OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

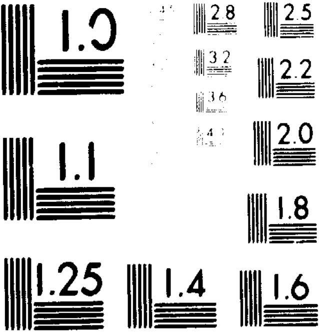
FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

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


1.0
2.8
2.5
3.2
2.2
3.6
2.0
1.1
1.8
1.25
1.4
1.6

E9811

26th May, 1980.
ENGLISH.

U.N.D.P./U.N.I.D.O. P R O J E C T
DP/SRL/78/031
S R I L A N K A

CEYLON MINERAL SANDS CORPORATION DEVELOPMENT PROGRAMME

Technical Report : Titanium Slag Production

Prepared for the Government of Sri Lanka by the United Nations Industrial Development Organisation, Executive Agency for the United Nations Development Programme.

Based on the work of W. Harrach, Expert in the Titanium Slag Production :

United Nations Industrial Development Organisation
Vienna.

May, 1980.

This report has not been cleared with the United Nations Industrial Development Organisation, which does not, therefore, necessarily share the views presented.

CONTENTS

A P P E N D I C I E S

Appendix No. 1
Chemical analysis data of C.M.S.C. Ilmenite Concentrates.

Appendix No. 2
Hong Gai/Viet-Nam anthracite coal specifications.

Appendix No. 3
Short description of O_2 type air separator.

Appendix No. 4
Composition of pig iron types .

Appendix No. 5
Flow sheet and product list of C.M.S.C. in the future.

Appendix No. 6
The price trend of titanoferous materials from 1972 to 1984.

Appendix No. 7
The production of fused zirconia.

Appendix No. 8
C.M.S.C. Development programme and the country's steel industry.

1. SUMMARY

This report concerns the Evaluation of the Titanium Slag Project (hereinafter TSPR) investigated in the Ceylon Mineral Sands Corporation (herein CMSC) Development Programme DP/SRL/78/031.

The aims of the TSPR Evaluation are to assist the CMSC and the Governmental authorities to make a decision concerning the implementation of an electrometallurgical plant for processing ilmenite at Pulmoddai.

There was one study submitted to CMSC and staying at Pulmoddai for about six (6) weeks the writer investigated the circumstances and possibilities of this TSPR in detail.

The 'FINDINGS' chapter of this report deals mainly with the technological, energy and personnel aspects of the project, but the economic and marketing questions are treated as well.

In section 3.5 'FUTURE' some ideas are shown concerning further steps of the development.

The 'EVALUATION' shows how the TSPR has been elaborated and whether this needs any further completion

The section 4.3 'CONCLUSION' shows that the project is feasible and competitive. The Titanium Slag (hereinafter TS) is a marketable product with an increasing price level. The pig iron as a byproduct of the process is an important metallurgical raw material in demand.

According to the recently achieved geological prospecting the quantity of the resources is quite higher than that indicated in previous studies. It is now estimated at about 13 million tons while the estimated figure in 1971 was 3.7 million tons of HM (Heavy Minerals).

Executing some modifications and completions the project can be a very competitive plant for the country, which can be developed with further processes in the future.

'RECOMMENDATIONS' chapter contains remarks and proposals concerning possible future action to ensure quick and efficient starting and running of the plant.

The attention of the reader is drawn particularly to recommendation No. 1. This is a fundamental prerequisite for a good start at the efficient functioning of the Titanium Slag Plant (hereinafter TSPL). It deals with the problem of power demand and supply which is the main question to be solved.

2. INTRODUCTION

2.1 CMSC DEVELOPMENT PROGRAMME

2.1.1 Concept

TSPR is in fact one part of the CMSC Development Programme DP/SRL/78/031. The full details of the background of this programme will be included in the terminal report on the CMSC Development Programme and are not included here.

2.1.2 Original aims :

The aims of the development of TSPR are given as follows :

a) To improve and upgrade present mineral sands mining and beneficication operations of Ceylon Mineral Sands Corporation (CMSC), and to evaluate the feasibility of introducing new processes for the conversion of ilmenite sands to more valuable intermediate products.

The expert will specifically be expected to :

b) Evaluate feasibility studies prepared by potential foreign joint venture participants in connection with titanium slag production in the country, and prepare a report on these for the Government's perusal.

c) Prepare separately or include in the above report, his own findings, conclusions and recommendations over and above those contained in the various feasibility studies, pertaining to titanium slag production.

d) If any negotiations were to take place with potential foreign partners during the expert's presence in the country, provide advice and assistance in these matters to the Government, if so requested.

e) The purpose of this project is to provide assistance to upgrade present operations at Pulmoddai of CMSC on the one hand and the advise the Government on the best, most economical and profitable approach (es) for expanding and broadening the production of ilmenite based products on the other.

2.1.3 Additional aims :

Additional aims have not been submitted by anyone.

3. FINDINGS

3.1 THE TECHNOLOGY AND EQUIPMENT OF TSPL

3.1.1 The technological process :

The demand for high grade titanoferous materials is increasing in such a way that the natural resources of rutile are not enough. High grade ilmenite concentrates suitable for direct chlorination (hereinafter CHR/Chlorine Route) may also become unavailable in the future. Slag produced from smelting operations may provide available alternative to the use of rutile or high grade ilmenite concentrates for the production of titanium sponge. It can be also used for the so called sulphate route (hereinafter SR) titanium dioxide pigment production.

'The Project Report for the CMSC Titanium Slag Plant of 75,000 mtpy Capacity' concerns the smelting of ilmenite concentrates by an electrometallurgical process.

The technology for smelting ilmenite with a carbonaceous reducing agent to obtain high grade titanium slag and pig iron has been known for about 30 years. Three main producers are using this process.

a) Quebec, Iron, & Titanium Corporation, Sorel, Canada (since 1950).

b) The Soviet Russian Titanium & Magnesium Plants at several cities of the U.S.S.R. (since 1950).

c) Richards Bay Iron & Titanium (Pty.) Ltd., South Africa (since 1978).

The proposed technology is based on the second producer's know-how.

The main advantages of the suggested technology are :

a) The process is flexible. Both SR Slag and CHR Slag can be produced in the same furnace and the change can be done quickly without any special complications.

b) There are no solid, liquid or gaseous pollutions.

c) Dangerous compounds need not be imported and handled.

d) The final product is of higher quality than that produced by the alternative reduction methods (DR Process).

e) The power demand of the proposed smaller units does not cause any problems in the electrical network.

The raw material (ilmenite) is available in large quantities in Pulmoddai. The reducing agent can be supplied mostly by the Country's industries. The power supply in 1979 was told to be ensured without any difficulty. This question will be dealt in the next subsection in more details. It can be, therefore, seen that the slag process is not a sophisticated method. It is an appropriate industrial technology using preliminary local resources and producing products for export and domestic consumption, as well (pig iron for the Sri Lankan Steel and Foundry Industries).

3.1.2 Power Supply :

The TSPL proposed in the study which was to be evaluated will produce 79,085 tons slag and 31,270 tons pig iron annually worth over 15.3 million US$ according to 1979 price basis.

The main question is whether the power demand of 178,400 MWhpy can be calculated in the power balance of the country for the years after 1984.

If all goes to schedule (anticipating the signing of a contract in 1980) the power demand of the TSPL will be as follows :

2nd Half of 1983	9,900 MWh	4 MW	Aver. Loading	5 MW	Peak Loading
1st Half of 1984	29,400 MWh	7.7 MW	-do-	8.7 MW	-do-
2nd Half of 1984	60,600 MWh	15.3 MW	-do-	16.3 MW	-do-
Total 1985	178,400 MWh	22.5 MW	-do-	23.5 MW	-do-

The electricity generation facilities available in the country are limited. The hydro stations' capacity is nominated at 327 MW. The only important thermal power station which runs is located in Kelanitissa and has a maximum of about 40 MW.

The demand for electric energy seems to be increasing according to the reports in the country's newspapers more than it was planned previously. Hence, there seems to be a gap between demand and installed capacity. The coming on stream of Bowatenne and Canyon with a capacity of 70 MW can reduce this gap in 1982 but according to a paper of Mr. James H. Lanerolle (Secretary to the Ministry of Power & Energy). 'The 70 MW which they will yield however will be inadequate to completely bridge the gap between demand and supply upto 1983/84.

The start of a new large power consumer of 178,400 MWh per year without any additional measure could raise new power problems. At the same time it seems to be too grave a responsibility not to properly exploit one of the most important

HM resources of the world in a period when the demand is increasing and new markets can be acquired. It must be stressed that demand for HM and rare earths is increasing because of the pigment, air-craft, space-craft and atomic industries. Based on the information received from the Sri Lankan Ministry of Power and Highways in the first half of 1979, it is expected in the study that the power supply system would have sufficient capacity to meet the power demand of the TSPL in a stable manner. Taking into consideration the present situation of the country's power balance, it must be emphasized that it is necessary to re-examine the power supply problem of this very efficient electrometallurgical project.

It can be accounted as an advantage that the electro-furnaces are flexible and they can be run in peak demand time on a lower capacity.

In case of power interruptions the slag can be tapped and the start after 8 - 10 hours can be executed without any problem. In case the power interruption lasts more than 24 hours the start of the electrofurnaces is possible as well but it needs some time to bring them to a full capacity. However, it must be remembered that the interruption or decreasing of the production enlarges the production costs and reduces the cash flow. Therefore, it is no doubt that the possibilities of establishing a diesel engine operated standby power station at the plant site or the construction of a stable power station at Pulmoddai or Trincomalee with an installed capacity of 20 - 25 MW should be thoroughly investigated. The construction of a power station at Pulmoddai has the advantage that the generating and consuming plants are close to each other, the power loss is insignificant, and the communication does not raise any problem. Only the inadequate capacity of the port facilities is a problem to be solved. These facilities are unable to unload coal or fuel oil. The state of these is to be examined any way for the development of the upgrading plant as well. A power station in Trincomalee does not need new port facilities only the overhauling of the existing equipment. The transformer station and the grid are to be enlarged. New transformers are to be installed but the costs of this installation are the same as at Pulmoddai. A 'Ring Main' is to be installed between Trincomalee and Pulmoddai and between the Colombo - Jaffna line and Pulmoddai, in any case. The whole matter needs a quick decision of the governmental authorities. If the setting up of a thermal power station is to be planned, a tender should be invited for this work immediately. The contractor for the TSPL should be invited to prepare the integration of the existing electric system with the TSPL's network.

3.1.3 Material input :

3.1.3.1 Ilmenite :

According to the prospecting achieved recently there are large quantities of HM in the area. The figures show much more than the earlier reserves. The reserves were estimated at about 3.4 million tons HM in 1978. According to the recent evaluation prepared by the Geological Survey Dept., Colombo and a foreign company, the reserves in the area are more than 13 million tons of HM. This quantity permits a production of 80,000 tons of slag per year for more than 50 years.

The quality of the ilmenite indicated in the tender is quite good to produce the SR slag (85 percent TiO_2) because the impurities act as fluxes.

Sometimes the production of CHR slag from the same concentrate might cause difficulties. The most deleterious impurities of the CHR slag forming high melting point chlorides during processing are Al_2O_3, MnO, CaO and MgO. The FeO content can be reduced during the melting process to the demanded minimum value.

The impurities Al_2O_3, Cr_2O_3, CaO and MgO in the ilmenite concentrate should be made as low as possible.

Care has to be taken in separating particles of shells from the ilmenite concentrate. The continuous detailed control of the ilmenite will be necessary in the future.

3.1.3.2 The reducing agent :

Three reductants were taken into consideration in the study. Coconut shell charcoal is sufficiently available but its price has increased in such a way that it is necessary to look out for a cheaper material. In spite of this fact, the increase of utilization of coconut shells to produce charcoal in the country and particularly in the nearest area around the plant site, is very urgent. The actual price of Rs.2,650/= per ton of coconut shell charcoal is rather high (ref. CEYLON DAILY NEWS dtd. 9th April, 1980) and hence an increased production is required. The production of the coconut plantations is much higher than the quantity of the used shells to the charcoal production. The aver. production was 20,760 tons per year for 10 years from 1968 to 1977.

The wood charcoal is cheaper in price but the anticipated supply is inadequate. The State Timber Corporation would be able to produce the major part of the charcoal demand of the TSPL during the implementation period of the Mahaveli Development Programme. However, following finalisation of this project the wood charcoal supply would be problematical.

Therefore, the production of charcoal on a small scale should be encouraged. The social benefits resulting from increasing employment in the rural sector developing the charcoal industry could make an important contribution towards developing the rural economy with little capital costs and without the use of any advanced technology.

There are good brown coal types with a low ash content available from India and anthracite coals from other countries, e.g. Vietnam. (See Appendix No. 2)

3.1.3.3 Oxygen :

Oxygen is required for opening the tapping hole of the arc furnace. It is pointed out in the study that Ceylon Oxygen Corp., will start operating a new plant, together with the existing plant by 1980. There are no indications that the proposed plant will commence construction this year. It is quite uncertain that there will be an agreement signed in the near future. The TSPL cannot be based on such a vague oxygen supply. Therefore, a decision should be taken to complete the Pulmoddai Plant with its' own oxygen type air separator. The oxygen production facility could incorporate the added possibility of supplying the whole northern area of the country as well as meeting the demand of the Pulmoddai plant.

This solution economizes only in the transportation costs of the oxygen to the value of concerning the TSPL, 248,464 tonskm annually.

Oxygen is also required for the synthetic rutile process elaborated by U.S. Bureau of Mines, Albany (OR) which uses titanium slag smelted from domestic ilmenite concentrates.

A short technical description of the O_2type Air Separator is given in Appendix No. 3. The estimated price of one separator with a capacity of 50 normal cu.m. per hour (excluding building costs and costs of cylinders) may be US$600 - 800 thousand.

3.1.3.4 Water supply :

It is pointed out in the study based on information received from the Ilmenite Plant that the capacity of the sedimentation cum filtering ditch established at the water intake site has a capacity of 10,896 cu.m. per day, so it can meet the total water demand of the TSPL (1,848 cu.m. per day). This figure has to be provided from the start of the implementation activities and if it is necessary a supplementary filtering ditch has to be constructed.

Because of the large water demand of the TSPL's cooling water system and the severe water quality requirements, the costs of the water treatment are rather high. It seems, that the available data concerning the water quality of the Yanoya river from 1973 are extremely bad. Investigating the Meteorological Data of 1973, it could be observed that the samples collected showing an inferior water quality, were taken in a short dry period. Both the costs of the equipment and chemicals for the water treatment can be decreased significantly if it is not necessary to take into account this inferior water quality during the whole year. The total treatment with its sophisticated process would be needed only in periods when the river produces badly polluted water. Particularly, the salt content and the hardness are extremely high and have to be re-examined.

It must be remembered that after the preparation of the TSPL study the Stage II Expansion Scheme of the upgrading plant has been decided by the CMSC Management. This new plant requires a large quantity of water. Therefore, a complete water balance for the present plant, the wet magnetic plant and the TSPL must be elaborated. This balance has to provide for a maximum of water re-cycling.

3.1.3.5 Other chemicals :

The costs of chemicals for the water treatment are estimated as US$ 76,000 annually. Chemicals worth of US$ 38,000 annually are to be purchased from abroad. The investigation of the water quality supplied from the Yanoya river and the continuous sampling of the used fresh water could decrease the operating cost of the water treatment by about US$ 30,000 annually.

3.1.4 Equipment and machines :

3.1.4.1 Technological equipment :

The equipment list of the study has been investigated and it seems to be sufficient for this stage. The list has to be completed and elaborated in more detail during the period of the projecting activity.

There is a charcoal drier proposed in the equipment list with a capacity of 5 tons per hour. During the factory visits it was noticed that in the Dry Mill was an installed drying kiln with a capacity of 20 tons per hour. This kiln had not been used except once or twice during the last ten years. If it could be integrated, the expenses of a new drier could be cancelled. The Dry Mill (ilmenite plant) is working intermittently. If in the case of an extremely long rainy season the Ilmenite Plant had to use the stored dry beach sand (15,000 tons) then it would be able to run at the normal capacity for about 38 to 40 days without additional drying.

160 Oxygen cylinders are proposed for the transport and storage of the purchased oxygen. If the setting up of an oxygen plant at Pulmoddai is decided on, then this item can be cancelled or alternatively the cylinders can be used for the sale of the excess oxygen produced.

The equipment list of the study comprises neither grinding mills (ball or rod mill) nor screens. In the case that the buyer asks for a grain size similar to that of the rutile, then grinding equipment could be a necessity. This question should be evaluated after discussions with the possible customers. There are pigment producers who require the slag in rocks or coarse size grain to eliminate the losses during the unloading and storage.

The equipment list does not include a casting machine which is required to cast the melted iron into 10 to 20 kg pigs. Therefore, the equipment list has to be completed with one machine of a capacity of 5 to 7 tons per hour to complete the iron process.

3.1.4.2 Non-technological equipment

The equipment list of the water treatment should be revised after the water quality of the Yanoya river has been investigated. There is a real possibility to reduce the capital cost as well as the operating costs of the water supply.

The investment cost of the water supply is the third highest item behind the melting shop and the slag processing shop.

The study considers the present port facilities to be sufficient. The experience during the shipment of about 9,000 tons of ilmenite in bulk and 2,000 tons of bagged rutile in April, 1980, showed that the upgrading of the shipment and port facilities must be achieved before or at the latest during the implementation of the Stage II Expansion Scheme (the new ilmenite plant).

The shipment of : 270,000 tons annually, i.e.

- Ilmenite	- 230,000 tons
- Rutile	- 20,000 tons
- Zircon	- 20,000 tons
- Total	- 270,000 tons

or

After the implementation of the TSPL altogether 150,000 tons annually, i.e.

- Titanium slag	- 79,000 tons
- Pig iron	- 31,000 tons
- Rutile	- 20,000 tons
- Zircon	- 20,000 tons
- Total	- 150,000 tons

cannot be carried out by the present port and transportation facilities without problems. The loading of the ships is interrupted for morethan 4 months and the unloading has not been solved yet.

Hence, the extension of the jetty, the implementation of a high capacity elevator installed on one of the barges or the establishment of a protected port usable during the entire year must rank as a high priority and an early decision is essential one way or the other.

Hydrological investigations are necessary for the decision to establish a port as to whether the breakwater proposed will, or will not disturb the replenishment of HM along the beach.

3.1.4.3 Spare parts :

The consumption and costs of spare parts are shown in several tables of the study (6-IV, 6-V, 10I, 12-II, 12-III, 12-IV) similarly the delivery of maintenance manuals is mentioned. It has been pointed out in the study that spare parts had been planned for two years operation.

In completion to the study it has to be emphasized that the maintenance and the supply of spare parts after the first two years should be prepared and carried out thoroughly. The assistance of the engineering firm could be requested as well if necessary.

The maintenance manuals and spare part lists have to be studied during the implementation period and completion by the engineering firm has to be requested if it is required.

3.1.4.4 Lay-out :

A tender has been invited by CMSC to enlarge or replace the present upgrading plant in Pulmoddai with a capacity of 150,000 tpy ilmenite (Stage II Expansion Scheme).

There is no doubt that the TSPL cannot be started without an operating upgrading plant of a capacity of 130,000 tpy as minimum. However, it must be also stressed that the electro-furnaces have to be placed near the power station and the 132 KV line has to be installed in a way that the 132/33 KV and the 33/11 KV transformer stations be in direct connection with the melting shop.

In reply to a concrete question of the writer it was pointed out by the Chairman/Managing Director of Ceylon Mineral Sands Corporation, Mr. F.B.P. de Silva that the facilities of the Stage II Expansion Scheme are planned to be located in the area of the feed preparation plant about half a mile northwards of the present plant site. It was also pointed out that the Stage II Expansion Scheme will not disturb the proposed lay-out of the TSPL. However, if there are different decisions taken regarding the site selection, a lay-out showing the new situation has to be submitted to the offerer of the TSPL to give him the possibility for remarks, objections or the elaboration of a new lay-out. However, this last solution would take time and costs.

3.1.5 Output :

3.1.5.1 Titanium slag :

There are two types of slags mentioned in the study. The SR slag has a TiO_2 content of 80 - 85 percent. As it is well known, rutile and leucoxene are generally insoluble in acid and cannot be used efficiently in the SR pigment production. Therefore, it is necessary to process the titanoferous minerals in a way that the upgraded product, in this case the TS contains the TiO_2 content as 'anasovite'. This phase contains substantially the titanium values originally present in the feed material. Anasovite is essentially a stabilised variety of the high temperature form of Ti_3O_5.

The CHR slag should have a minimum of 90 percent TiO_2. As it has been mentioned in subsection 3.1.3.1. the impurities Al_2O_3, MnO, CaO and MgO should be decreased to a minimum. First of all the CaO and MgO content must not surpass together 1.0-1.5 percent, when applying fluid bed chlorination, technology because there is a risk that the non-TiO_2 impurities would lead to high boiling chlorides which would condense and deposit in the chlorination exit ductings, etc., leading to a restriction in operation and possibly necessitate frequent cleaning. The figure of these impurities is to be dropped to the demanded ratio. The upgrading technology for the ilmenite concentrate produced to the CHR slag process has to be adjusted thoroughly (e.g. elimination of the shell particles).

3.1.5.2 Pig iron :

The pig iron obtained as a by product of the slag production can be used both for the steel production and the foundry industry. The steel industry needs a raw material with a relatively low carbon content. Therefore, the pig iron led directly into the electro furnaces of the Steel Plant has to be treated by oxygen in the laddle or in a separate furnace. This treatment can take place in the melting shop immediately after the tapping or in the furnaces of the steelwork as well. The pig iron can be used as a batch component without any special treatment.

For cast iron the carbon content could be higher than in the pig iron mentioned in the study. A carbonizing process would be a solution to obtain a product commanding a higher price. Australian carbonized pig iron has a price of US$ 260-270 per metric ton FOB Hamburg.

The expected phosphorous content of the pig iron seems to be fairly high. 0.025 percent of P is requested but 0.1 percent can be tolerated as a maximum. An investigation is required to determine where the P content comes from and then measures have to be taken to reduce it to acceptable levels. Appendix No.4 shows the analysis data of several types of pig iron.

The sulphur content has to be in the range of 0.015 percent to 0.025 percent, otherwise the Mg demand for the desulphurization will be too high. The expected S content is sufficient.

The pig iron produced with the expected composition is marketable as well, however, for the future the establishment of a foundry in Pulmoddai should be investigated as a further step of the development.

3.2 THE MANAGEMENT AND LABOUR FORCE

3.2.1 The organization

The proposed scheme of the Plant Organisation after the start of the new upgrading and TSPL takes into account that the present management is mainly capable to meet the requirements of the new plant. Only the establishment of independant positions of the Production Manager and Plant Engineering Manager are suggested. The number of executives for the TSPL should be sufficient. Measures are to be taken for the training of this staff. Proposals are pointed out under subsection 3.2.4 'Training', concerning this question.

3.2.2 Supervisory and managerial staff

Experience has shown that in most cases, it is not too difficult to implement a new project if it has a good management structure. Therefore, the source and cost of managerial staff should be determined. The offerers have to define the requirements for the supervisory and managerial personnel, so that they can be recruited by the C.M.S.C. Management well in advance. The timely provision of qualified staff to manage all the functions of the plant is most important. The present staff management is highly qualified and capable to meet the requirements of the new plant as well. A short theoretical training programme concerning the special problems of the TS production could be useful. This question will be dealt with in the subsection 3.2.4 'Training'.

3.2.3 Labour force :

The number of personnel for the proposed skilled maintenance team appears to be insufficient due to the increased maintenance problems in Pulmoddai. Therefore the proposed number of welders, electricians and mechanics should be re-examined.

During the pre-production phase the man-power requirements occur mainly in conjunction with the preparatory measures needed to start the operational phase. Thus some specialized machine operators and some foremen have to be recruited in advance to be trained and also to attend to the construction of buildings and the installation of equipment which will be operating later. The qualifications and skills required and shown in the study should be described and detailed into categories of labour in order to provide a framework for recruitment.

3.2.4 Training

The TSPL study provides a training of one month for 15 people including metallurgists in a factory of the Sowiet Union. According to the proposal, 3 persons possessing a respective university degree should be capable of acquiring the knowledge for the supervision. Three persons should be electro technicians or electricians and three other persons should be skilled fitters.

The present labour force to be utilized for the future slag production is totally untrained. Therefore, a thoroughly detailed training programme should be prepared. This programme should be larger than that proposed in the study.

The training of two analytical experts should be realized in a Hungarian Plant or Research Institute. One part of the training costs could be eventually covered by UNIDO.

3.3 IMPLEMENTATION

The time schedule for the implementation of the TSPL with a duration of 60 months seems to be long but taking into account that in 16 months after the delivery of the first equipment, two furnaces will start this time schedule can be accepted. If building construction could be carried out in a shorter time than the start of the first furnace could be considered earlier. The time schedule requires close co-operation between the contractor of the civil works and buildings on one side and equipment suppliers and contracting firms charged with the construction works on the other.

Any delay or lack of scheduling in respect of any aspect would inevitably delay the start of production.

A project implementation management is to be set up as soon as possible to expedite the implementation. The location of one or two members of the implementation management team at the offerers' (Engineering firm) head quarters for a one month period would be conducive to co-operation for the implementation activity.

The main critical stages during the implementation phase are the testing of equipment, trial production and commissioning of the plant. Therefore the training of the plant personnel and the supervisory staff has to be completed by this time.

The initial time schedule should be reviewed from time to time in the course of project implementation and pragmatic adjustments made if necessary.

The man power and supervisory staff of the first two furnaces can be used to take part in the training of the next unit's labour as advisors.

3.4 COMPUTATIONS, CALCULATIONS

The necessity to check each computation and item of the study was not pursued because of the short time duration and unavailability of comparative figures in Pulmoddai. Therefor only the most important items have been investigated partly on the basis of data obtained from CMSC and partly on the basis of data available from the world market.

3.4.1 Fixed assets :

A detailed breakdown of the equipment is not given in the study. Therefore, findings concerning the total investment sum can only be roughly estimated.

The unit figures for most of the important engineering and construction activities are based on world prices and will most probably be lower in Sri Lanka. The tender for the civil engineering and building activities should be invited and evaluated with the assistance of the engineering firm (or main contractor) of the TSPR.

The following items of the fixed assets can be decreased or some of them can be totally cancelled on the basis of the experiences in the present plant.

01 Terrain correction

02 Road network inside the fence

03 Industrial waste water, rainwater

04 Water supply

The estimated sum decrease could be approximately US$ 500,000. The item 24 'Customs duty charges' will probably be lower because of the decreased custom charges since July, 1979.

Unfortunately, there is a world-wide increase in equipment prices. Therefore, the postponing of the implementation will lead to higher fixed assets.

This should be considered by the governmental authorities timing the implementation.

3.4.2 Sales revenue estimate

The estimated price of US$ 1.55 per metric ton related to 1 percent TiO_2 content at FOB rate can be accepted concerning the SR slag but the price of the CHR slag will be higher. The increase of the slag price in the next years' period can be expected as well. (See Appendix No.6)

The annual sales revenue of US$ 15.35 million is acceptable as a minimum.

3.4.3 Operating costs

The largest items of the operating costs are as follows :

a) Electric energy US$ 2.5 million annually. This item will be probably higher in the future because of the international and domestic power costs. There is only one possibility to decrease this item, i.e. if the specific consumption can be reduced. The technology has to be followed exactly and any waste of time or heat cannot be tolerated. Producing more SR slag the power consumption can be reduced without a significant decrease of the net profit.

b) Graphite electrodes US$ 3.2 million annually. This amount is proportional to the power consumption and it can be decreased producing mainly the more energy saving product i.e. SR slag.

c) Ilmenite concentrate
The input price of ilmenite concentrate (US$ 18.80 per metric ton) is over-estimated. Accepting the FOB price of US$ 19.00 per metric ton a deduction of US$ 0.20 per ton is too low. The actual loading cost excluding the loading losses are higher than Rs.30.00 per ton (= 2,0 US$). Substituting the correct figure in the calculation of the TSPR the operating costs per ton CHR slag would be lowered by US$ 3.13 and the costs of SR slag US$ 2.91.

A new calculation is not needed but this fact must be remembered.

d) The costs of the chemicals for the water treatment can be decreased US$ 0.38 per metric ton of slag.

3.4.4 Cash flow analysis
The conclusions drawn on the results of the Cash Flow Analysis in the study can be accepted as follows :

The return on the investment ROI 11.62 per cent.
The return on equity ROE 10-09 per cent.
Financial problems in the 7th to 9th years of the operation may occur if in the grace period an appropriate fund has not been raised.
Net operating profit for the average of 10 years operation after attaining the full capacity, US$ 20.86 per metric ton of slag (as a minimum).

3.5 THE FUTURE

After investigating the TSPR a look at the long range development of the Pulmoddai Plant is necessary (see Appendix No.5). Several new products can be produced and marketed after the completion of the technological process.

a) The sale of ilmenite will be only an insignificant item due to its stagnant price following the processing of almost the total produced quantity to product of a higher value.

b) The total quantity of rutile will be sold and the price will be higher .

c) One part of the produced slag will most probably be processed by chemical methods to synthetic rutile. The other part is available for export.

d) The direct sale of the produced pig iron will decrease on the long-range basis and beneficiated products will be produced from it.

e) Establishing a foundry would allow the domestic production of several simple castings.

f) Using the induction furnace implemented for the treatment of pig iron (carbonization, equalization) ferro-aluminium can be produced by feeding purchased aluminium scrap to the melted pig iron. This alloy is demanded by the steel industry in the BO and BOF processes. These are used in large quantities and the production at the Pulmoddai plant depends on the resources of aluminium scrap.

g) Zircon will be sold in three qualities: standard grade, intermediate grade and premium grade. The price of the standard grade quality will not increase as significantly as the price of the premium grade product. It is well known that the chemical leaching is a dangerous and onerous process which should only be started after precautionary measures. The purchasing of good technical know-how is important.

h) One part of the standard grade zircon can be processed in the same type of electrofurnaces as the slag to produce fused zirconia and ferrosilicon.

The price of the fused zirconia is more attractive than the price of the zircon.

i) The price of the ferrosilicon depends on the Si content. The quantity of the possible production is proportional to the produced fused zirconia and the quality of melted raw materials (pig iron, zircon, reducing agent).

j) The sillimanite and kyanite content of the beach sand can be at a minimum one percent. Processing more than 300,000 tons of sand annually, produces 3,000 tons of sillimanite which can be stockpiled, melted to electromullite or sold. The present price of electromullite is about US$ 175 to US$ 220 per metric ton depending upon the quality.

k) The monazite phase from the wet mill will be treated in the future to produce rare earths.

l) Annually 330,000 cu.m. of oxygen would be available for sale in the case that the Corporation's own oxygen separator was implemented in connection with the TSPL. The sales revenue can be estimated at about Rs.1,500,000.

Recommendations concerning this section have not been submitted because of the wide range of possibilities requiring decisions in this field.

The purpose of this very short summary is to emphasize which measures require decisions to be taken in the next 15 - 20 years.

4. EVALUATION

4.1 WEAKNESSES OF THE PROJECT

There are of course an immense number of problems and requirements in any plant even in the most advanced stage of development. It will therefore be appreciated that in the TSPR there are also many points to consider. This being the case it is not intended to restrict the development, but rather to emphasize the efforts required.

The problems dealt in the previous sections will be summarized in this section as follows :

a) The start of the TSPL cannot be decided without a governmental decision concerning the implementation of a "Ring-main" to Pulmoddai.

b) Governmental authorities have to take a decision whether the power demand of the TSPL can be calculated in the country's power balance for the years after 1984 or the implementation of a stand-by or a stable power station of 20-25 MW capacity is to be decided on.

c) The Stage II - Expansion Scheme has to be co-ordinated with the TSPR both in time scheduling and site selection.

d) Care has to be taken for the supply of domestic charcoal, coconut shell charcoal or imported anthracite coal.

e) To meet the oxygen demand of the TSPL the expansion of the Ceylon Oxygen Corporation's production or the implementation of C.M.S.C's own oxygen plant in Pulmoddai will be necessary.

f) To cover the total water demand of the present plant, the Stage II Expansion Scheme and the TSPL, a water balance is needed in which the maximum benefit of water recycling is to be gained. The waste water may be used for the irrigation of the area's paddy fields.

This water balance will indicate whether the present water intake will need enlarging.

g) The present port and transportation facilities in Pulmoddai are inadequate for an enlarged production.

The implementation of an up to date loading system has to be decided in any case.

4.2 STRENGTHS OF THE PROJECT :

The most important advantages of the project including those against other processes are as follows :

a) The indigenous resources of the country are available in large quantities and can be utilised in a competitive and efficient way.

b) The process is flexible and does not produce any solid, liquid or gaseous waste. (Waste disposal not needed).

c) Dangerous chemical compounds (e.g. chlorine, hydrochloric acid) need not be handled.

d) The electrical load of the furnaces can be dropped in the case of power problems associated with the national grid.

e) The main technological units are robustly constructed and can withstand harder treatment.

f) There are no special corrosion problems because acids are not used.

g) Sophisticated chemical equipment is not needed (chlorination distillation, etc.).

h) Pending a decision to produce synthetic rutile, the use of one part of the produced slag blended with ilmenite concentrate can be taken into consideration.

i) The factory in Pulmoddai can be enlarged to an important chemical and metallurgical establishment using indigenous by-products and wastes to produce further marketable products.

4.3 CONCLUSION

The TSPL implemented in Pulmoddai with a capacity of 80,000 tpy TS (minimum 50,000 tpy) will be a profitable extension tp the present plant being capable of processing the ilmenite produced by the decided Stage II Expansion Scheme as well.

The TSPL will be more advantageous because an increase in the slag price following the world price of rutile can be expected in the future.

The plant will promote the national economy not only directly producing competitive goods, but also indirectly utilizing several indigenous materials and services. The TSPL will be one of the best power consumers of the national power system because of its flexibility concerning loading, the power factor of the electric arc furnaces, and its 24 hour operation. The product list of the plant can also diversified in the future thus ensuring flexibility.

Co-operating with the Container Cargo Service (Colombo - Felixstone - Hamburg - Rotterdam) of the Ceylon Shipping Corporation, a fully containerized transportation of bagged products can be realized to Europe. This service can be enlarged to Japan as well in the future.

Establishing a protected port and declaring the plant area to be a "Free Trade Zone", Pulmoddai could be a new industrial centre of the country.

The question of the two stage technology (pre-reduction in the first stage and electrosmelting in the second stage) should be re-examined after the implementation of the first two furnaces. Probably a new investigation will supply better results than those in the study. The reduction of the demand of power, graphite electrodes, cooling water and the increase of the plant capacity can be expected in the positive case.

5. R E C O M M E N D A T I O N S

It will be appreciated that the recommendations which follow in this report are based on the 'FINDINGS' and discussions conducted with several persons concerned with the upgrading of HM sands and running the present plant in Pulmoddai. Should the project be approved the following are the recommendations :

5.1 RECOMMENDATION NO.1

Assuring a compatible supply for the power demand of the TSPL.

It is recommended that :

a) An urgent decision be taken to erect the 132 kV 'Ring-Main' Trincomalee - Pulmoddai - Colombo/Jaffna line as soon as possible and

b) An urgent decision be taken to set up a Diesel operated stand-by power station of 20 - 25 MW in Pulmoddai

or

c) A thermal power station of 20 - 25 MW be constructed in Pulmoddai and indegrated to the national grid

or

d) A thermal power station of higher installed capacity be constructed in Trincomalee or elsewhere and to invite tender for this investment.

5.2 RECOMMENDATION NO.2

In assuring the availability of the ilmenite quality necessary to produce high grade slag.

It is recommended that :

a) Provision be made to remove all particles of shells during the upgrading operations from the HM.

b) Provision be made to decrease the ZrO_2 content of the ilmenite concentrate.

5.3 RECOMMENDATION NO.3

Assure the availability of the long long range supply of reductants for the TS production.

It is recommended that :

a) The production of coconut shell charcoal be developed in pilot plant scale located in rural areas.

b) The production of wood charcoal using worthless wood be urged mainly in forest areas.

c) Tenders be invited to supply brown coal and anthracite coal from abroad (India, Vietnam).

d) Tests be initiated to produce charcoal from paddy husk and use it as a suplementary reductant.

5.4 RECOMMENDATION NO.4

Setting up of an oxygen plant in Pulmoddai.

It is recommended that :
The TSPL be completed with an oxygen plant of a minimum output to ensure an adequate supply for the oxygen demand and possibly the demand of the northern area as well.

5.5 RECOMMENDATION NO.5

Investigation of the water quality of the Yanoya river.

It is recommended that :

a) Water samples be taken frequently and analysed. The duration of the periods when the river supplies polluted water should be determined and recorded.

b) The water balance of the total plant (incl. the new plants) be calculated.

c) The process and equipment of the water treatment be re-examined on the basis of the new water balance and quality data.

d) The installed filtering of the water intake be made to work.

5.6 RECOMMENDATION NO.6

Installation of a casting machine for pig iron.

It is recommended that :

The equipment list be completed for a casting machine of sufficient capacity to cast the tapped pig iron into 10 kg. to 20 kg. pigs.

5.7 RECOMMENDATION NO.7

Completion of the shipping facilities.

It is recommended that :

a) The equipment for shipping be enlarged.

b) Equipment for unloading input materials be installed.

c) A decision be made for the implementation of a protected harbour usable during both the monsoon and the dry periods.

5.8 RECOMMENDATION NO.8

Decision concerning a definitive lay-out including the planned new plants.

It is recommended that :

a) A definitive lay-out be elaborated which includes both the new Wet Upgrading Plant and the TSPL.

b) The implementation of the Stage II - Expansion Scheme be planned in a way that the proposed TSPL should be taken into consideration.

c) The offerer of the TSPP be made aware of any changes in the lay-out. This will facilitate necessary revisions to his proposal.

5.9 RECOMMENDATION No.9

Further processing of pig iron -

It is recommended that :

a) The produced pig iron be carbonized and dephosphorized in a later stage.

b) An induction furnace be installed to carry out the processing of tapped liquid pig iron.

c) Establishment of a decarbonization step of the pig iron be investigated for the distant future.

d) The establishment of a foundry as a further step tobe investigated.

5.10 RECOMMENDATION NO.10

Elaboration of a detailed training programme -

It is recommended that :

a) A detailed training programme be prepared for the supervisory staff and skilled labour (including training requirements, timing, duration etc.).

b) A request be submitted to UNIDO to give assistance towards the preparation and arrangement of this training including the covering of one part of the training costs.

5.11 RECOMMENDATION NO.11

Preparation of maintenance works -

It is recommended that :

a) The supply (production and/or purchase) of spare parts after the first two years' period be prepared thoroughly.

The suggestions of the UN expert concerned with the plant maintenance should be incorporated in the new proposal.

b) The assistance of the engineering firm for the leading of the maintenance activity be requested as continuous technical support.

5.12 RECOMMENDATION NO.12

Co-ordination and supervision of the project schedule -

It is recommended that :

a) The most critical activities during different stages of implementation be high-lighted by the offerer (or engineering firm) to serve as guidlines for the regular review and periodic updating of the schedulé as required.

b) The project implementation management team be set up as soon as possible.

c) One or two members of the project implementation team be assigned and sent to the offerer's head quarters to commence the co-operation of the implementation activity.

5.13 RECOMMENDATION NO:13

Completion of equipment and review of fixed assets -

It is recommended that :

a) Decisions be made concerning :

- A casting machine,
- An induction furnace and
- An oxygen separator, etc.

A casting machine for casting of the pig iron, an induction furnace for treating of the molten pig iron and an oxygen separator to supply oxygen needed to the tapping of the slag.

b) The fixed assets be review after recommended steps have been taken.

A C K N O W L E D G E M E N T S

My thanks are due to the many persons who helped to prepare this technical report.

The necessary information was given by all people consulted in such an amicable way that it was always a pleasure to discuss various problems with anybody concerned.

Their friendly attitude and immense patience have made my work considerably easier.

The thanks are especially extended to :

Mr. F.B.P. de Silva	-	Chairman/Managing Director.
Mr. K. Tharmalingam	-	Production Engineer.
Mr. P. Kathirgamanathan	--	Accountant.
Mr. T. Sathasivam	-	Mining Engineer.
Mr. A.A. Paul	-	Chief Chemist.
Mr. B.C. de Mel	-	Assistant Engineer (Electrical).
Mr. K.G. Dias	-	Chief Clerk.
Mr. J.C. King	-	U.N. Expert from Australia.
Mr. K.L. Little	-	U.N. Expert from Australia.

for their help and guidance.

W. Harrach.

CHEMICAL ANALYSIS DATA OF C.M.S.C. ILMENITE CONCENTRATES *

	1960	1960	1960	1960	1962	1962	1963	1964	1970	1970/72	1975	1978 Tender	1980
TiO_2	52.02	53.60	53.60	53.45	53.21	53.11	54.46	53.60	54.11	51.33	53.99	53.21	54.39
Fe_2O_3	22.48	21.77	22.45	22.18	22.88	22.35	21.75	22.10	22.32	19.63	22.21	22.07	24.30
FeO	19.06	20.45	20.05	20.45	19.35	19.83	20.50	20.60	20.35	23.30	18.49	20.50	18.56
Total Iron (Fe)	30.53	31.01	31.16	31.28	31.02	31.02	31.03	31.35	31.31	31.70	29.79	31.26	31.32
ZrO_2	Nil	0.19	0.17	0.16	0.14	0.15		0.17	0.04	0.86	0.57		0.67
SiO_2	1.28	0.51	0.43	0.52	0.52	0.62	0.72	0.48	0.39	0.94	0.92	0.89	0.43
Cr_2O_3	0.10	0.093	0.089	0.091	0.08	0.08		0.09	0.07	0.10	0.097	0.10	0.05
MnO	0.76	0.94	0.92	0.93	0.71	0.79	0.92	0.93	0.81	0.89	0.79	0.90	
V_2O_5	0.26				0.25	0.25		0.18	0.08	0.20	0.188	0.20	
Al_2O_3	1.20	0.57	0.46	0.58	0.68	0.64		0.50	0.47	0.82	1.07	0.32	
MgO	1.02	1.38	1.36	1.46	0.91	0.91		1.40	1.28	0.77	0.51	0.72	
CaO	Tr.				0.41	0.38			Nil	0.3	0.15	0.10	
P	0.028	0.026	0.024	0.022	0.002	0.002	0.016	0.03	0.01	0.02	0.017		
S	Tr.	0.016	0.016	0.016	0.03	0.01		0.02	Tr.	0.04	0.004		
Total RE		Nil	Nil	Nil					Nil		0.053		
Others											0.873		

Zaporoshye

* The analytical work was carried out by different domestic and foreign institutes.

C.M.S.C., Pulmoddai.
06/05/80.
-/lm.

APPENDIX NO. 1

TONG CONG TY XUAT NHAP KHAU
KHOANG SAN

MINEXPORT HANOI

HONGGAI ANTHRACITE COAL
SPECIFICATIONS

GRADES	SIZES	TOLERANCE	CALORIFIC VALUE	MOISTURE	ASH	VOLATILE MATTER	SULPHUR
HONG-GAI ANTHRACITE COAL			KCal/kg	(Basic)			(Maximum)
No. 1A	+50 mm	30% under 50 mm	8300-8100	4%	3-5%	5-7%	0,5%
3	35/50 mm	25% under 35 mm	8300-8000	4%	3-5%	5-7%	0,5%
4	15/35 mm	20% under 15 mm	8200-7900	5%	4-6%	5-7%	0,5%
5	6/18 mm	20% under 6 mm	8100-7900	5%	5-7%	5-7%	0,5%
6	0/10 mm		8000/7800	8%	6-8%	6-8%	0,5%
7	0/10 mm		7800-7600	8%	8-10%	6-8%	0,5%
8	0/10 mm		7600-7200	8%	10-15%	6-8%	0,5%
9	0/10 mm		7200-6500	8%	15-22%	6-8%	0,5%
10	0/10 mm		6500-5500	8%	22-32%	6-8%	0,5%
11	0/10 mm		5500-4600	8%	32-40%	6-8%	0,5%

APPENDIX No: 2.

APPENDIX NO. 3

SHORT DESCRIPTION OF O_2 TYPE AIR SEPARATOR.

Out put : 99.5% by Vol. O_2	Nm^3/h	50	60
97 % by Vol. N_2	Nm^3/h	220	268
Built-in electric power	kW	140	150
Effective power consumption	kW	75	87
Specific energy consumption (Bottled at 150 Kgf/cm^2 pressure)	$kWh/Nm^3 O_2$	1,7	1,65
Cooling water consumption at 15° inlet temperature	m^3/h	4	4,8
Labour demand	per shift	3	3
Operation pressure when cooling	Kgf/cm^2	40	40
Pressure in steady-state operation	Kgf/cm^2	20-25	20-25
Starting time after heating up	Hours	[illegible]-10	[illegible]-10
Heating up time	Hours	12	1[illegible]
Floor space of plant building	m^2	180	180
Inside height (Plant building) Bottling shop	m	518	518

The equipment works by the double rectification without using a pressure expansion engine.

The main devices making part of the equipment are :

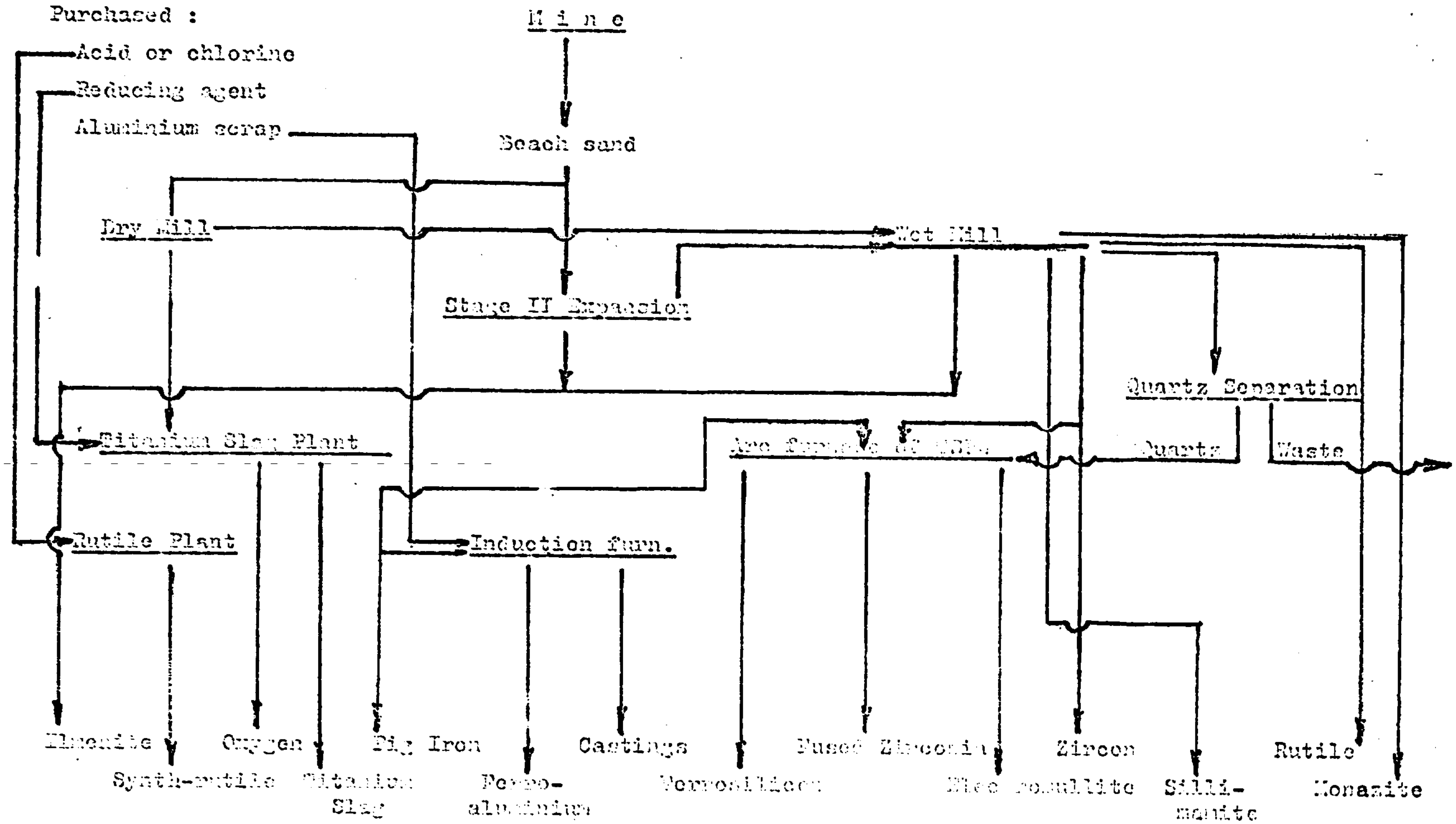
1. Air filter
2. Three stage air compressor
3. Spray catcher
4. Air filter
5. Electric heater
6. Separator equipment
7. Expansion engine
8. Oxygen reservoir
9. Distilled water reservoir
10. Oxygen compressor
11. Spray catcher
12. Oxygen filling station (if needed)
13. Water distillation equipment.
14. Distilled-water hand pump.

COMPOSITION OF PIG IRON TYPES - Wt %

X = not indicated.

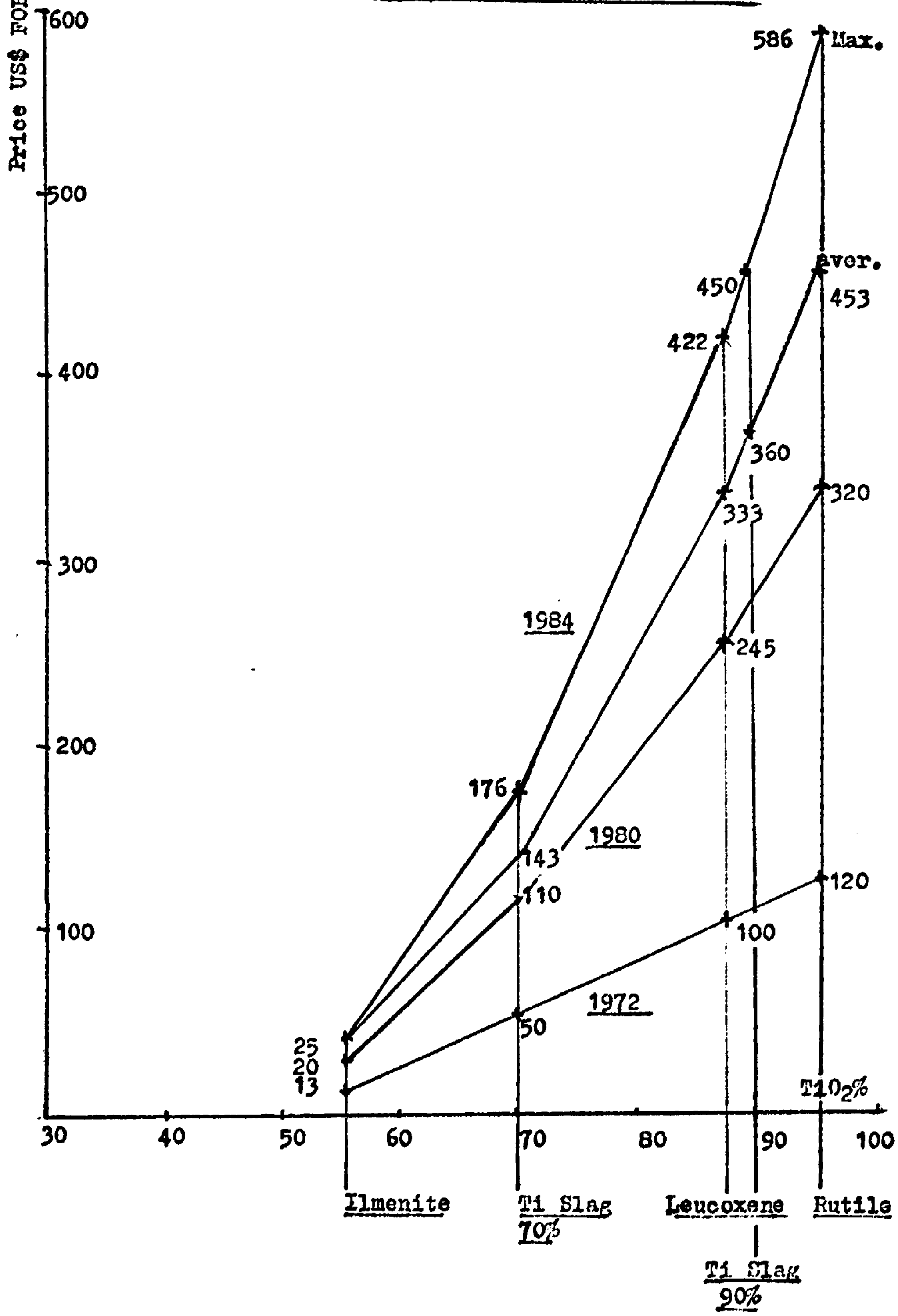
	C	Si	Ti	Mn	Ni	Cr	V	P	S	Cu	Nb	Zr			TiO_2	Na_2O	Al_2O_3	Remarks
Sorel F1	4.30	0,18	X	0,009	X	X	X	0,027	0,006	X								Specially treated.
Sorel F2	3.95	0,18	X	0,009	X	X	X	0,027	0,020	X								- do -
Sorel D1	2.85	0,18	X	0,009	X	X	X	0,027	0,020	X								- do -
Sorel S110	4.10	1.05	X	0,009	X	X	X	0,027	0,010	X								- do -
C S I R O	2.8	0.3-1.8	X	0,3-11	X	0.1	X	X	0.03-0.15	X								Experimental Product from W.Australian Ilmenite.
Albany Met.Res. Centre	0.29-3.68	X	0.007-0.02	0.029	X	X	0.06-0.1	0.15-0.43	0.004-0.11	0.052								Experimental Products from pre-reduced concentrates without treatment.
- do -	0.01-2.8	X	0.007-0.019	0.05	0.004-0.13	X	0,000-0.33	0.04-0.55	0.007-0.19	<0.078								After dephosphorization & scrap and/or ferroalloys feeding.
Titanium Institute Saporoshie	2.3-2.73	0.038-0.15	0.010-0.1	0.03-0.06	0.15-0.16	0.024-0.063	0.008-0.04	0.059-0.25	0.006-0.135	X								Experimental product from Sri Lankian Ilmenite concentrate.
US Bureau of Mines, Reno	X	X	X	0.1	X	0.[illegible]	0.1	0.02	0.01	0.03	0.007	0.01	X	X	0.02	0.01	4.[illegible]	Byproduct of a soda ash slag smelting process Experimental product without special treatment.
Expected Pig Iron (CHR)	2.50	0.15	0.04	0.05	X	0.05	0.03	0.14	0.02	X								
- do - (SR)	2.50	0.05	0.03	0.04	X	0.05	0.02	0.14	0.02	X								- do -

FLOW SHEET AND PRODUCT LIST OF C.M.S.C. IN THE FUTURE



APPENDIX No. 5

The Price Trend of Titanoferous Materials



Appendix No.7

The Production of Fused Zirconia.

Fused zirconia is used to produce high grade refractories. It is produced by melting of chemical grade zirconia or baddelayite in the electric arc furnace.

A lower grade fused zirconia can be obtained by reduction melting of zircon with a reducing agent and iron. About one third of the SiO_2 content of the fed zircon will be evaporised during the melting operation. The main use for fused zirconia is in the refractories for the glass and the steel industries.

To avoid the recrystallization from monoclinic to tetragonal structure, 3-5 per cent of lime or magnesia is added. In this way the crystal structure can be stabilized in a cubic form. The melting point of pure zirconia is 2973K (2200°C).

The main reactions of the process are :

$$ZrSiO_4 \rightarrow ZrO_2 + SiO_2$$

$$SiO_2 + Fe + 2C = Fe\,Si + 2CO$$

$$SiO_2 + 2C = Si + 2CO$$

The roughly estimated specific consumption figures are as follows:

Input	Zircon	1.5 t
	Fe borings, pigiron	0.4 t
	Coke (charcoal)	1.4 t
	Graphite electrodes	0.03 t to 0.05 t
	Power	5.5 MWh to 6 MWh
Output	Fused zirconia	1.0 t
	Ferrosilicon	0.5 t to 0.55 t

Appendix No. 8

C. M. S. C. Development Programme and the Country's Steel Industry

According to a statement of Prof. P.A. de Silva, Chairman, Ceylon Steel Corporation, in the 'Ceylon Daily News' on 15th May, 1980, the new iron billet manufacturing plant, 'built with aid from the Soviet Union, would need 60,000 tons per year of scrap once it reaches full production. Making allowance for the time needed for attaining full production and the scrap that would be added to the stock in the future, the scrap available locally would last only two-and-a half years'.

'We need a small plant preferably with an annual capacity of 100,000 tons. But the smallest steel plant available for sale has an annual capacity of 300,000 tons', Prof. Silva said.

At the same time C.M.S.C. exports 40,000 to 60,000 tons of ilmenite annually which contents 17,000 tons to 25,500 tons of iron oxides being equivalent to 12,000 tons to 18,800 tons of Fe metal.

The TSPL could cover a major part of the Steel Plants iron requirement without any particular measure to be undertaken by the Ceylon Steel Corporation. TSPL could ensure 31,000 tons of pig iron annually. This quantity can be increased by about 10 - 15 per cent if it is necessary and an adequate price has been agreed. Such a solution would save foreign currency worth US$ 5.6 to 6.00 millions, for the Fe metal and additionally the transportation cost of this quantity without any particular investment cost on the Ceylon Steel Corporation's part.

The TSPL could also solve the ferrosilicon supply of the steel industry in the distant future.