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# How critical is the Sponge-iron feeding rate in Electric steel making?

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**Abstract**— Most of the steel plants were facing the problem of feeding the Sponge-iron continuously as sponge berg formation in the EAF posed lot of problems. The sponge berg, once formed makes the operation very unsteady. It increases the electrode consumption due to the open arcing instead of closed one. It also increases electricity consumption due to the same reason. Refractory consumption too goes up. These are the three major critical parameters in electric steel making.

**Index Terms**—Electrode, Electricity, Refractory, Sponge-Iron, Submerged-Arcing, Ammeter, EAF, LRF, VOD, VD

## INTRODUCTION

ELectrometallurgy talks about EAF (Electric-Arc-Furnace), LRF (Ladle-Refining-Furnace), Converter, VOD (Vacuum-Oxygen-Decarburization), VD (Vacuum-Degassing) and Bloom-Caster[1][2]. The EAF is the furnace where scrap is charged and melted using electrodes and electrical energy [3]. After complete melt-down continuous feeding of Sponge-iron, which is another charge material, is started. Many a times the Sponge-iron feeding rate is kept substantially high in order to speed up the process but it is ended up in sponge berg formation which was due to the floating of Sponge-iron that falls into the liquid metal pool that did not get enough time to melt down. Sponge-iron floats because its density is only 2 tons/cubic meter as against around 6.5 tons/cubic meter of liquid metal. This was leading to many problems like sudden boiling, open arcing, potential accidents, delays and losses. Since there was only one load cell showing the amount of Sponge-iron remaining in the bunker, it was never known how much Sponge-iron was fed in unit time to the furnace and how much energy was required to melt it.

## EXPERIMENT 1

Hence to determine the unknown parameter of Sponge-iron rate of feeding (in tons per hour) was the first aim. The equipments involved were a conveyor belt with rollers, a motor to rotate them, a bunker to store Sponge-iron with a rectangular opening and an ammeter for the motor. The area of opening of the bunker with the measurements of length and breadth of the opening was calculated. Then the length travelled by the belt in one hour was calculated. This gave us the volume of Sponge-iron falling into the furnace in one hour. Further multiplying with the density of Sponge-iron, the weight of Sponge-iron falling into the furnace in an hour was arrived at. There was no investment required for this experiment to be conducted.


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## EXPERIMENT 2

The next task was to establish the link of Sponge-iron feeding rate with a display in the panel room and that was nothing but the ammeter of the motor which rotates the conveyor belt. First of all the rpm (rotations per minute) of the motor at different ampere levels on the ammeter was found out. Then a graph between ammeter reading and rpm was plotted. It was found that the line of graph was coinciding with the origin of the axis. This meant that when the motor was not running there was zero Sponge-iron falling into the furnace. This in fact confirmed that the mathematical modeling was going in the right direction. From the rpm of motor the rpm of the conveyor roller was derived. Further the length of the belt traveled in one hour was also derived. With this the volume of Sponge-iron travelled in one hour was derived and from this volume, the weight of Sponge-iron in one hour was derived by multiplying it with the density of Sponge-iron (2 tons/cubic meter). Thus the ammeter reading was linked with the Sponge-iron feeding rate in tons/hour per ampere.

## EXPERIMENT 3

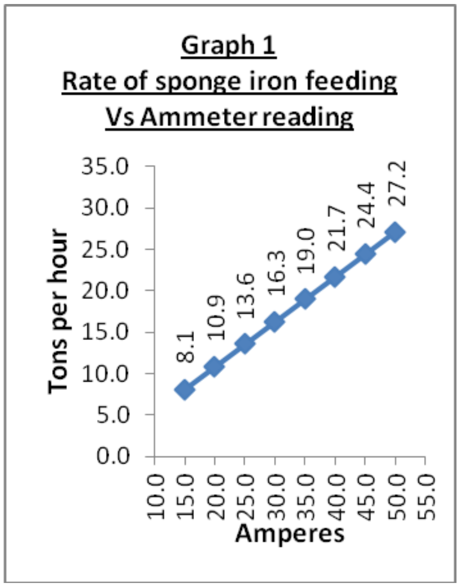
The next task was to establish the energy required to melt one ton Sponge-iron. It was calculated theoretically first. From the elementary books of metallurgy, it was found out that the specific heat [4] and latent heat of fusion [4] of iron (Specific heat= 0.443 Joules/kg, Latent heat of fusion= 13800 Joules/mol). With this the energy required to melt one ton of Sponge-iron was calculated (Energy required= 955228571 Joules). Further this energy was converted into electrical energy [5] (Electrical energy= 265 Kwh/ton). Thus the electrical energy required to melt one ton of Sponge-iron was derived. Thus the maximum rate of Sponge-iron feeding without sponge berg formation for a given power input was also derived. Later it was found that the practical value (520 Kwh/ton) of energy consumption was almost double the theoretical value. This was mainly because of the radiation loss of heat generated in the furnace. So necessary changes in the calculation was incorporated and arrived at most practical values in the commercial scenario. With this experiment we found a balance in the process throughout.

## Experiment 4

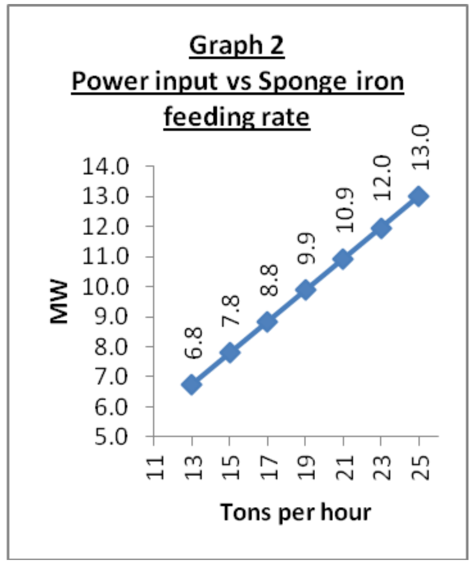
Then the final task was to establish the link between the ammeter reading and power input. As the link between Sponge-iron feeding rate and ammeter reading was already known, a graph between power input and ammeter reading could easily be drawn.

## Results

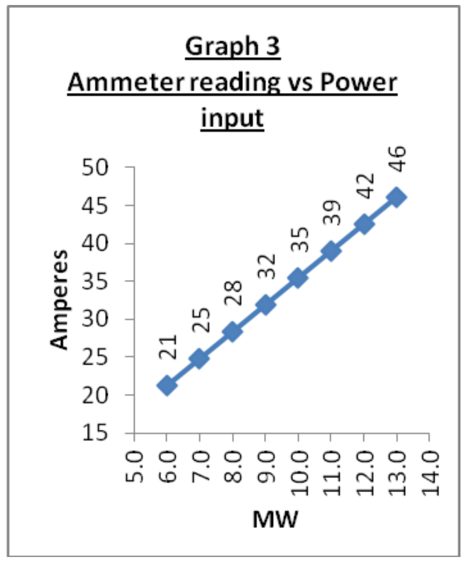
1. The relationship of the Sponge-iron feeding rate vs. ammeter reading of the conveyer motor has been established. Refer Graph 1




2. The relationship of the electrical power for the complete meltdown of the input Sponge-iron as and when it falls into the bath vs. Sponge-iron feeding rate has been established. Refer Graph 2. This was a break through which brought stability in the EAF (Electric Arc Furnace) process. All of a sudden the Tap to Tap time reduced to 1 hour 50 minutes as against 2 hours 20 minutes. With this there was a drastic drop in electrical energy consumption. The Kwh/ton started touching below 500Kwh as against the earlier values of 560Kwh/ton. As the process became smooth there was drastic drop in Electrode consumption as well as the Electrode breakages came down to almost nil. So consumption was taking place only due to the arcing. The values started zeroing around 4kgs/ton. As the open arcing was under full control, the water cooled-panel failure and refractory consumption reduced drastically. The fettling or the repair required after every batch of product became literally unnecessary. This reduction was intangible as we could not calculate it directly. So we assume that there is a saving of at least a kg/ton of the refractory materials though actually the figure may be many folds of this value. However in the annual consumption of refractory there was a marked improvement.




3. Finally the relationship of the ammeter reading of the conveyer motor vs. electrical power for the complete meltdown of the input Sponge-iron as and when it falls into the bath has been established. Refer Graph 3




4. When Sponge-iron feeding rate was monitored with the help of graph 3, smooth melting took place without any sponge berg formation.
5. The energy consumption level came down from 562kwh/ton to 499Kwh/ton on an average.
6. The electrode consumption level came down from 4.51kg/ton to 3.98kg/ton on an average.
7. The refractory consumption level came down intangibly as the fettling and water-cooled-panel failure frequencies reduced substantially.
8. The overall melting process became very smooth whenever the Sponge-iron feeding rate was monitored according to graph 3.

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## CONCLUSION

From the above results it can be concluded that the rate of Sponge-iron feeding plays an important role in Electric steel making.

In addition, an Ammeter can be calibrated to use as a new device called Sponge-Iron-Meter for ensuring ideal sponge-iron feeding rate for continuously feeding into a pool of liquid iron.

## COST EFFECTIVENESS

Batch size = 30 tons

Daily production = 30 x 10 batches
= 300 tons

Monthly production = 300 x 30 days
= 9000 tons

Annual production = 9000 x 12 months
~ 1,00,000 (approx)

Electrode saving has been 0.50 kg/ton @Rs. 100
Hence savings in money = 0.50 x 100
= Rs. 50

Annual savings in electrode consumption
= 50 x 1,00,000
= Rs. 50,00,000

Electricity saving has been 60 kwh/ton @Rs. 5.00
Hence savings in money = 60 x 5
= Rs. 300/ton

Annual savings in electricity consumption
= 300 x 1,00,000
= Rs. 3,00,00,000

Refractory savings has been 1 kg/ton @Rs. 60.00
Savings in money = 1 x 60
= Rs. 60

Annual savings in refractory consumption
= 60 x 1,00,000
= Rs. 60,00,000

Grand total of annual savings
= 5000000 + 30000000 + 6000000
= Rs. 4, 10, 00, 000

**This project was actually implemented 1990 and these savings have been recurring since then.**

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## DEDICATION

We dedicate, commit and devote this paper to our beloved Heavenly Father the guide and mentor of all of us and, His manifestation Mother Nature.

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