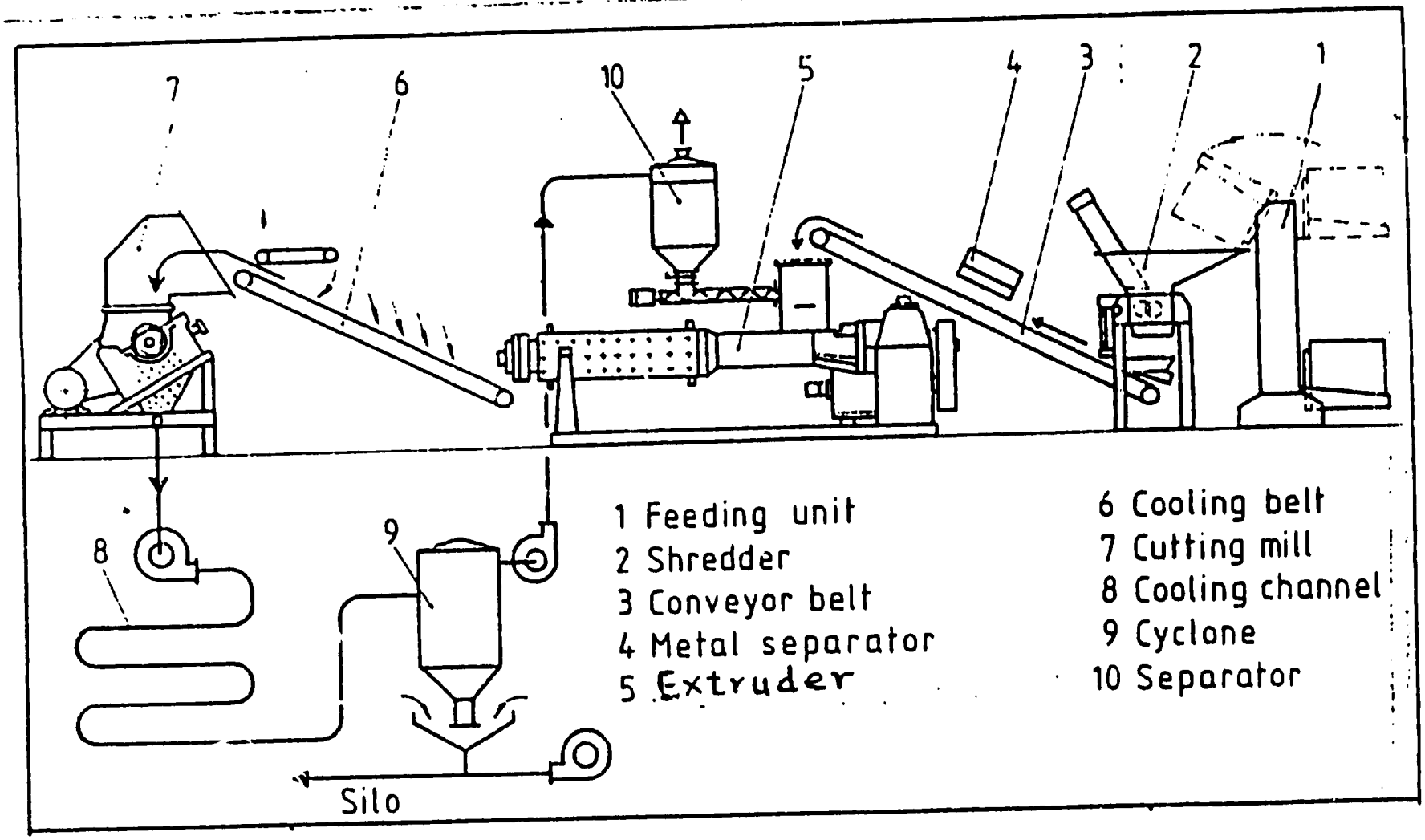
PLASTIC WASTE RECYCLING IN COTTAGE INDUSTRY



POLYESTER WASTE RECYCLING
Flow diagram



PLASTIC WASTE RECYCLING PLANT DIAGRAM



PLASTIC WASTE RECYCLING AND USE IN THE PHILIPPINES

by

Dr.-Ing. Adolfo Jesus R. Gopez

1.0. THE PLASTICS INDUSTRY IN THE PHILIPPINES[1]

1.1. Historical Background

The Plastics Industry in the Philippines, can be said to have started with the production of plastic pipes in 1947 by a firm called Plastic, Inc. In the early 50's, there were only about 25 firms engaged in the commercial fabrication of simple items such as house and novelty wares. By the mid 50's, the fledgling plastics industry had diversified into packaging materials and other consumer products.

The establishment of Mabuhay Vinyl Corporation in 1963 marked a milestone in the growth of the plastics industry. This was the first synthetic resin plant capable of supplying part of the industry's requirement for polyvinyl chloride (PVC) resin.

From then on there has been a progressive increase in the number of firms involved in plastics processing and/or production.

1.2. Description and Status of the Local Plastics Industry

The local plastics industry is mainly that sector involved in the transformation of thermoplastic resins commonly used into various plastic products (finished or semi-finished) both for consumer and industrial application.

This sector has already gained considerable impact on several areas of the country's economic activity. However, many opportunities still exist in the plastics industry, both in the domestic and export markets, due to the increasing participation of plastics in several industries such as packaging, automotive, housing, construction, health, agricultural, electronics, furniture and others.

Based on the recent study conducted through the combined efforts of experts and the Materials Science Division of the Industrial Technology Development Institute, the industry, at present, is made up of approximately 500 firms engaged in the production of resins and in plastics processing. Most of these firms are located within the areas of Metro Manila, although a growing number are in

Cebu, the fastest growing region of the country today. About [illegible]% of the plastics manufacturing industry are composed of small and medium scale industries.
Firms in this industry maybe categorized into three areas which are as follows:

1. The Raw Material Manufacturers - the producers of primary and compounded plastic resins. Among the four major thermoplastic resins being used, namely, polyethylene (PE), polypropylene (PP), polystyrene (PS) and polyvinyl chloride (PVC), PVC and polystyrene are the only resins being produced locally. Two local manufacturers are producing PVC and three manufacturers are producing polystyrene. These local manufacturers are:

For PVC:

Nabuhay Vinyl Corporation
Philippine Vinyl Incorporated

For. PS:

Polystyrene Manufacturing Co., Inc.
Philippine Petrochemical Manufacturing Co.
D & L Industries, Inc.

A PVC compounding plant is expected to operate this year through the Phelps Dodge International Corporation. Its product will be used in the insulation for copper wires.

In 1992, another company, the Bataan Petrochemical Corporation should be onstream for the production of polyethylene and polypropylene. Expected production rates are 120,000 MT/year of PE and 1,000 MT/year of PP.

2. The Processors of the Plastics Industry - transform synthetic resins into semi-finished products. About 200 firms are engaged in this field.

3. The Fabricators and/or Finishers - conduct further transformation of the semi finished products into various finished products in order to be ready for both industrial and consumer application. About 200 firms are involved in this sector.

1.3. Raw Materials:

The main raw materials used by plastics processors are thermoplastic resins: polyvinyl chloride, polyethylene (HDPE, LDPE, LLDPE), polypropylene, and polystyrene. The industry is highly import dependent, particularly since PP and PE, which together account for more than 60% of the

resin used are not produced locally. Although PVC and PS are locally manufactured, import of these resins is still markedly high due to the limited supply from our local resin producers. Table 1 shows the statistical data of imported thermoplastic and thermoset materials and semi-finished products, from 1984-88. The data were gathered from the Foreign Trade Statistics of the National Statistics Office. Most of the synthetic resins and plastic materials are imported from USA, Japan, Germany, Australia, and Taiwan. For PE, PP, PS, the importation quantities of "other forms" (finished and semi-finished products) are small compared to that for PVC. This could be explained by the fact that although PS and PVC are locally produced, the demand of the local market for PVC products is higher since PVC pipes are widely used in plumbing and electrical systems in building construction.

In 1985, the economic conditions in the country were not good and this was reflected in the reduced importation of various thermoplastic and thermosetting materials and products. A gradual increase, however, was observed afterwards because of the import liberalization granted by the government. 1986 imports of PS and PP dropped while the other resins experienced slight growth. This is perhaps due to the high prices of both resins.

1.4. Local Consumption:

The apparent domestic consumption of the four major thermoplastics is shown in Table 2. The data gathered for local production of PVC and PS were taken from its raw material manufacturers. For the thermoplastics alone, the share of each commodity in the local market in 1988 are:

	% of Total
PE	= 40
PP	= 26
PS	= 9
PVC	= 19
others	= 6

The estimated 1988 consumption per capita is 1.6 kg, while the 1987 figure is 1.4. Average increase in total consumption is around 15% per year, although the 1985-86 growth rate is a phenomenal 25%. Table 3 shows the market shares of the different resins from 1984 - 88.

1.5. Plastics Products:

Plastic products manufactured locally are classified as finished or semi-finished products. The major products manufactured for domestic market include film bags,

Table I IMPORT DATA OF PLASTICS AS PER QUANTITY IN METRIC TONS
1984 TO 1988

COMMODITY	1984	1985	1986	1987	1988
Polyethylene (PE) [1] (HDPE,LDPE,LLDPE)	60802	57166	89892	113915	83340
Polypropylene [1]	30401	35376	58819	75090	57883
Polystyrene [1]	1612	1244	2031	3534	4696
Polyvinyl Chloride [1]	14034	14101	18934	20495	20085
Other Thermoplastics [2]	9883	8010	16410	16053	15692
Thermosets [3]	6121	4584	7817	9353	10709

---

[1] Primary forms (powder, flakes, lumps, granules, etc.) and other forms (plates, shells, films, foils, monofil, rods, seamless tubes, etc.)

[2] Polyamides, acrylic, polymers, copolymers, cellulose, elastomers,polyvinyl acetate,etc.

[3] Urea and phenolformaldehyde compounds, polyesters, epoxides, aminoplasts, phenoplasts, silicones, etc.

SOURCE OF DATA: National Statistics Office

Table 2 APPARENT CONSUMPTION OF PLASTICS (PE,PP,PVC,PS)
METRIC TONS

COMMODITY	1984	1985	1986	1987	1988
PE					
IMPORTED	60002	57166	89092	113915	83340
EXPORTED	35	44	81	433	910
APPARENT CONSUMPTION	60767	57122	89011	113482	82430
PP					
IMPORTED	30401	35376	58819	75090	57883
EXPORTED	1577	2231	2004	4410	4288
APPARENT CONSUMPTION	28824	33145	56815	70680	53595
PVC					
IMPORTED	14034	14101	18934	20495	20085
EXPORTED	3024	6350	7262	6305	6226
LOCAL PROD.	11000	12000	16055	20550	24660
APPARENT CONSUMPTION	22010	19751	27727	34740	38519
PS					
IMPORTED	1612	1244	2031	3534	4696
EXPORTED	1	306	2186	4543	2989
LOCAL PROD.			11000	14000	16800
APPARENT CONSUMPTION	1611	938	10845	12991	18507
OTHER THERMOPLASTICS					
IMPORTED	9883	8010	16410	16053	15692
EXPORTED	2607	3888	3619	4532	2818
APPARENT CONSUMPTION	7276	4122	12791	11521	12874
THERMOSETS					
IMPORTED	6121	4584	7817	9353	10709
EXPORTED	2678	1544	1357	1479	2036
APPARENT CONSUMPTION	3443	3040	6460	7874	8673
TOTAL					
APPARENT CONSUMPTION	123931	118118	204449	251288	214598

Table 3 DOMESTIC MARKET

	1986 METRIC TON	% SHARE	1987 METRIC TON	% SHARE	1988 METRIC TON	% SHARE
PE	89811	43.90%	113482	45.20%	82430	38.40%
PP	56815	27.80%	70680	28.10%	53595	25.00%
PVC	27727	13.60%	34740	13.80%	38518	17.90%
PS	10845	5.30%	12991	5.20%	18507	8.70%
OTHER THERMOPLASTIC	12791	6.20%	11521	4.60%	12874	6.00%
THERMOSETS	6460	3.20%	7874	3.10%	8673	4.00%
	204449	100.00%	251288	100.00%	214598	100.00%
POPULATION*	56004130		57356042		58721307	
PER CAPITA USE	3.65		4.38		3.65	

* SOURCE : NATIONAL CENSUS AND STATISTICS OFFICE
ESTIMATED FIGURES

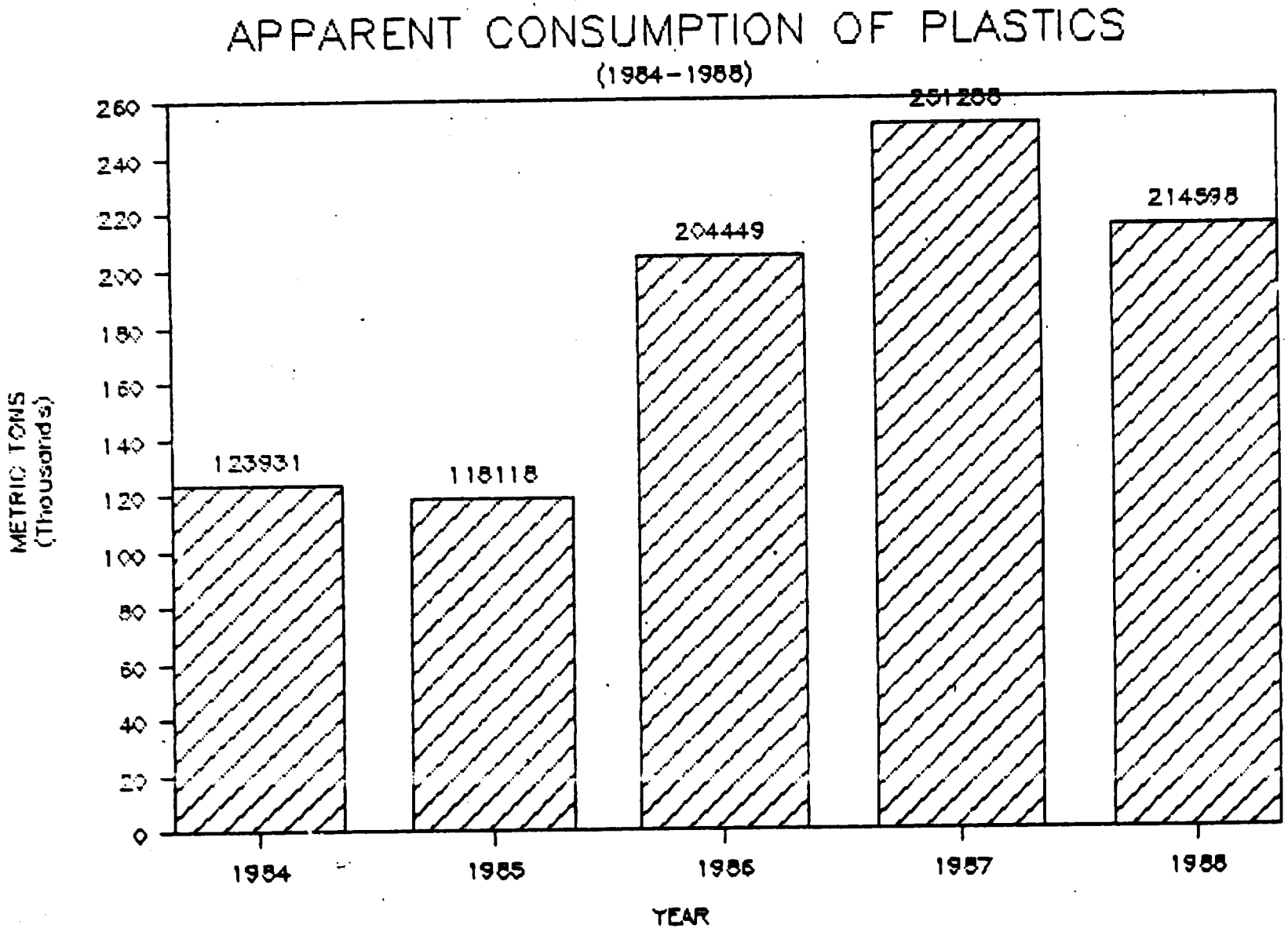

APPARENT CONSUMPTION OF PLASTICS
(1984-1988)
METRIC TONS
(Thousands)
260
240
220
200
180
160
140
120
100
80
60
40
20
0
123931
118118
204449
251288
214598
1984
1985
1986
1987
1988
YEAR

Figure 1

calendered products, housewares, woven sacks, industrial products such as pipes and fittings, and packaging containers. The plastics industry is also engaged in the manufacture of products for use in electronics and automotive industry. The electronics industry accounts for a major part of the consumption of thermosetting resins, due to encapsulation and packaging of integrated circuits.

Imports of plastic products were also noted and are averaging some US$ 15 Million/year (P315 M), and apparently increasing yearly at an average rate of 15%. Table 4 and 5 show the 1988 statistical data.

On the other hand, exports of plastic products are making good and are dramatically increasing. Plastic products manufactured from PVC and PP constitute 90% of the total exports. There were however, minimal exports of PE and PS products. Some products are considered as indirectly exported such as polybags used by garments, packaging adhesive tapes used by fruits exporters. The Philippine Plastics Industries Association projects a conservative growth rate of 5% per year in the export market.

1.6. Problems in the Local Plastics Industry:

The 1985 and 1988 surveys conducted by the Materials Science Division of Industrial Technology Development Institute (ITDI) identified the key problems and needs of the industry. These are as follows:

- lack of adequate national technology sources for formulation and processing, design of products and moulds, and development of new products and applications.
- limited or no quality control facilities in factories.
- development of new products, applications and markets is not carried out systematically.
- insufficient human resources trained in plastics technology.
- high external technological dependance
- high cost of importation of raw materials particularly polymer resins.

2.0. RECYCLING AND WASTE UTILIZATION

2.1. National Plan for Land Pollution Prevention

Table 4 IMPORT DATA OF PLASTICS (1988)

COMMODITY	QUANTITY	FOB ($)
Polyethylene		
Primary Form [1]	32337	$77,145,095
Other Forms [2]	1003	$2,135,172
Total	83340	$79,280,267
Polypropylene		
Primary Form [1]	54909	$48,806,437
Other Forms [2]	2974	$6,916,691
Total	57883	$55,723,128
Polystyrene		
Primary Form [1]	4587	$6,737,717
Other Forms [2]	109	$104,159
Total	4696	$6,841,876
Polyvinyl Chloride		
Primary Form [1]	14807	$16,201,600
Other Forms [2]	5278	$7,227,769
Total	20085	$23,429,369
Other Thermoplastics [3]	15692	$21,190,269
Thermosets [4]	10709	$22,823,938
TOTAL	192405	$209,288,847

[1]Could be in the form of powder, flakes, lumps, blocks, granules or liquids.

[2]Could be in the form of plates, sheets, films, foils, monofil, seamless tubes, rods, etc.

[3]Polyamides, acrylic polymers, copolymers, cellulose, elastomers, polyvinyl acetate, etc.

[4]Urea and phenolformaldehyde compounds, polyesters, epoxides, aminoplasts, phenoplasts, silicones, etc.

SOURCE OF DATA : National Statistics Office

Table 5 EXPORT DATA OF PLASTICS (1988)

COMMODITY	QUANTITY	FOB ($)
Polyethylene		
Primary Form[1]	445	$515,994
Other Forms[2]	910	$1,197,395
Total	1355	$1,713,389
Polypropylene		
Primary Form[1]	683	$64,481
Other Forms[2]	3605	$6,532,437
Total	4288	$6,596,918
Polystyrene		
Primary Form[1]	2986	$4,420,061
Other Forms[2]	3	$6,011
Total	2989	$4,426,072
Polyvinyl Chloride		
Primary Form[1]	508	$845,945
Other Forms[2]	5718	$8,653,113
Total	6226	$9,499,058
Other Thermoplastics[3]	2818	$5,025,661
Thermosets[4]	2036	$1,960,743
TOTAL	19712	$29,221,841

[1]Could be in the form of powder, flakes, lumps, blocks, granules or liquids.

[2]Could be in the form of plates, sheets, films, foils, monofil, seamless tubes, rods, etc.

[3]Polyamides, acrylic polymers, copolymers, cellulose, elastomers, polyvinyl acetate, etc.

[4]Urea and phenolformaldehyde compounds, polyesters, epoxides, aminoplasts, phenoplasts, silicones, etc.

SOURCE OF DATA : National Statistics Office

The increasing use of plastics in an expanding range of applications is posing problems in the disposal of waste plastic articles. The Philippines is apparently facing problems on solid waste disposal of which plastic wastes is one of those contributing to the dilemma.

In 1985, the Environmental Management Bureau (EMB) which is under the Department of Environment and Natural Resources conducted an intensive survey on the solid waste generation in Metro-Manila. The selection of this place is due to the fact that it is the most densely populated area in the Philippines and contains about 10% of the total population.

Table 6 show the approximate quantities of the solid waste generation by composition and source. The total quantity of waste plastics is estimated at 197 tons per day (tpd) and is about 7.5% of the total solid waste (2632 tpd). The biggest source of waste is the residential sector (Table 7).

The solid waste disposal is being managed by the Environmental Sanitation Center. They were able to collect and dispose 63% of the wastes of the Metro Manila Commissions. Private haulers collected an additional 7%. The remaining 30% are either recycled, burned or scavenged, thrown into water system like esteros and sewers, or simply not collected at all.

Solid waste generation in Metro-Manila was projected to increase from 967,000 tpy in 1982 to 1,126,620 tpy in 1985. (Table 8) By 1990, according to this projection, 1,318,620 tons of waste will be generated per year. It is estimated that by the year 2000, the metropolis will have to cope with around 1,928,800 tpy.

An alternative method to solid waste disposal is to be recover at least a part of these wastes and to reprocess them into useful by-products . Estimates of the resource recovery potential of Metro Manila's solid waste output and the projected percent recovery of each component are shown in Table 8 and 9. In 1982, the percentage of total waste which is considered recoverable was 50% and is expected to continue at this level until the end of century. For plastics wastes, about 54% (491 tpy) could be recovered.

The collection and selling of waste plastics is now being actively done by the junk shop owners. They buy waste plastics from scavengers for about P6/kilo and sell to small-scale plastics industries. However not all types of plastics are being sold. They select the clean type plastics container such as the pails, bottles, plates, etc.

Table 6 SOLID WASTE GENERATION BY COMPOSITION
(1982)

COMPONENTS TYPE OF WASTE	RESIDENTIAL		MARKET		COMMERCIAL		INDUSTRIAL		CONSTRUCTION & DEMOLITION		STREET WASTE		INSTITUTIONAL		OTHER WASTES		T O T A L	
	Tpd	%	Tpd	%	Tpd	%	Tpd	%	Tpd	%	Tpd	%	Tpd	%	Tpd	%	Tpd	%
PAPER	117.0	9.1	14.6	4.3	33.1	23.0	30.7	20.0			35.0	7.2	27.2	20.0			257.6	9.8
CARDBOARD	49.0	3.8	6.1	1.8	33.1	23.0	15.3	10.0			12.1	2.5	6.8	5.0			122.4	4.7
FOOD & KITCHEN WASTE	460.5	35.8	240.1	70.6	18.7	13.0	3.1	2.0			90.8	18.7	23.1	17.0			836.3	31.7
TEXTILES	23.7	38.8			2.2	1.5	2.3	1.5			6.3	1.3	1.4	1.0			35.9	1.3
RUBBER & LEATHER	21.0	1.6			2.2	1.5	2.3	1.5			4.4	0.9					29.9	1.1
PLASTIC, FILM	67.3	5.2	10.9	3.2	15.8	11.0	23.0	15.0			20.4	4.2	17.7	13.0			155.1	5.9
PLASTIC, HARD	21.4	1.7	1.0	0.3	5.8	4.0	7.7	5.0			4.8	1.0	1.4	1.0			42.2	1.6
YARD WASTE	126.7	9.9	49.3	14.5							25.3	5.2					201.3	7.7
OTHER COMBUSTIBLE	52.3	4.1	2.0	0.6	10.1	7.0	38.4	25.0	5.8	20.0	10.7	2.2	17.7	13.0	20.9	35.0	157.9	6.1
METAL	74.1	5.8	1.0	0.3	13.0	9.0	18.4	12.0			8.3	1.7	13.6	10.0			128.4	4.9
GLASS	44.4	3.5	1.4	0.4	7.2	5.0					6.3	1.3	12.2	9.0			71.5	2.7
OTHER NON-COMBUSTIBLE	38.1	3.0	0.3	0.1					23.4	80.0	18.5	3.8	2.7	2.0	38.9	65.0	121.0	4.6
SCREENINGS (10 MM)	188.9	14.7	13.3	3.9							242.9	50.0					445.1	16.9
SPECIAL HAZARDOUS WASTE					2.9	2.0	12.3	8.0					12.2	9.0			27.4	1.0
T O T A L	1284.4	100.0	340.1	100.0	144.0	100.0	153.4	100.0	29.2	100.0	485.7	100.0	136.0	100.0	58.8	100.0	2632.6	100.0
% OF T O T A L	48.8		12.9		5.5		5.8		1.1		18.4		5.2		2.3		100	

Table 7 WASTE PLASTICS (HARD/FILM)

SOURCE	QUANTITY	
	TONS/DAY	%
RESIDENTIAL	88.7	44.96%
MARKET	11.9	6.30%
COMMERCIAL	21.6	10.95%
INDUSTRIAL	30.7	15.56%
CONSTRUCTION & DEMOLITION		
STREET WASTE	25.3	12.82%
INSTITUTIONAL	19.1	9.68%
OTHER WASTE		
T O T A L	197.3	100.00%

Table 8 PROJECTION OF METRO MANILA RESOURCES RECOVERY POTENTIAL

YEAR	1982		1985		1990		2000	
TOTAL WASTE STEAM (TONS/PER)	967,000		1,126,620		1,318,680		1,828,000	
RECOVERABLE COMPONENTS	TONS PER YEAR	RECOVERABLE	TONS PER YEAR	RECOVERABLE	TONS PER YEAR	RECOVERABLE	TONS PER YEAR	RECOVERABLE
PAPER	94,766	38,864	110,409	45,268	129,231	52,984	179,222	73,481
CARDBOARD	45,449	24,512	52,951	28,594	61,978	33,468	85,953	46,415
FOOD & KITCHEN WASTE	387,506	186,053	357,139	192,855	418,022	225,732	591,558	314,042
TEXTILE	12,571	3,897	14,646	4,540	17,143	5,314	23,774	7,370
RUBBER AND LEATHER	10,637	3,286	12,393	3,829	14,505	4,482	20,117	6,236
PLASTIC, FILM	57,853	30,889	66,471	35,894	77,802	42,013	107,899	58,266
PLASTIC, HARD	15,472	8,355	18,026	9,734	21,099	11,393	29,261	15,801
METALS	47,383	25,587	55,204	29,810	64,615	34,892	89,611	48,390
GLASS	26,109	12,010	30,419	13,993	35,604	16,378	49,378	22,714
TOTAL	816,946	313,403	717,658	364,517	839,999	426,656	1,176,773	592,716

The EMB has also issued its first bulletin (Dec. 1988) entitled "Industrial Waste Exchange (Philippines)" which gives details on industrial wastes such as acids, alkalis, solvents, plastics/rubber, metal sludges, wood/paper, other inorganic chemical, other organic chemicals, oils/waxes, textile/cotter, miscellaneous. This project is being undertaken in collaboration with Geotechnical Research Centre (GRC) of McGill University Canada under a financial grant from International Development Research Centre (IDRC) Canada. It aims to market the industrial waste which have a potential value for reuse to another industry. The EMB acts as the mediator between the waste generator and the potential user.

Table 9. Projected Percent Recovery of the Components of Solid Waste (Year 2000)

Components Type of Waste	% Recovery
Paper	41
Cardboard	54
Food and Kitchen Waste	54
Textiles	31
Rubber and Leather	31
Plastic, Film	54
Plastic, Hard	54
Metal	54
Glass	46

2.2. Import-Export of Plastic Waste and Scrap

2.2.1 Import

Based on the statistical data (Table 10) gathered from the National Statistics Office, the Philippines imports a large amount of plastics waste and scrap. In 1988 alone, a total of 7,245 MT with FOB value of $4,013,231 was imported. PVC has the largest importation volume, accounting for about 77% share of the total imported plastics waste and scrap. This is followed by polypropylene which is about 35% of the total import of plastics wastes

Table 10 IMPORT STATISTICAL DATA OF PLASTIC WASTE AND SCRAP
METRIC TONS

COMMODITY	1984	1985	1986	1987	1988
Phenoplasts	73	8	27	32	19
Polyethylene	1670	1128	3036	6594	6127
Polypropylene	636	727	623	3411	7840
Polyvinyl Chloride	2582	948	2478	4965	8260
TOTAL	4961	2811	6164	15002	22246

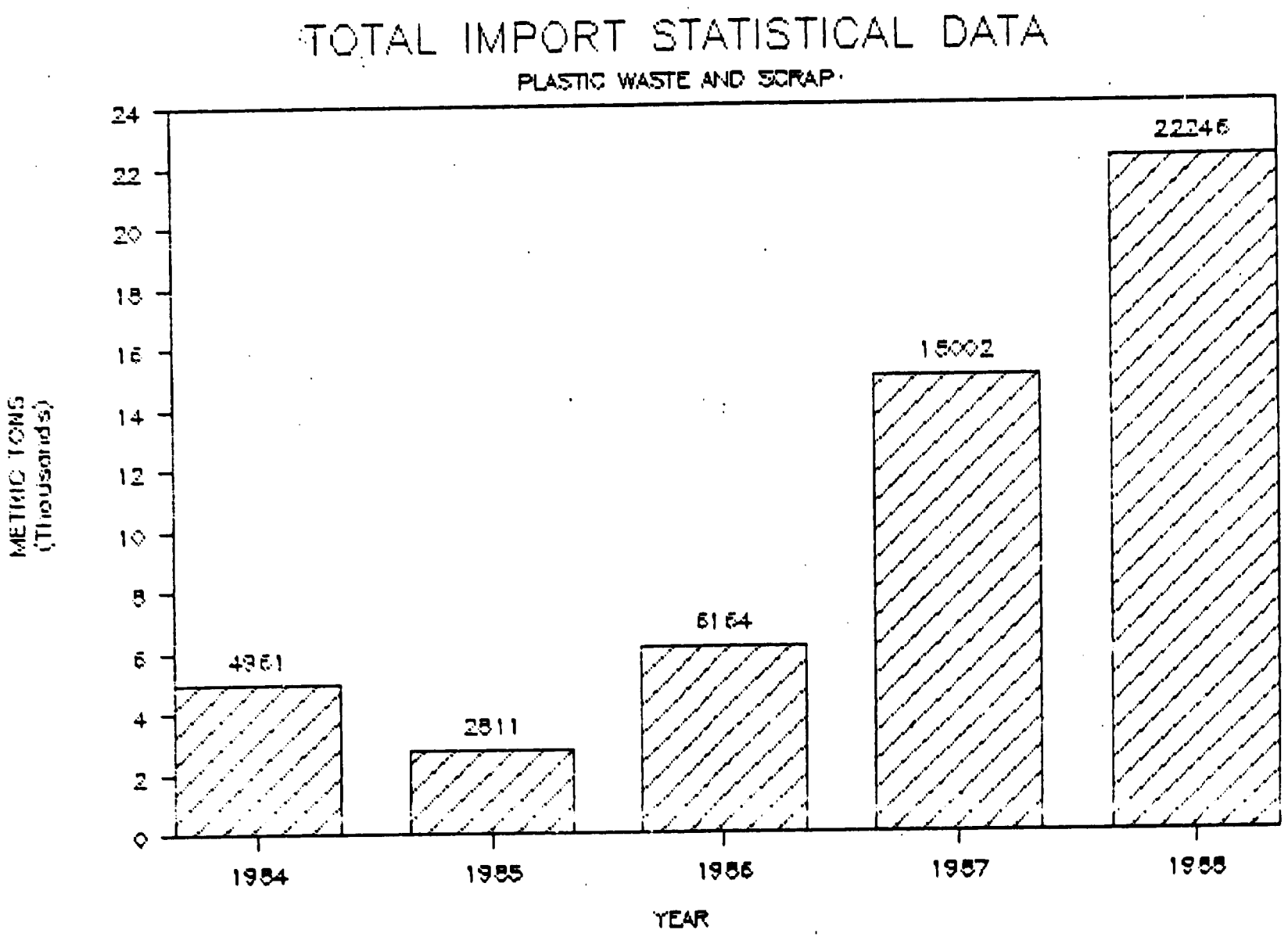

TOTAL IMPORT STATISTICAL DATA
PLASTIC WASTE AND SCRAP
METRIC TONS (Thousands)
24
22
20
18
16
14
12
10
8
6
4
2
0
4861
2811
6154
15002
22246
1984
1985
1986
1987
1988
YEAR

Figure 2

and scrap. From 1984 - 1988, import of wastes and scrap is generally increasing except for polyethylene. There has been no import of polystyrene waste and scrap.

There are approximately 80 local companies which import these commodities.

2.2.2 Export

Due to a duty drawback system on raw materials, the Philippines exported a total of 520 MT of plastics wastes and scrap in 1987 and 1988. (See Table 11). In 1984 - 1986, only PS scrap was being exported but at a small volume. Export of plastics waste and scrap is mainly dominated by polystyrene which has a market volume of about 171 MT and 724 MT in 1987 and 1988. These figures maybe attributed to the fact that technically the industry has not yet mastered the use of PS. It is also probably because PS is more difficult to use as reprocessed. Other scraps such as PE, PVC Polyamides are now being exported but in smaller quantities.

According to the data gathered from the National Statistics Office, Hongkong is known to be the major importer of our plastic waste and scrap. Many of the plastic products are also exported to Hongkong. Philippine plastic products accounted for 5.6% of Hongkong plastic imports in 1985.

2.3. PVC Recycling

Polyvinyl Chloride products presently, have a wide range of applications both in domestic and industrial applications. Generally, the Philippines exports a relatively large volume of PVC products, which actually, constitutes 56% of the total plastics products exported.

A large exporter of PVC products producing films for packaging, mats, PVC floor materials and PVC adhesive tapes is producing at least 1500 to/month of products or 1800 MT of plastic products in a year. It is estimated that 30% of the raw material used is recycled. The estimated total scrap generated during production is approximately 7500 MT/year. The scrap is recycled mainly for use in the production of vinyl linoleum flooring materials. Incidentally, this company is the sole exporter of this product. The company also imports PVC, waste and scrap and buys PVC scrap from local sources as well. The backing of this multi-layer flooring material is made up of 100% recycled PVC.

2.4. PP Recycling

Table 11 EXPORT STATISTICAL DATA OF PLASTIC WASTE AND SCRAP
METRIC TONS

COMMODITY	1984	1985	1986	1987	1988
Polyamide					60
Polyethylene					107
Polypropylene				402	346
Polyvinyl Chloride					17
Polystyrene	31		50	171	724
TOTAL	31		50	573	1254

SOURCE : International Trade Division
National Statistics Office

Plastic Cases

The Philippines now has a total population of approximately 40 million plastic cases for beer and softdrinks. This number is increasing since the present capacity of the two major case plants is now 6.1 million cases per year. Total resin consumption for plastic cases is approximately 12000 MT/year accounting for about 15% of the total yearly use of PE resin. According to estimates the number of scrap or damaged cases is presently around 400000 cases per year or about 500 MT/year. This amount (about 5% of the resin used) is processed as regrind. There are at present proposals in the industry to carry out systematic reprocessing of plastic cases by looking at the carbonyl content of the used cases. The life of plastic cases in the Philippines has been estimated by the industry at 8-10 years, shorter than the 12-15 years estimated by German plastic case makers.

Other Products

A large producer of various PE products for domestic and industrial applications has been adopting the scrap recycling system by using only the scrap generated within the plant. The company is basically a large consumer and importer of PE (HDPE, LDPE) resins. The estimated total consumption of PE resin is about 3500 MT/yr amounting to about 4% of the total resin imported yearly. Some specific products to which scrap recycling is applied are "containers" (used as chemical containers, motor oil containers, film bags, housewares and bathroomwares. The plant is actually engaged in three forming processes: blow moulding, injection moulding and blow film making; all of which are generating scrap.

In blow-moulding, about 47% of the raw material used is generated as scrap. While in injection moulding 10%, scrap is generated and for blow film 2%. Therefore, a maximum of 55% of the production capacity of the plant is generally recycled. According to estimates, for every piece of blow moulded product, scrap utilization is 60% and 40% is the virgin resin; for injection moulded products, 85% scrap and 15% virgin resin and for blown film products (bags) only 12% scrap is used. Hence, for a total of 3500 MT of PE resin used, 1500 MT scrap is generated and re-used during operation in the plant. There is no import of PE waste and scrap reported for this particular producer.

2.5. PP Recycling

The application of PP products is dramatically expanding today and constitutes a high percentage use in the packaging industry. However, according to the industry, an average of about 30% of their total raw material used is generated as scrap during production. A large producer of PP products such as housewares, bags, woven sacks, and others has gone through recycling of its scraps generated within the plant for the past years. This producer is a large importer of PP resin averaging to about 10% of the yearly total imports of PP. For the total of 360 MT/month of PP resin used, about 39 MT of scrap is being generated. Therefore, PP scrap generation is averaging to 450 MT yearly.

Most of the PP products manufactured are made up of about 24% scrap materials. In this case, the 30% scrap generated after grinding is later mixed with PP virgin resin for the next production cycle.

3.0. CONSIDERATIONS

3.1 Need for systematic waste classification and separation

Success in plastic waste recycling requires practical separation technologies or systems which at this present time have not yet been developed in the Philippines. An economic system of identifying and separating different plastics waste would be required. Dealing with the problem of separation of plastics wastes, W. D. Ruckelshaus, Director of an American Environmental Protection Agency points out that in Sweden, the housewife is asked to sort waste and put it in a different container. This could be adopted in our country as a practical and simple method of waste sorting. In fact a local contractor proposes to pay for sorted garbage in order to encourage households to classify garbage.

3.2 Need for a coordinated industry effort

For waste recycling to be more workable, a coordinated industry-based effort is necessary. The pioneering efforts of PMI in this respect are laudable. However, industry must be convinced and if needed, made to cooperate. Government agencies must also coordinate since very often, agencies which deal closely with industry are not those concerned with the environment or with waste recycling, while those agencies which are concerned with the environment are viewed by the industry as adversaries.

3.3 Need for plastics recycling in preparation for increase in consumption

The present per capita use of plastics in the Philippines (3-4 kg/year) is still small both in relative and in absolute terms. However, plastic waste is already adding to disposal problems due to its non-biodegradability. It is therefore indicated that systematic plastic waste recycling and disposal be put in place as soon as possible. This statement would be valid for the overall situation in waste handling and disposal in the Philippines.

3.4 Need for a plastics development center

Recent surveys assisted by the UNIDO point out the need for the establishment of a plastics development center. The most recent proposal calls for a unit which will render assistance to the plastics industry in training, testing, process and product development and technical information. If established, plastics recycling could be one of the concerns of this unit.

4.0. SUMMARY AND CONCLUSIONS

Plastic waste recycling is being done on a limited scale in the Philippines, notably with PVC, for which waste PVC is being bought back by some companies. This material is processed as regrind and for some products recycled content is as high as 100%. PET is also recycled, particularly for plastic case but the recorded amount that is recycled is relatively small. Scrap reuse on the other hand, is relatively widespread in the sense that many plants carryout "on-site recycling" and even import scrap plastic.

As far as approach to waste is concerned, the Environmental Management Bureau is spearheading efforts for resource recovery and "waste exchange". Plastic wastes are part of this effort. Initial activities are centered in Metro Manila.

In conclusion, although the technical aspects of plastics recycling maybe understood adequately, considering that most of the plastic waste comes from the household sector, a generalized approach to waste could be better at this point. Carrying out activities towards having sorted garbage may be needed.

Efforts for waste recycling and/or disposal require coordination between the industry, government and government administration, and must be carried out as soon as possible.

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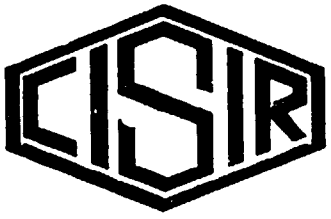

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இலங்கை விஞ்ஞான கைத்தொழில் ஆராய்ச்சி நிலையம்
கொழும்பு — ஸ்ரீ லங்கா.

CEYLON INSTITUTE OF SCIENTIFIC AND INDUSTRIAL RESEARCH
COLOMBO - SRI LANKA.

SARVODAYA PRINTERS

WORKSHOP ON "PLASTIC WASTE RECYCLING" TO BE HELD IN SHANGHAI, PEOPLES" REPUBLIC OF CHINA FROM 10 - 12 APRIL, 1989

COUNTRY REPORT FROM SRI LANKA

Ms. P.I. Iddamalgoda
Ceylon Institute of Scientific and Industrial Research

INTRODUCTION

Sri Lanka, with a population of about 16 million people has a popular demand for plastic items in both domestic and industrial use. Morethan 100 large small and medium industrial units are registered in the manufacture of plastics goods. The main items produced are household articles, bottles and containers for storing foods and chemicals, plastic film, electrical appliances, woven bags, fishing nets etc. It is estimated that about 30,000 tons of plastics raw materials are used annually in Sri Lanka, for the manufacture of these plastics goods.

Sri Lanka imports about 90% of the plastic raw material used in the manufacturing sector and the only plastic produced in Sri Lanka is Nylon - 6 with a production of about 1500 tons annually.

The following table gives some data on the manufacture of different types of plastics goods in Sri Lanka

Product	Output in MT				
	1983	1984	1985	1986	1987
Rigid PVC pipes	6.2	6.1	6.5	7.8	8.1
Flexible PVC pipes	0.4	0.4	0.4	0.5	0.5
LDPE film	5.3	5.1	5.5	6.3	6.9
HDPE film	1.0	1.2	1.2	1.3	1.3
PP film	0.6	0.6	0.7	0.7	0.8
Woven PP	2.6	2.8	3.0	3.2	3.4
Sheets	1.6	2.0	2.0	2.1	2.1
Others (Blow, Injection moulded etc.)	5.0	5.3	5.5	5.9	6.1
Total	22.7	24.8	24.8	27.8	29.5

2.0 PLASTICS WASTE IN SRI LANKA

In Sri Lanka, plastic waste is generated in two different ways.

1. From processing of plastics - this waste is estimated to about 3000 tons/year.

2. From production of Nylon - 6. Waste nylon of about 200 tons is produced in this plant each year which has some export value.

3.0 NECESSITY FOR RECYCLING PLASTICS IN SRI LANKA

The need for recycling plastics raw materials in Sri Lanka is mainly due to economic reasons. Cost of raw materials in the plastic goods manufacturing sector has increased very much during the recent past.

Following table gives the current price of some plastics raw materials used in Sri Lanka.

	US $ per ton
PP	1000
HDPE	1200
LDPE	1200

If the plastics waste in the processing and manufacturing sector which is about 3200 tons per year could be recycled in an appropriate manner, it will help lowering the cost of production tremendously.

Though plastics waste has not become a threat so far to the environment in Sri Lanka, development of recycling methods of plastics will enable to overcome any problem of that sort in the future.

4.0 RECYCLING OPERATIONS IN SRI LANKA

At present all above plastics are recycled in Sri Lanka. The recycled material is used for applications which do not require strict food and drug regulations e.g. use in film manufacture for agricultural purposes, disposable garbage bags, pipes etc.

Method of recycling is as follows :

(a) Collect waste material especially from factory off cuts, wash and dry.

(b) Feed in to automatic reclaim system consisting of heavy duty extruder, screen changer and pelletizer.

(c) Use mixed with virgin material

The following table gives a comparison of properties of recycled film material.

Comparison of Polyethylene film

Virgin Material vs recycled material

Tensile Strength at yield (M Pa)

	Virgin material		Recycled Material	
	Length-wise	Crosswise	Length-wise	Crosswise
Mean	17.6	11.5	18.6	14.4
Standard Deviation	1.2	0.3	4.5	1.9
Coefficient of Variation %	6.9	2.5	24.3	13.2

Elongation at Broak (%)

	Virgin Material		Recycled Material	
	Length-wise	Crosswise	Length-wise	Crosswise
Mean	238	125	300	530
Standard Deviation	89	51	154	153
Coefficient of variation %	37	41	51	29

4.1 Description of a Typical Recycling Plant

The following is a cost estimate of a recycling plant available in Sri Lanka.

Value of machinery	-	Rs. 1,500,000
Value of buildings	-	Rs. 500,000
Working capital	-	Rs. 1,000,000
Annual production capacity	-	200 MT
Ex - factory selling price of recycled plastic	-	Rs. 36 - 45/kg
Employment	-	25 people
Estimated annual foreign exchange saving (US $ - Rs. 33.03)	-	Rs. 9 million

It is estimated that about 1500 tons of polyolefine waste is produced annually in Sri Lanka but only about 500 tons are recycled. The following are the reasons for low recycling efficiency.

(a) Difficulty in collecting waste

(b) Machinery imported from developed countries are too expensive and also sophisticated

(c) Poor technical know-how on efficient recycling.

5.0 FUTURE OF RECYCLING PLASTICS IN SRI LANKA

Growth in plastics will generate enough raw material for recycling. Immediate need is for recycling technology in following plastics :

(a) PVC : At present PVC is used widely and facilities are available for recycling to some extent. Recycled PVC is used for manufacture of building construction material. (e.g. Gutter pipes and conduit pipes)

(b) Nylon : Waste material is generated in the Nylon-6 plant. Difficulties in recycling due to absence of know-how and quality control procedures.

(c) Polystyrene and other thermoplastics : Especially, blends if recycled could produce materials for decorative purposes.

(d) Polyolefine : The biggest growth area is envisaged in polyolefines. Present technology appears adequate but there is a need for small scale machinery to be used at a cottage (SMI) level. This type of equipment is not available with the larger manufacturers and it may be necessary to carry out development work to produce this type of machinery.

Considering the drain on foreign exchange it may be advisable for Sri Lanka to import scrap plastics and recycle in Sri Lanka according to well-defined technologies.

6.0 POLICY AND PLANNING ON RECYCLING OF PLASTICS IN SRI LANKA

Matters relating to recycling of plastics are dealt by the Ministry of Industries and Scientific Affairs. At present approvals for import of recycled material and machinery are granted by the local Investment Advisory Committee of Ministry of Industries and Scientific Affairs. Policy is governed taking note of factors such as safe use of plastics and other technical matters

where CISIR are consultants to Ministry of Industries and Scientific Affairs. Present tariff and non-tariff restrictions discourage import of recycled material but no distinction appears to be made between scrap (unfit for processing) and recycled material (fit for processing blended with virgin material). It would be advisable to formulate policy on this matter so that use of reclaim is not misused and benefits are accrued according to international practices of use of reclaim.

COUNTRY PAPER

"THE SITUATION OF THE PLASTICS WASTE RECYCLING INDUSTRY IN THAILAND"

"PHIETOON TRIVIJITKASEM"

In Thailand, plastic products have been considered as one of the most important essential factor for a standard of living. It has been used or even been manufacturer in widely different varieties e.g. table wares, housewares, ropes, nets and etc. Hence the plastic industies have been well-known for more than thirty year under the production process ranging from simple munual injection machines upto. sophisticate automation ones.

At present, the plastic industry has been widely extended not only for just import substitution but also for export to the international markets with a substantial foreign income. On the other hand, the plastic material industries have been also developed by utilizing the natural gas being sufficient to supply commercially for more than thirty year with the daily output of 400-1000 million cubic feet. In 1987, several grades of plastic resin e.g. LDPE, HDPE, PVC, PS can be manufactured with a total capacity of 22,000 metricton per year together with another yearly output of 10,000 metricton for thermoset grade e.g. PF, UF, MF, and UP.

There are many plastic reprocess factories ranging from small to large factories with a number around 2000 totally. It is believed that 70 percents are the ones with yearly capacity below 500 metricton and half of these factories are of the yearly output less than 100 metricton. They cover several production processes as follows:-

1. EXTRUSION PROCESSES

   1.1 extrusion blown film or tubular blown film
   1.2 extrusion casting or flat film or T-die
   1.3 extrusion blown molding
   1.4 extrusion profile

Cont. page 2...

2. INJECTION MOLDING
3. THERMOFORMING
4. COMPRESSION MOLDING
5. HAND LAY-OUT (Fiber glass or unsaturated polyester)
6. CALENDERING (PVC sheet or artificial leather)
7. LAMINATED (Furniture)

There is promising potential trend of drastically rise in plastic utilization in Thailand. From the comparison data with some industrialized countries or even with the other ASIAN countries, a substantial different rate of plastic utilization per capita per annum can be clearly noted in Table I

Table I Plastic utilization data

COUNTRY	POPULATION (MILLION)	PLASTIC UTILIZATION (KG/CAPITA/ ANNUM	RATE OF GROWTH YEAR'81-86
Thailand	55.0	5.5	13.3
Singapore	1.5	61.8	8.4
Malaysia	10.5	10.6	9.0
Indonesia	110.0	1.8	7.7
Phillipine	46.0	3.1	6.1
Taiwan	20.0	88.0	21.8
Hong Kong	5.5	72.0	10.4
Korea	45.0	33.0	17.2
Japan	121.0	53.8	-
U.S.A.	240.0	62.6	-

From Table II, the total demand of plastic resin in 1987 and 1988 in Thailand has been increased with an average rate approximately of 20 percents.

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Table II : Total demand of plastic resin in Thailand

RESIN	DEMAND'87 (TON)	DEMAND'88 (TON)	GROWTH RATE (%)
PE	260,000	325,000	25
PP	154,000	171,000	11
PVC	161,000	181,000	37
PS	66,000	80,000	22
ABS	4,100	5,000	22

The above total demand quantities of each grade are certainly inclusive both quantities of domestic and export utilized amounts.

In the meantime, the resin production capacities growth in Thailand are listed in Table III. The first phase of natural gas development, so called NPC 1, will be fulfilled in 1991.

Table III : Resin production capacity in Thailand

RESIN	CAPACITY 1987	CAPACITY 1989
PE	125,000	255,000
PVC	140,000	140,000
PS	32,700	32,700
ABS	4,400	4,400
PP	-	100,000

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From the above informations, we may figure out the whole demand quantity solely of domestically used as 300,000 metricton yearly.

In general the plastic waste may come from two sources. Firstly, it comes from industrial waste which normally estimates of 3 percents exclusion from inline recycle process. Secondly, it comes from post consumer waste with estimated rate of 20 percents. Thus the total plastic waste collected yearly may be around 69,000 metricton.

Due to the rapid increase of plastic utilization, the proper scrap recycle process has been overlooked. Most of the recycle process plants are treated in homemade method which is considerable poorly controled. It is bought from plastic factories or collected from junk. Then it is cleaned and classified. After palletization, the recycle material will be sold back to the factories for low grade product production. This trading has strongly created many problem to the society enviroment. Hence the ecology of the plastic waste must be carefully investigated and be considered seriously in order to avoid any big disaster in the future.

Finally, we may state that if one can achieve the plastic waste properly by using the new technology controled process. It is not only providing good recycle material but also, in return, we may enjoy the safety enviroment and obtain more value added amount yearly over 30 million US Dollars i.e. for Thailand.

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