EXECUTIVE SUMMARY

0.1.0 INTRODUCTION

0.1.1 History

Arc type furnaces had their beginning in the discovery of the carbon arc by Sir Hymphrey Davy in the U.S. in 1800, but their practical application began (also in the U.S.) with the work of Sir William Siemens, who was the first man to melt steel with electric current in 1878-79.

At this early date, the availability of electric power was limited and also the quality of carbon electrodes required to carry sufficient current for steel melting had not been developed. Thus the development of electric melting furnace awaited the expansion of the electric power industry and improvement of carbon electrodes.

Three main types of Electric Arc Furnaces were tried during the mid-eighties of the 19th century.

— Direct arc type
— Indirect arc type
— Core-less induction type

Of the three types of furnaces, the most widely used is the direct are furnace which is used to make all grades of steel.

0.1.2 Share of Electric Arc Process in the world of Production

The present world crude steel production is about 740 million tons and the share of the Electric Arc Furnace in it is approx. 30%, which is expected to rise to about 40% by the year 2000.

0.1.3 Share of Electric Arc Process in total production in India

In India, presently (1993-94), the Electric Arc Furnace steel share of the total finished steel production is about 14.1%. The rest of the steel comes from Integrated Steel Plants (LD converter and open hearth route) and Induction Furnaces.

0.1.4 Finished Products of Electric Arc Furnace

The Electric Arc Furnaces are used to melt steel scrap, sponge iron and pig iron to produce liquid steel which is subsequently refined by various secondary metallurgical processes equipment such as the Ladle Furnace, VD/VOD etc. and then solidified into shapes such as ingots, billets, blooms, slabs or castings. The most advanced and popular method of converting liquid steel into semi-finished products (excepting castings) is the method of continuous casting.

0.2.0 STRUCTURE OF INDIAN ELECTRIC ARC FURNACE INDUSTRY

0.2.1 Production & Capacity Utilisation

The production from the EAF Industry in the form of ingots, billets, flats, slabs and castings in the year 1993-94 was about 2.5 million tons, against an installed capacity of about 7.65 million tons.

The percentage utilisation has gradually fallen from about 70% in the mid-eighties to less than 33% in 1993-94. The average capacity utilisation from 1986-1987 to 1993-94 was about 53.6% which cannot be seen as remarkable. The factors perennially plaguing the EAF Industry were scarcity and high cost of power, high cost and duty of imported scrap and inefficient operation. The reasons that brought the capacity utilisation levels still lower to 40% in the recent past, were still higher cost of raw materials, i.e. scrap and sponge iron, (with the imported scrap price rising, the sponge iron industry also increases it's prices), low demand of both mild steel and alloy steels due to an over-all economic scenario and cheaper imports of finished steel due to lower custom duties.

The current situation is that out of approximately 175 units, as many as 100 units have been closed down in the last two or three years due to the reasons quoted above.

0.2.2 Competition with Induction Furnaces

The growth of the EAF industry has been adversely affected by the mushrooming of Induction Furnaces in India and this trend is expected to continue. This has contributed to the lowering of the steel making quality used for rolling. World wide, there are only a handful of Induction Furnaces which make ordinary steel for rebars and invariably these re-bars have to be sold as sub-standard material at much lower prices. However, the Induction Furnaces in India have taken to using HBI/DRI to the extent of 70% which improves their quality slightly in terms of controlling phosphorous and sulphur within acceptable limits for ordinary structural steel. Some of the bigger Induction Furnace units are in the process of installing Ladle Furnaces as a part-refining and heating equipment, coupled with Continuous Casting Machines.

Because of its slightly lower direct production cost and installed cost per ton (leading to lower financial cost per ton of steel produced) and the fact that low capacities with smaller investments are affordable by smaller entrepreneurs, Induction Furnaces have grown and are still growing in numbers. However, in the near future, their survival in the face of competition with Integrated Steel Plants based on mini and normal size Blast Furnaces producing Rebars and small-medium structurals of high quality might not be as easy. A fact should always be remembered, that because of the inherent problems, an induction furnace is not suitable for making low carbon unalloyed quality steel.

0.2.3 Special & Alloy Steel Production by EAF Units

Most of the running EAF units are producing value added products through secondary facilities and their own rolling mills or installing or planning these facilities to produce value added products. There is very little production of mild steel for rebars and structurals as it is not remunerative these days.

0.2.4 Long Term Demand and Availability of Finished Steel

The EAF industry is a part of the total steel industry which also includes the Integrated Steel Plants of SAIL, RINL and TISCO and the Induction Furnace Industry. They share common end products, and as such the demand projections cannot be worked out separately for different sectors. To assess the gap between demand and availability, therefore, the total demand of finished steel and the overall production of finished steel is considered. Recently, the Steel Ministry projected the finished steel demand for the year 2000-2001 as 37 million tons (31 million tons home demand and 6 million tons for exports). This, according to the Steel Ministry, is a conservative estimate of GDP growth and does not take into account any major jump in economic activities.

The availability of finished steel production on all India basis by the year 2000-2001 has been worked out taking into consideration:

— production reached after implementing the expansion and modernisation plans by 2000-2001 of SAIL, RINL and TISCO Plants totalling about 15.01 million tons (95% of 15.85 mt installed capacity, 14.22 mt of finished steel, plus 1.75 mt of semis)

— production from plants of Essar Gujarat, Jindal Strips, Malvika Steels, Nippon Denro, Rajinder Steels II, Mid-East, Bhushans and NECO being implemented (all except Essar Gujarat and Nippon Denro are through the Blast Furnace Route, Jindals are going through Corex) totalling approx. 8 million tons (95% of 8.4 mt installed capacity).

— present production of about 3 million tons from the EAF units (it is expected that a few more EAF's will close down but the present production is assumed. This is because it is expected that a few present EAF units lying closed will be converted to casting units and with the overall improvement in power availability, the utilisation of the EAF units will increase) plus another 1.9 million tons liquid steel from the Electric Arc Furnace Plants being implemented given in Table-B (except Essar and Nippon which are considered above) on the basis of an average of 14 heats per day and 300 net working days.

— production from the Induction Furnaces of about 2 million tons (1993-94 estimate) with the addition of another 2 million tons of Ingot Steel by 2000-2001.

— present availability from the ship breaking industry of about 0.8 million tons increasing to about 1.6 million tons by 2000-2001 (about 65% of 1.6 million tons will be re-rollable, the rest will be melting scrap).

The overall availability, therefore, considering finished steel, works out to about 32.65 million tons. This leaves us with a gap of about 4.35 million tons to be filled by 2000-2001, considering the 37 mt projected demand. The present trend indicates that the route adopted to fill this gap will be Corex and Blast Furnace.

The import of finished steel in the year 1992-93 was 1.11 million tonne and in the year 1993-94, 0.98 million tons. It is expected that the imports will gradually decrease and only some special and high alloy grades will be imported in the coming years.

Out of the over-all production of finished steel in 1992-93 of 17.84 million tons, about 1 million tons was exported and in 1993-94 out of an over all production of 17.68 millions tons about 2 million tons were exported. It is expected that in the near future, the over all production, exports and the domestic consumption will rise at a high rate.

0.2.5 Major Electric Arc Furnace Units incorporating modern technologies installed in the recent past and being installed

The major UHP-EBT type EAF units incorporating modern technologies that have been installed in the recent past have been listed in Table 0.1. Brief information about these units is also given here.

TABLE 0.1

MAJOR EAF UNITS INCORPORATING MODERN TECHNOLOGIES INSTALLED IN THE RECENT PAST

S. No.	Name	Location	Capacity/ dia of EAF & Make	Trans-former rating	Type of secon-dary Refining	Present Status
1.	Sunflag Iron & Steel Co.	Bhandra Mahara-shtra	50T/4.8 M dia of	40 MVA	LF	Working satisfa-ctorily
2.	Ispat Profiles Ltd.	Pune Mahara-shtra	50T/5.0 M dia of 'Danieli'	47 MVA	LF/VD-VOD	Not wor-king satisf-actorily
3.	Mukand Ltd.	Kalwe, Bombay	40T/4.6 M dia of HBB	36 MVA	LF/VD-VOD	Working satisfa-ctorily
4.	Shri Ishar Alloy Steel	Indore, M.P.	40T/4.3 M dia HBB	32 MVA	LF/ MRP	Working satisfa-ctorily
5.	Raipur Alloys & Steel Ltd.	Raipur M.P.	25T/3.7 M dia of HBB	18 MVA	LF	Working satisfa-ctorily
6.	Kesari Steels Ltd.	Dewas M.P.	25T/3.8 M dia 135 of GEC	25 MVA	LF	Lying closed
7.	Hindustan Development Corporation	Gwalior, M.P.	70T/5.5 M dia of Demag	70 MVA	LF VD/ VOD	Working satisfa-ctorily
8.	BHEL	Hardwar, U.P.	70T/5.2 M dia of HBB	48 MVA	VAD/ VOD	Recently commis-sioned for castings)
9.	East Coast	Pondi-cherry	25-T of ISPL	18 MVA	LF	Working satisfa-ctorily

Table 0.1 (Contd.)

S. No.	Name	Location	Capacity/ dia of EAF & Make	Trans-former rating	Type of secon-dary Refining	Present Status
10.	Nova Udyog	Haldwani U.P.	40T/4.6 M dia of GEC	36 MVA	LF	Lying closed
11.	Kusum Ingots	Indore, M.P.	30-T/4.2 M dia of GEC	20/24 NVA	LF/ MRP	Working satisfa-ctorily
12.	Marmagoa	Goa	25-T/4 M dia of GEC	18/21 MVA	LF —	Working unsatis-factorily
13.	ISSAL	Pune, Mahara-shtra	40-T/4.6 M dia of HBB	36 MVA	LF/VD/ VOD	Working satisfa-ctorily
14.	Bhushan Indstl. Co.	Chandigarh Punjab	30-T/4.1 M dia of GEC	12 MVA	LF	Working satisfa-ctorily
15.	Rathi Alloys	Alwar, Rajasthan	35-T/4.2 M dia of GEC	12 MVA	LF/VD/ VOD	Working satisfa-ctorily

The major UHP-EBT type EAF units that are being installed and that are expected to be commissioned by 1995-96 are listed below in Table-0.2. Brief information about these units is also furnished here.

TABLE 0.2

EAF PLANTS UNDER CONSTRUCTION

S. No.	Name	Location	Capacity dia of furnace & make	Trans-former rating	Type of secondary Refining
1.	Essar Gujarat	Hazira, Gujarat	150t, Clecim make (2 Nos. DC)	160 MVA	LF, VD
2.	Nippon Denro	Dolvi, Raigad (Mah.)	180t, twin shell, AC. Demag make (2 Nos.)	130 MVA	LF, VD
3.	Rajinder Steels	Raipur, M.P.	45t, 4.6m dia of ABB	36 MVA	LF, VD
4.	Mohta Alloys	Ludhiana, Punjab	30t, 4m of GEC	20 MVA	LF
5.	Somani	Kanpur, U.P.	50t, 4.8m dia of GEC	40 MVA	LF
6.	Lloyd Steels	Wardha, Maharashtra	50t, 4.8m dia of Demag (2 Nos.)	40 MVA	LF, VD
7.	Remi Metals	Baruch, Gujarat	30t, 3.8m dia of ISPL	24 MVA	LF,VD-VOD
8.	Aarti Steels	Ludhiana, Punjab	30t, 3.9m dia of ABB	18 MVA	LF
9.	Nova Steels	Bilaspur, M.P.	45t, 4.6m dia of ABB	36 MVA	LF

Table 0.2 (Contd.)

S. No.	Name	Location	Capacity dia of furnace & make	Trans-former rating	Type of secondary Refining
10.	Panchmahal	Baroda, Gujarat	45t, 4.6m dia of ABB	36 MVA	LF, VD-VOD CONV.
11.	Jindal Strips	Raigad, M.P.	60-t of 21st Century	30 MVA	LF
12.	Bellary	Bellary, AP	220-t of GEC	122 MVA	LF

It will be seen from Table-0.2 that the majority of the EAF's are of 45-50t capacity. The biggest capacity AC EAF presently in operation is of 70t at M.P. Iron & Steel Co., Malanpur, Gwalior. With the commissioning of 150T DC EAF of Essar Gujarat in April-May 1995, the Indian Electric Arc Furnace Industry has come of age in terms of capacity and technology. Nippon Denro's twin shell AC EAF's that are being installed are also of the latest concept/design.

0.2.6 Raw Material Availability

i) Sponge Iron

The present capacity of DRI in the country is 5.2 million tons. With the implementation of about 2 lakhs TPA of Lloyds and the second 1 lakh module of Monnet Ispat, DRI capacity in India will reach 5.5 million tons by 1996-97. Assuming 95% utilisation factor, the sponge iron availability would be 5.2 million tons by 1996-97. (The production in 1994-95 was 3.4 million tonnes).

It will be interesting to note that the Electric Arc Furnaces listed in Tables 0.1 and 0.2 (excluding Essar's & Nippon Denro's in item 2.4 have a total installed capacity of about 4.12 million tons liquid steel (excluding EAF of BHEL as it is a casting unit and will produce very little) on the basis of an average of 14 heats per day and 300 net working days. If we add another 1.0 million tonne liquid steel availability from the EAFs that will remain, and 4.46 million tonnes from the Essar's and Nippon Denro's EAF's on the basis of an average of 22 heats and 320 net working days, the total figure of the installed capacity would be about 9.58 million tons liquid steel.

Considering 60% usage of HBI/DRI of the total metallic charge and an 85% average yield from HBI/DRI to liquid steel, 30% usage of scrap with 92% yield and 10% use of Pig Iron/Cast Iron with 94% yield (0.680 t of HBI/DRI, 0.340 t of scrap and 0.116 t of Pig Iron/Cast Iron for 1 t of liquid steel) for all EAF units considered above except Essar's and Nippon Denro's, the total requirement of Sponge Iron would be about 3.5 million tons. For the liquid steel from Essar and Nippon Denro's EAF units based on an average of 50% DRI and 50% Hot Metal usage, the requirement of DRI comes to 2.45 mt (0.551 t of DRI based on 87% yield and 0.551 t of Hot Metal based on 94% yield for 1 ton of Liquid Steel). This excludes the DRI needed for the induction furnace industry, which for about 4.3 million tons liquid steel on the basis of 50% HBI/DRI and 50% Scrap will require another 2.4 million tons. (0.56 t DRI/HBI on the basis of 0.86 yield and 0.56 t scrap on the basis of 0.92 yield).

The requirement of DRI/HBI from EAF and IF units as worked out above comes to 8.35 mt.

The above does not include the requirement from the new Blast Furnace/Corex based Integrated Steel Plants which will require sponge iron and scrap from outside sources to the extent of about 7.5% on finished steel for use as coolant in LD converters. A rough estimate of this on the basis of 3.5% DRI and 4% scrap on 3.8 mt finished steel comes to 0.13 mt of DRI and 0.15 mt of scrap. The Integrated Plant of RINL at 2.41 mt capacity would need 0.085 mt of DRI and 0.085 mt of scrap. The Integrated Plants of SAIL nd TISCO also require a little purchased scrap/DRI as they are partly modernising. It is assumed that by 2000-2001, their purchased scrap will be about 4% on the total finished steel which comes to 0.5 mt (0.25 mt of DRI & 0.25 mt of scrap.)

The total requirement of DRI, therefore, by 2000-2001 will be 8.8 mt. Taking into consideration the 5.2 mt availability by 1996-97, the gap to be filled would be 3.6 mt.

ii) Scrap

Presently indigenous availability of steel scrap is about 3 million tons. The requirement of steel scrap as worked out in (i) above works out to 3.75 mt. The demand of steel scrap shall, therefore, be met more or less by the indigenous availability, provided additional capacity of Sponge Iron/ DRI shown above is created.

Note

The Raw Materials' demand has been worked out on the basis of the projected finished steel availability of 33.4 million tons by 2001.

0.3.0 TECHNOLOGY STATUS OF INDIAN INDUSTRY

0.3.1 Technology Source and Status of Industry in General

The source of technology both for equipment design and process has been the developed countries like Germany, Japan and America. Until now there has been no significant indigenous research and development in the EAF sector. The main reasons for this are :

— Capacity restrictions till recently on the size of the plant as per the licensing policies, which did not permit installation of EAFs of capacity more than 15T, which size is too small and does not lend itself to economic application of modern technological concepts. Consequently indigenous R&D activities have been negligible.

— With the sudden removal of restriction on the size of the Electric Arc furnace, the manufacturers of EAFs haven't been able to develop their own designs. Hence, they preferred to buy the equipment designs and manufacturing drawings outright from foreign suppliers. HBB bought the designs from their Swiss principals and Demag have set up an Indian subsidiary-Indomag.

— Hardly any interaction between equipment manufacturers, EAF operators and technical institutes (a common malady in all sectors of industry in the country).

— Poor theoretical knowledge of both designers and process people and lack of exposure to modern design and operational technologies.

— Lack of opportunity for absorption of foreign technology, which was irrelevant to hitherto low capacity of Electric Arc Furnaces.

0.3.2 Modern Technologies being Adopted in India

In the last few years, many modern technologies of Electric Arc Furnaces have been adopted in India. These are :

— Ultra High Power Transformer

— Water cooled panels for side walls and roofs

— Eccentric bottom tapping facility

— Ladle Refining Furnace

— Electrode Economizers (Water spray cooling)

— Carbon Injectors

— Continuous Feeding or DRI

— Slide Gates for Ladles ande Tundishes

There are still many Electric Arc Furnaces of 5 t, 10 t and 15 t with transformer rating of about 350 KVA per ton. These are not economical, as they have a higher tap to tap time, refractory consumption and power consumption. It also produces inferior quality of steel when compared with the units that have the technologies described above.

0.3.3. Production Process

In quite a few of old and modern EAF units, it is observed that the operational practices followed are not correct, leading to higher production cost and poor quality.

0.3.4 Operating Results of Modern EAFs

A. Authentic operating data of EAF units is hard to procure. These units for various reasons do not like to share their operating results. A modern UHP Electric Arc Furnace unit, incorporating all modern technologies like high powered transformer, water cooled panels and roofs, ladle furnace, continuous DRI/Lime/Coke feeding system with automation, Melt Controller etc. has been used for reference operating results.

1. The brief specifications of the EAF are :

EAF tapped weight	—	approx. 27 tons
EAF shell diameter	—	3.7m
Transformer rating	—	15 MVA
Electrode current	—	22 KA max.
Arc voltage	—	400 V max.

2. The metallic input mix is as follows :

Coal based DRI	—	approx. 60%
Cast Iron	—	approx. 20%
M.S. Skull	—	approx. 10%
Local light scrap	—	approx. 10%

The location of the unit is in central India, therefore the imported scrap's landed cost is very high.

3. The consumption data per ton of billet is as follows ;

i)	Power at EAF	—	640	KwH
	Power at LF	—	40	KwH
	for auxiliaries	—	70	KwH

ii)	Electrode consumption at EAF	—	3.5	Kg
	Electrode consumption at LF	—	0.4	Kg
iii)	Lime consumption	—	70	Kg
iv)	Oxygen consumption	—	10	NM cube
v)	Tap to tap time	—	120	min.
vi)	Approx. heats per day	—	12	

The above consumption data can be considered as representative of similar capacity EAF's in India.

B. In a slightly higher range, Sunflag's 50 t EAF is reported to be averaging about 14 heats per day presently. The tap-to-tap time reported is about 90 minutes (not corresponding to the heats per day) on the basis of 70% DRI (86% ± 2% metalisation and about 0.12% carbon) and 30% scrap (which has about 65% cast Iron/Pig Iron and 35% turning boring). The power consumption is about 670 KWH at EAF and about 60 KWH at LF on liquid steel. The oxygen consumption reported is around 15 cm per ton of LM.

It should be noted, that the consumption norms given in the above two cases seem very high when compared with similar norms in foreign countries. This is attributed to ;

— poor operational practices

— high usage of DRI and Heavy Melting Scrap (especially coal based DRI that has low metallisation, low carbon and high gangue content compared to gas based DRI).

— non-usage of 100% scrap based technologies.

0.3.5 Installation of EAF's using Hot Metal

A. An EAF has been installed in the country using the KORF-ARC process in which hot metal from a blast furnace is being charged to the extent of about 60% and DRI to the extent of about 35% and 5% scull. The process involves slight modifications to the Electric Arc Furnace mainly to be able to blow oxygen through submerged tuyers, atmospheric injector and door lances. This process is also suitable for steel making for special and alloy grades and flat products in general, as there will be no tramp elements in the steel and the nitrogen levels will be extremely low because of aggressive boiling in the EAF. It is India's first project using this novel method of using scrap/DRI and Hot Metal in an EAF. The idea originated at ISCOR works of Pretoria, South Africa, and now is in use in 3 or 4 other plants in the world.

B. Nippon Denro in their twin shell AC EAF's shall be using 40-50% Hot DRI and 50-60% Hot Metal.

In twin shell operation, there is one transformer/electrical system and the electrodes swivel from one shell to the other. The process is divided into two stages - heating with electrical energy and heating with alternative source (in the case of Hot Metal usage - heating with oxygen). These two stages, if they were combined in one shell would result in long "power-off" times. two shells are therefore installed with common transformer/electrodes system, which is shared, resulting in extremely low "power-off" times and optimum utilisation of the electrical system.

C. Essar Gujarat are also installing Mini Blast Furnaces to feed Hot Metal in their EAF's to the extent of 40%.

0.3.6 Use of Pig Iron as Metallic Input

The practice of using pig iron in the EAF as a part of the metallic input has already begun in India to the extent of about 10% — 15% depending upon the proximity of the EAF unit to the

Integrated Steel Plants. Basic Pig Iron from these ISP's is available at reasonable rates.

0.4.0 INTERNATIONAL SCENARIO

0.4.1 DC Arc Furnaces

DC EAF is one of the most advanced technologies of EAF. It was primarily developed to take care of the problems in operation of A.C. Arc Furnaces due to the instability of the A.C. Arc and the resultant problems of fluctuations of current in large range, low power factors, thus causing serious fluctuations of voltage and the flicker effect on the network. Today, the economic and operational advantages of D.C. Arc furnaces are generally acknowledged and there are more than sixty D.C. Arc furnaces, world-wide, which are either already under operation or are to be commissioned in the next two years. Two such furnaces, each of 150 T capacity with 160 MVA transformers and 7300 mm diameter are set up at Hazira for Essar Gujarat and have been commissioned in May, 1995.

In D.C. Arc furnace, unlike the A.C. furnace, there is generally only one electrode and there can be one/two or even three bottom electrodes, which act as anode. In some cases, the hearth is made of conducting type, and in such cases, the melt itself is used as an anode.

The advantages of DC Arc Furnaces are :

— Reduced Graphite Electrode Consumption
— Improved Stirring Effect
— Reduced Flicker Generation
— Reduced Average Noise Level after initial bore-down
— Reduced Electrical Energy consumption
— Reduced maintenance costs due to less moving parts.

It is estimated that a newly built DC EAF will cost about 80% more if no SVC system is required for the AC EAF. However, if

SVC system is to be installed for the AC EAF, then a DC EAF may cost about 10% lower.

It is estimated that a newly built DC EAF will cost about 80% more if no SVC system is required for the AC EAF. However, if SVC system is to be installed for the AC EAF, then a DC EAF may cost about 10% lower.

The DC arc furnaces have a promising future in developed countries, it may be little early in India to install a DC furnace due to the following reasons.

— Very high equipment cost (This helps in case of AC Electric Arc Furnace 50-60 tons where an SVC can be avoided)

— Imported consumables in the form of bottom refractory and graphite electrodes.

— Difficulty in flat bath operation due to very long arcs.

— Difficulty in melting DRI with a single electrode as the arc flare tends to push the DRI towards the furnace lining.

Essar Gujarat has commissioned its two DC arc furnaces and is melting HBI. However, they will have the following advantages because of which they are not likely to face the problems of melting DRI with DC arc.

— They would charge hot sponge iron, which melts much quicker than cold DRI, thereby eliminating the problem of formation of iceberg or unmelted DRI floating on top.

— They would use gas based HBI, which gives the advantage of high carbon (gives ease in making foamy slag), higher bulk density and quicker melting.

— Some modifications carried out in the placement of the bottom anodes and the DRI feeding system.

0.4.2 Conversion of small capacity AC Furnaces into DC Arc Furnaces

Conversion of existing AC furnaces of small capacity upto 25 T into furnaces is not an economically viable solution due to the following reasons :

i) For converting the AC furnace into a DC furnace, the expenditure would be approx. 1.5 times the cost of a new AC EAF of the same capacity. Such high costs are involved due to the following :

— But for the furnace shell and tilting arrangement, all other mechanical and electrical equipment would need replacement.

— Power factor on the primary side of the Rectifier Transformer for the DC furnace is very low.

In order to ensure the same productivity with AC EAF, higher power by 15 - 20% is required for DC furnace. Therefore, to install a new heavier transformer with thyristor rectifier, a bigger transformer room is needed.

— There is large harmonic generation in a DC furnace, and therefore it is important in a DC furnace to install three or more filter units tuned to different frequencies.

ii) The key element in DC furnace design is design of the bottom electrodes which are different with different suppliers. It is important to have a well designed bottom electrode system to get an accurate control of the arc deviation, which a lone can optimise operating performance and keep hearth repair costs low.

As it is difficult to operate small furnaces with the required liquid metal heel, which is a prerequisite for a DC furnace bottom, it is highly unlikely that any dependable DC furnace supplier shall undertake the work of converting a small AC furnace into a DC furnace.

There are some other problems expected with DC furnace operation, due to the fact, that in India, the bulk of the charge is likely to be DRI.

0.5.0 TECHNOLOGY ABSORPTION AND GAPS

0.5.1 General

Technological improvements are results of years of well-directed R&D efforts of equipment designers, process people and technical institutions, and interaction between these agencies. In the absence of R&D activities, a country has to resort to technology import. The imported technology has to be accurately and thoroughly implemented, often adapted to local conditions and constantly upgraded to be successful.

In the Indian EAF industry, R&D activities have been altogether missing, the main reason being that the plants were too small to afford them. Equipment design and process know-how imported once, were not upgraded either by our own efforts or by importing upgraded technology. In the few cases where basic engineering/process know-how were imported, the desired results have not been achieved. Probable reasons are :

— Foreign technology suppliers do not appreciate fully the Indian conditions.

— At times, lack of systematic training of Indian technologists/engineers at various stages in their career, leaving them with insufficient technical knowldege.

— In certain places, lack of discipline and application in the work force. The implementation of technology is then half-hearted.

— The recording and measuring facilities in a plant, which form the basis of monitoring the process and technical investigation, are inadequate.

0.5.2 Need for Adoption of Foreign Technology using DRI as Raw Material

With the scarcity of scrap and production of DRI in the country, an inherent difference in the process between the advanced countries and India has been created. The Indian technologists/ engineers will have to meet the situation with intelligent adaptation of the available technology.

There are however a few companies in the world that use DRI as part of their metallic input in their EAF divisions and have mastered this technology. Among them are ;

i) Krakatau, Indonesia (using gas based DRI)

ii) Sidbec Dosco, Canada (using coal based DRI)

iii) New Zealand Steel, New Zealand (using coal based DRI)

iv) ISCOR, South Africa (using gas based DRI)

v) Vespasiano, Brazil (using gas based DRI)

vi) HSW, Germany (using gas based DRI)

Equipment suppliers like Mannesmann Demag have considerable experience in steel making with DRI in AC EAF's. The companies mentioned above could also be approached for process know-how.

0.5.3 New Technologies

There are some technologies in developed countries which are not applicable in Indian conditions as these are for 100% scrap based plants like scrap pre-heaters, burners, and post combustion, Consteel process (continuous pre-heating of scrap) etc.

The technologies which are applicable in Indian conditions are given below :

— Submerged inert gas stirring in the EAF

— Submerged oxygen and coke injection in the EAF

— Use of a series reactor with the furnace transformer to control system reactance, to have high power factor and lower current operation and to reduce electrode consumption.

- Ladle Induction Stirring
- Conductive Electrode Arm
- Automatic Electrode Jointer
- Electrode Resetting Device
- Secondary Fume Extraction System (now being installed by Essar Gujarat and Panchmahal)
- Robotic Gunning Machine
- Scrap Management
- Twin Shell EAF (now being installed by Nippon Denro)
- Artificial Intelligence System for EAF automation

0.6.0 RECOMMENDATIONS

0.6.1 A few existing mini steel plants with EAFs of 5 to 15/17 T capacity may have to be scrapped. As mentioned earlier, many such plants have already closed down.

0.6.2 Till enough experience is gained in the working of a modern EAF, it shall be desirable to make use of foreign expertise in profitable running and exploitation of full production potential of the state-of-art facilities that have been set up and are being set up in the country.

The foreign operational know-how would require some modifications because of differences in the chemical composition and characteristics of the indigenously produced DRI, refractories, the use of Hot Metal as metallic input, etc. For this, our plants will have to have adequately qualified and motivated staff. Proper measuring and recording facilities should also be installed in all the units to assist in establishinng correct operating practices.

0.6.3 On a long term basis, more money and effort should be spent on R&D activities.

0.6.4 House keeping in the EAF units should be improved. It is well known that good house-keeping leads to better maintenance and therefore higher utilisation of the plant.

0.6.5 For better health of the workers in the plant and the community at large, pollution control norms in India may be examined and reviewed, if necessary.

0.6.6 More capacity of sponge iron in the country needs to be created to reduce dependence on imported scrap, the prices of which are expected to constantly rise in the future.

0.6.7 Due to the high cost and low availability of power and scrap, the technology of using hot metal in the EAF assumes greater significance. The hot metal can be used in the EAF in the range of 25-60% (the rest being sponge iron/scrap) with certain modifications to the furnace hardware and refractories. In case of use of Hot Metal in the lower range, it is possible that no modifications are required with use of DRI. The benefits of using hot metal in the EAF are ;

— Reduction in tap-to-tap time due to enthalpy and high carbon in the hot metal, thereby increasing productivity and making higher number of sequence heats possible at the CCM.

— Substantial reduction in electrical energy consumption.

— Reduction in electrode & refractory consumption.

— Maximum demand will be reduced because of requirement of lower power consumption. There is, therefore, the possibility of lowering the capacity or avoidance of SVC and lowering the electrical system capacity for EAFs.

— Lower nitrogen levels due to intense boiling.

— Final refining done along with oxygen blowing upto tapping, i.e. melting and oxidation is done at the same time, reducing the overall heat time.

Because of the reasons of low availability and high cost of scrap and power in the future, it is recommended that the existing EAFs and the new EAFs being installed, that happen to be located suitably, should install Mini Blast Furnaces for the production of Hot Metal to be fed into the EAFs.