ABSTRACT

Iron and Steel are amongst the most important materials of our times. The iron and steel industry remains a viable and dynamic industry. Competition, the driving force of invention and innovation, has forced steel makers to adopt new technologies that reduce cost without sacrificing quality. Steel production has shown increasing trend world wide due to industrialization and infrastructure developments in the developing countries.

Blast Furnace (BF) continues to maintain its dominant position for iron making. Prior to 1960s, Open Hearth Furnace (OHF) was popular for converting iron to steel. Since 1960s, LD converter has been the most popular route for processing iron to semi-finished steel for large size integrated steel plants due to high productivity. For medium size steel plants, Electric Arc Furnace (EAF) was the popular route for converting scrap to steel. The subsequent operations, such as, secondary refining, continuous casting, and rolling are proven methods that meet specific customer requirements. The main issue was how to convert iron to steel most economically considering the capital investment and the recurring manufacturing cost.

At CS-Pains, Divinopolis, Brazil, three OHFs (30 MT capacity), were in operation, producing 200,000 MT (Metric Ton) of steel per annum. They were not competitive against the LD converters. The Korf group, at their steel plant at Divinopolis, Brazil, developed Energy Optimizing Furnace
(EOF) in 1982 to solve their company problems. EOF is a combined blowing, basic oxygen furnace where a combination of hot metal and scrap is converted to liquid steel suitable for secondary refining and continuous casting. Korf group designed the EOF, which had the advantages of LD converter and EAF, along with post combustion and scrap pre-heating within the same vessel. EOF was designed for low capital investment, high productivity and ease of working when compared to EAF or LD converter. 30 MT EOF at CS Pains, replaced all the three OHFs and more than doubled their steel production to compete with LD and EAF based steel plants. There were some deficiencies in the first EOF put up by CS Pains, which they improved in the second 30 MT capacity modern EOF installed in 1988 which is still in operation. Up to Dec 07 C S Pains has manufactured over 10.5 million tons of steel which establishes the fact that EOF is a proven route for steel making.

Based on the success on EOF at CS Pains, four new installations of EOF were put up in different parts of the world – Alliperti, Brazil (60 MT), RIFS, USA (40 MT), TISCO, India (80 MT), and AFS, Italy (60 MT). Unfortunately, none of the above EOFs were a commercial success for one reason or the other. The repeated failures of the EOF almost brought this technology into the category of being ‘non-viable’ until one 40 ton EOF installed at Hospet Steels Ltd. India, and the other 35 MT installed at SISCOL, Salem, India, which were successful on commercial scale. The scholar was responsible for putting up these projects and bringing them to operational levels at the desired productivity and cost. The challenge was that while four installations of EOF had failed, the EOF installed at CS Pains is
still in operation and working successfully. Therefore, effort was made to optimize the steel making process through EOF route under Indian conditions such that it was a viable process on commercial scale.

A number of modifications and design changes have been carried out in the EOF to suit the local conditions: (a) Increase the EOF capacity from 35 to 45 MT that resulted in 20% increase of productivity. (b) Removal of scrap pre-heater fingers and follow 80% hot metal, 20% solid charge in the EOF which is an auto-thermic process. (c) Introduction of double shell practice to ensure good maintenance of water cooled panels and reduce the bottom change over time within eight hours. (d) The submerged tuyere diameter was reduced from 18 mm to 14 mm and the location of the tuyere in the furnace hearth was suitably adjusted to achieve short blowing periods.

Several measures were taken to improve the productivity and reduce the steel cost through EOF. Charge to liquid metal yield was improved from 90.2 to 92.2 %. The oxygen blowing time per heat was reduced from 36 min per heat to 31 min. Total refractory consumption was reduced from 9.65 Kg/MT to 7.44 Kg/MT. This was achieved through certain external factors but primarily through successful implementation of ‘Catch Carbon Process’ in the EOF where steel could be tapped above 0.1% carbon with 85% consistency. Close correlation was found between the drop of carbon and total oxygen consumed through submerged tuyeres and oxygen injectors. Software was installed in the EOF computer through which facility was available to the operator screen to tap the steel after specified oxygen consumption based on % C in the second sample. The implementation of
catch carbon process also resulted in saving of the ferro alloys consumption to the extent of Rs.100 to Rs.200 per MT depending on steel grade.

SISCO took up expansion programme to increase the steel manufacturing capacity from 0.3 million ton to 1.0 million ton per annum. After careful evaluation, amongst various options, decision was taken to install a 65 MT EOF, which in combination with the 45 MT EOF, would produce 1.0 million ton of steel per annum. The various parts of 65 MT EOF were carefully designed for high productivity and reliability. The world’s largest 65 MT EOF was commissioned at SISCO on 18.10.2007. The EOF operation was successful from the very first heat and it achieved 603 heats life in the first campaign. Carbon and low alloy steel grades were manufactured through the 65 MT EOF. The capital investment was significantly lower than the cost of the comparable size LD or EAF which supported the decision taken in favour of 65 MT EOF for SISCO expansion to one million ton.