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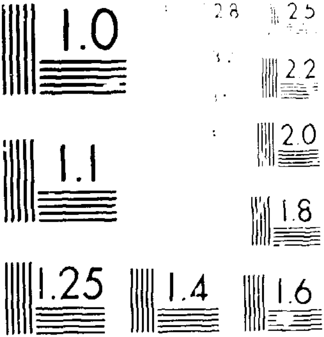
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FACILITIES AVAILABLE AND ACTIVITIES OF THE DEMONSTRATION PLANT FOR THE PRODUCTION OF SPONGE IRON, KOTHAGUDEM, ANDHRA PRADESH, INDIA *

by

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and

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SUMMARY

A Demonstration Plant for production of Sponge Iron has been established by Sponge Iron India Limited (SIIL) at Paloncha, near Kothagudem in Khammam District of Andhra Pradesh with UNDP/UNIDO assistance. The plant is intended to test various combinations of iron ores and coals occurring in India to establish the techno-economic feasibility of producing sponge iron from lump iron ore and non-coking coal. The plant has an adjunct a well equipped laboratory for carrying out bench scale test work.

This plant based on the SL/RN process of Lurgi was constructed by SIIL Engineers under the supervision of Lurgi. SIIL have also received documentation which would facilitate setting up of

identical plants elsewhere in the Country. The SIIL Plant is well equipped to render assistance in carrying out feasibility studies on raw materials, erection, commissioning and optimisation of future sponge iron plants. It has also facilities to impart training for the operating crew of sponge iron plants. Recognising these facilities, UNIDO have registered SIIL as a consultancy organisation in this field.

1.0 BACK GROUND

1.1 The Indian Steel Industry has an installed capacity of 15.62[1] million tonnes of which 11.40[2] million tonnes is in integrated steel plants which smelt iron ore using metallurgical coke and the hot metal thus obtained is refined into steel in basic oxygen or open hearth furnaces. The remaining capacity is available in electric arc furnaces which recycle arisings of ferrous scrap and produce steel ingots/ billets which provide the feed material for a number of small rolling mills.

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1 Proceedings on Electric Steel making - A strategy for development and future growth - The Indian Institute of Metals (Delhi Chapter) - Page 20.

2 Proceedings on Electric Steel Making - A strategy for development and future growth - The Indian Institute of Metals (Delhi Chapter) - Page 20.

1.2 The Country has over 20,000[3] million tonnes of iron ore reserves, whereas the reserves of prime metallurgical coking coal from which coke is produced are limited to only to 5,000[4] million tonnes. Further, the avilable coking coal is of high ash contributing to lowered productivity of the blast furnaces. From present indications, the available coking coal reserves are estimated to sustain production for about 40 years only.[5] In recent times, the Country has started imports of coking coal to a limited extent for blending with domestic coal and thereby limit ash content.

1.3 The Electric Arc Furnaces have also not been operated to full capacity due to

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3 Project Document of Demonstration Plant for the production of sponge iron, Kothagudem, Andhra Pradesh.

4. Project Document of Demonstration Plant for the production of sponge iron, Kothagudem, Andhra Pradesh - Page III - 1.

5. The Economic Times dt 15.6.1980.

constraints in the availability of power and ferrous scrap. The capacity utilisation of the Electric Arc Furnace Industry is furnished in the table below:

Table

Region	No. of Mini steel Plants licenced	Installed Capacity[5]	Actual Production in 78-79[6]
Eastern	46	983,700	450,310
Northern	54	1,230,000	609,330
Western	65	1,348,000	538,900
Southern	29	663,300	343,540
	194	4,224,000	1,942,080

2.0 NEED FOR DEVELOPMENT OF SPONGE IRON PRODUCTION CAPACITY

2.1 With the recent investments made in the power sector and the improvement already recorded in the availability of power, it is anticipated that lack of electrical

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5 Steel Furnace Monthly - February 1980 - Page 56

6 Proceedings on Electric steel making - A strategy for development and future growth - The Indian Institute of Metals (Delhi Chapter) - Page 66.

energy may no longer be an impediment for fuller utilisation of electric furnace capacity. As such, providing a dependable feed material to the electric arc furnaces was accorded a high priority by the Government of India. Sponge Iron which is a product of the Direct Reduction of iron ore into metallic state has been established as a substitute for ferrous scrap. However, of the commercial production capacity of 22.86[7] million tonnes existing in the world today for production of Sponge Iron, the bulk is based on iron ore pellets and natural gas. India has a small capacity for production of iron ore pellets which is completely earmarked for export. The natural gas reserves available have so far been committed to other critical industrial needs and it seems unlikely, on present indications, that large quantities

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7 Skillings' Mining Review, January 3, 1981; Vol 70 No. 1 Page - 12

of natural gas will be available for production of sponge iron.

2.2 The Country has reserves of 65,000[8] million tonnes of non-coking coal and even on global basis, the availability of non-coking coal far exceeds that of natural gas and other petroleum based fuels, as can be seen from the table below:

Table

ENERGY RESOURCES IN THE WORLD & INDIA[9]

Energy Source	Unit	World Reserve	India reserve
Coal Lignite	10^5 K cals	58,000	467.3
Oil	"	730	1.7
Natural Gas	"	410	0.8
Hydro Power	Million K.W.	-	25

2.3 Government of India, therefore, considered it expedient to develop capacity in the country for production of sponge iron using lump iron ore and non-coking coal,

8 CMAI Monthly News Letter Vol. X, May, 1981 No. 2 Page - 20

9 Transactions of the Indian Institute of Metals Vol. 31, No. 2, April, 1978 Page - 133

so that sponge iron could supplement the raw material requirements of the electric arc furnaces and provide an alternative steelmaking route which does not depend on scarce metallurgical coal. Further, the sponge iron - electric arc furnace route has the following additional advantages:

(i) Lower investment in comparison to the Blast Furnace - Basic Oxygen Furnace route.

(ii) Permits smaller incremental growth of steelmaking capacity.

(iii) Enables dispersal of steel industry so that small capacities can be created close to raw material sources to cater to regional demands.

(iv) Plants have a shorter gestation period.

(v) Makes available feed material of consistent quality to the arc furnaces and insulates them from the vagaries of scrap market.

3.0 ASSOCIATION OF UNDP/UNIDO

3.1 While the production of sponge iron from natural gas is now an established practice consistituting about 85% of the total installed capacity all over the world, in contrast processes using non-coking coal have not made much head-way. These processes use Rotary Kiln as the main equipment, the Rotary Kiln representing a well understood technology, being mechanically reliable and well suited for continuous processing. Nearly 4[10] million tonne capacity based on Rotary Kilns has been set up during the last 15 years in different parts of the world. Of these plants, some have closed down due to technological problems and economic reasons. However, in recent times, the technology using non-coking coal has gained some ground as the earlier problems on account of process and equipment have been overcome

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10 Transactions of Iron & Steel Institute of Japan Vol. 21, 1981, - Page - 90.

through careful selection of raw materials and better designed equipment. Yet a break-through in this field could not be achieved due to the following reasons:

(i) The process is sensitive to the characteristics of raw materials used.

(ii) Detailed test work and process adjustments are essential before reliable commercial scale operations can be achieved.

(iii) Process success with one set of raw materials does not automatically ensure success with a different set of raw materials.

3.2 When Government of India approached UNDP for assistance in developing a technology for production of sponge iron from non-coking coal, the above considerations and constraints of the rotary kiln processes were taken due note of by UNIDO, who deputed a Mission of Dr. Nijhawan and Mr. Miller to study the scheme. UNDP endorsed the recommendations of the team that in the first instance a Demonstration Sponge Iron Plant of 100 tonnes per day capacity be set up to establish the techno-economic feasibility of producing sponge iron from lump iron ore and non-coking coal. The immediate objectives for such a plant were set out as follows:

(i) To demonstrate the technical and economic feasibility on a semi-commercial basis of producing sponge iron by a direct reduction process using iron ore and non-coking coal available in Andhra Pradesh in India.

(ii) Thereby to supplement local supplies of iron and steel scrap and make possible an increase in local steel production.

(iii) To carry out semi-commercial scale tests to determine the feasibility of producing sponge iron from materials drawn from other localities in India.

(iv) To develop sponge iron production technology appropriate to the raw materials available at various regions in India.

3.3 Government of India accepted the recommendations of UNDP/UNIDO and decided upon setting up such a plant near Kothagudem in the Singareni Collieries region of Andhra Pradesh which produces about 10[11] million tonnes of non-coking coal per year. It was decided that the plant would be set up by Sponge Iron India Limited (SIIL), a Joint Undertaking of the Government of India and the Government of Andhra Pradesh. Govt. of India decided to implement the project on the cost sharing principle whereby they would provide the balance foreign exchange cost after accounting for the UNDP contribution as well as the rupee cost of the project. The various technology options available were considered

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11 Deccan Chronicle. Dt. 12.5.1980

and it was decided to adopt the SL/RN process of Lurgi Chemie (Lurgi) as this process envisages use of 100% non-coking coal and a contract was awarded by UNIDO in November 1977 to Lurgi for the equipment, engineering and personnel services needed for the plant.

3.4 Before taking up the engineering design, extensive tests were carried out on the raw materials at the National Metallurgical Laboratory, Jamshedpur and also at the Plant Laboratory at Paloncha. This was followed by bulk tests conducted at the Lurgi Test Centre in Frankfurt Main, FRG. The results were carefully evaluated before deciding upon the parameters for the design and operation of the plant.

3.5 SIIL selected M.N.Dastur & Company as consultants for the Engineering and inter-phasing of Indian equipment, building and structural designs.

4.0 **PROJECT IMPLEMENTATION:**

4.1 Major civil construction at the Site started in June, 1978 and the erection was completed by March, 1980. The trial runs of the Plant commenced immediately thereafter when it emerged that certain modifications are required in the equipment supplied by Lurgi. This was attended to and the plant commenced regular manufacture from 1.11.80 and was formally inaugurated by the Vice-President of India on 31.12.1980.

4.2 As an adjunct to the Reduction Plant, UNIDO assisted in establishing a well equipped laboratory for testing of raw materials to establish their suitability for sponge iron production, for process control and for testing the quality of the product. Taking note of the facilities available in the laboratory and at the demonstration plant, UNIDO have recognised SIIL as a Consultancy Organisation in the field of Direct Reduction.

5.0 REVIEW OF THE OPERATIONS SO FAR

5.1 SIIL Sponge - Very stable and high quality product:

During the last twelve months over 25,000 tonnes of high quality Sponge Iron produced at this plant has been used by Electric Arc Furnaces at Hyderabad, Bombay, Madras and Nagpur with very satisfactory results. Sponge Iron, a substitute material for scrap used in Electric Arc Furnaces is a highly metallised form of iron ore, i.e., the iron oxide in ore is converted to metallic iron at temperatures well below the molten state of iron. SIIL sponge iron is extremely stable and can be stored with minimal precaution in stacks of average height of 1 metre. All that is required is a roof prevent rain water from getting in. Experiments conducted at the plant revealed that the drop in metallisation in a 1,000 ton pile is not more than 0.5 per cent in a month. Some rail wagons carrying the material encountered a cyclonic storm close to Madras and even though the wagons had a tarpaulin cover some water leaked through. About 10 days later when analysed it was found that only 5% of the total consignment of about 250 tonnes suffered a drop in metallisation of about 4%.

5.2 Melting trials with SIIL sponge:

When the Plant began making sponge iron, the product was introduced into the market according to a carefully planned out programme. First, experimental melting trials were conducted in a 3 tonne furnace in the steel foundry of Singareni Collieries Company Limited with varying proportions of sponge iron in the charge from 5 to 30%. This was followed by trials in a 5 tonne furnace at Padmavathy Steel Melters, Rajahmundry. This plant produces billet size ingots for rolling into bars and rods. In this furnace proportions of sponge iron upto 85% of the charge are being used. In the operation of the furnace, sponge iron amounting to 60% of the charge is first spread over the bottom of the furnace upto the charging door level. Contrary to normal practice arcing is initiated directly on the bed of the sponge iron and as melting starts, the remaining sponge iron is continuously shovelled into the molten bath through the door. This plant has reported that the melting behaviour of sponge iron is excellent and so is the quality of bars rolled from billet sized ingots. To evaluate the results on bigger furnaces having continuous casting facilities and also see the effect on production of special quality steels, melting trials were conducted at Tamil Nadu Steels, Arakkonam; Zenith Steels, Bombay; Poddar Steels, Hyderabad and A.P. Steels next door. In these furnaces proportions upto 25% of the charge were tried. A summary of these results is shown at Annexure.

5.2.1 A.P.Steels, where between 700-900 tonnes of sponge iron is consumed on a regular basis every month, had the advantage of closer monitoring of operations by SIIL and our computer analysis reveals that there has been an increase of 10% in the over all productivity. Even though there have been marginal increases in the consumption of electrical energy (about 30 KWH per tonne) and Limestone 15 to 20 kg per tonne with a drop in yield by about 1 to 2%, the increase in the productivity arising from the lesser number of batch charges as also the density of the charge, low sulphur and phosphorous levels resulting in better quality have more than off-set the disadvantages mentioned.

5.3 Batch charging technique:

All the furnaces have used the intermittent or the batch charging technique. In the batch charging technique, a mixture of Scrap and Sponge Iron is carefully loaded into the bucket. Charge preparation consists in taking required proportion of sponge iron and distributing the material within scrap in the charging bucuket in sandwiched layers of Heavy Melting Scrap, Sponge Iron and Commercial Scrap. The sandwiched layer helps in uniform distribution and minimises/avoids sticking problem in furnace. After careful charge preparation. the material is charged in the first charge, followed by a second charge. Normally, it would be possible to complete entire charging of sponge iron and scrap in 2 to 3 charges.

5.4 Continuous Charging:

The above preparation ensures that Sponge Iron goes into the pool of liquid metal and gets rapidly melted. Otherwise, sponge iron being of the same density as slag, it tends either to float on the metal when it will be carried away in the slag or stick to the walls of the furnaces. To derive, however, the best advantages from the use of sponge iron, it is to be fed from an overhead bin on top of the furnace through a hole in the furnace roof into the bath. In this method, the furnace is filled with light scrap and after the electrode bores a hole through the charge and a pool of liquid metal is formed, the feeding of sponge iron starts. Melting and refining take place simultaneously the slag being flushed continuously. This contributes to a reduced tap-to-tap time. Our own estimates suggest that upto an hour's saving could be obtained for every heat. As the sponge iron is of known chemistry, it is possible to keep tramp elements low, which is an advantage to continuous casters.

5.5 <u>Charging System developed by SIIL:</u>

With the assistance of UNIDO, a simple and inexpensive continuous feeding system, which is within the reach of most of the Ministeel Plants in India has been developed by SIIL. Due, however, to practical limitations, continuous charging system is not suitable for furnaces smaller than 10 tonnes. For the smaller fixed roof furnaces, continuous shovelling through the door as practised by Padmavathy Steel Melters is recommended. Through continuous charging, sponge iron could be used upto 50% of the charge weight.

5.6 SIIL is equipped with the largest laboratory and testing facilities available in a Direct Reduction Plant anywhere in the world backed by Engineers and Metallurgists who have had experience in production of sponge iron, melting of steel in Electric Arc Furnaces, continuous casting and rolling. When the first supply is made of SIIL Sponge Iron, Metallurgists are outposted at the user's plant to assist in charge preparation, develop an operating sequence so that the proportion of sponge iron in the feed is adjusted to achieve optimum results. The operational data is analysed to ensure that the Steel Plants can deal with further operations on their own. Test checks, if required, are carried out at the SIIL laboratory. Thereafter, a continuous customer liaison is maintained so that technical information is exchanged. This is a free service being provided with the view of establishing satisfactory use of sponge iron. Every consignment of sponge iron despatched from the plant is accompanied by a Test Certificate covering the following:

(i) Metallisation is the ratio of metallic iron to total iron present in sponge iron and indicates percentage of metallic iron present in the product.

(ii) Total Iron is a combination of metallic iron and iron oxide in the form of FeO (wustite) and the value helps to estimate free iron oxide and consequent necessary carbon adjustment required for converting FeO into metallic iron while melting in electric arc furnace.

(iii) Sulphur Content.

5.6.1 Through a process adjustment made recently, we have been able to supply sponge iron having 0.3 to 0.5 Carbon in the product. Such a product when melted behaves as if it were having an additional 2 to 3% metallisation i.e., if the product supplied by us is 90% metallisation with 0.4% Carbon it has in effect an equivalent metallisation between 92.0% and 92.5%. Being from lump ore our product has a size range of 6-15mm. Due to handling it may generate about 20% of a fraction having a size range of 1-6mm. Thus compared with sponge iron made from pellets it would seem that the SIIL sponge iron has a lot of fine material. However, there is no difficulty in handling and melting of this material if the charge is carefully prepared.

5.6.2 The success of the plant is, in the main, due to the considerable amount of test work carried out on the raw materials prior to engineering. This has helped in assessing correctly the behaviour of raw materials and the plant could be designed adequately. As the process is very sensitive to the characteristics of raw materials such testing is essential before engineering and design parameters are finalised.

5.6.3 The operating crew were selected during the construction stage itself and were fully associated in the construction and erection of the plant. In addition, selected engineers and technicians were sent abroad for training in the operation and maintenance of the plant as a result of which the " learning period " after start-up was kept to the absolute minimum.

5.6.4 Right from the beginning of the plant operations a system was developed for carefully logging the operations using the computer facility available at the plant. The computer analyses has enabled the engineers to make process adjustments to adapt and optimise the technology to local conditions. It has therefore been possible to operate the plant on a sustained basis at high levels of capacity utilisation.

5.6.5 A close and conscious effort is directed at continuously improving the operating and maintenance practices. This is necessary as replacement parts are not always readily available and due care has to be taken to avoid costly and expensive plant stoppages.

6.0 SERVICES THAT CAN BE MADE AVAILABLE BY SIIL

6.1 With the experience gained in the setting up and operation of the Demonstration Sponge Iron Plant,(SIIL) is in a position to offer the following services for future coal based Sponge Iron Plants:

(i) Laboratory Scale Tests
Detailed tests can be carried out on the raw material proposed to be used, to establish their compatibility for production of sponge iron. On the basis of these tests, feasibility of setting up a commercial plant with any set of raw materials can be determined.

(ii) <u>Pilot and Demonstration Scale Tests:</u>

After selection of raw materials, further tests can be carried out on bulk quantities of raw materials to establish the engineering and process parameters for commercial plants.

(iii) <u>Training:</u>

Theoretical and practical training can be imparted to the operating crew in operation, maintenance and quality control aspects.

(iv) <u>Supervision, Erection and Start-up</u>

Assistance can be provided for supervising erection of equipment, trial runs and commissioning of the plant. After the plant is run in, a programme of continued assistance could be worked out for optimising the plant operations.

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ANNEXURE

SUMMARY OF RESULTS OF MELTING PERFORMANCE

Description	A.P.Steels	Poddar Steels	Zenith Steels	Tamil Nadu Steels	Padmavathy Steel Melters
i) Proportion of Sponge Iron used	10 to 20%	10 to 30%	10 to 25%	10 to 25%	30 to 85%
ii) Type of Charging	Batch Charging	Batch Charging & shoveling of material	Batch Charging	Batch Charging	Shovelling of material simulating continuous charging conditions
iii) Melting Behaviour	Good with tendency for sticking	Very good	Good	Good with tendency for sticking	Excellent
iv) Liquid metal yield (%)	89.0 (1% to 2% less than with 100% scrap)	87.0 (1% less than with 100% scrap)	89 (1% to 2% less than with 100% scrap)	88.0 (2% less than with 100% scrap)	87.0 (1% less than with 100% scrap)
v) Power consumption	Marginal increase of 30KWH when 20% proportion used.	Marginal increase of 10 to 30 KWH	30 KWH increase.	Same as 100% scrap with marginal increase in a few heats	20 KWH increase when higher proportions are used
vi) Electrode Consumption	Almost same with marginal increase	Same as with 100% scrap	Same as with 100% scrap	Same as with 100% scrap	Same as with 100% scrap

SUMMARY OF RESULTS OF MELTING PERFCRMANDE (Continued)

vii)	Slag volume	10% increase	10 to 15% increase	15% increase	15% increase	15 to 50% increase
viii)	Lime consumption	-do-	-do-	-do-	-do-	-do-
ix)	Réfractories	Same with bank cutting in a few heats	Same with bank cutting in a few heats.	Same with bank cutting in a few heats	Same with bank cutting in a few heats.	Same with bank cutting in a few heats.
x)	Heat Time	15 to 20 mts. saving	20 to 25 mts. saving.	No change.	No change.	30 to 40 mts. saving.
xi)	Product Quality	Sulphur and Phosphorous in Steel lowered below 0.035 level	Sulphur and Phosphorous below 0.04 level and ingot quality better.	1) Same as with 100% scrap. Possible to produce quality steels En 31, En 44, En 45A. (2) Tramp element levels were low.	i) Sulphur and phosphorous levels lowered and sulphur control easier. (ii) Carbon opens low and needs adjustment.	Sulphur level below 0.03 in some heats and ingot quality excellent with 10% improvement in productivity