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EFFICIENT USE OF ENERGY IN A ELECTRIC ARC FURNANCE BY HEAT INTEGRATION APPROACH

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ABSTRACT

Based on the principles of heat integration, the present work investigates the design and operational modifications which can lead to efficient energy integration in an electric arc furnace being operated with direct reduction process. This process is one of the oldest and most widely applied processes amongst the commercially used process in India. For the purpose of energy integration stream data is extracted from the actual flow sheet of the plant, which consists of supply and target temperatures, flow rate and specific heat capacity of all process streams. In the present paper, for the utilization of heat of waste gas, are proposed based on preheating of inlet streams. Based on sensible heat requirement for preheating air and feed material, the reaction of heat lost through the furnace wall is carried out by preheating of steel scrap, direct reduced iron and feed material and latent heat required for evaporation of moisture of feed material, energy consumption is computed [11]. For modified heat integration process, operability analyses are presented which include coal consumption, water requirement and energy consumption. One additional advantage of this system is that it gives simpler modified method in comparison to other scenarios and thus makes the process and its control easy. It minimizes the waste gases to the atmosphere that makes the process environment-friendly.

KEYWORDS: Electric arc furnaces (EAF), Direct Reduction Iron (DRI), steel scrap, mass analysis, Energy analysis.

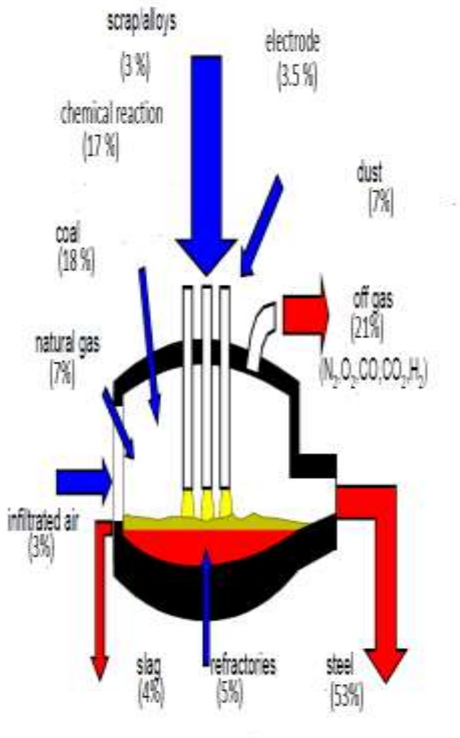
INTRODUCTION

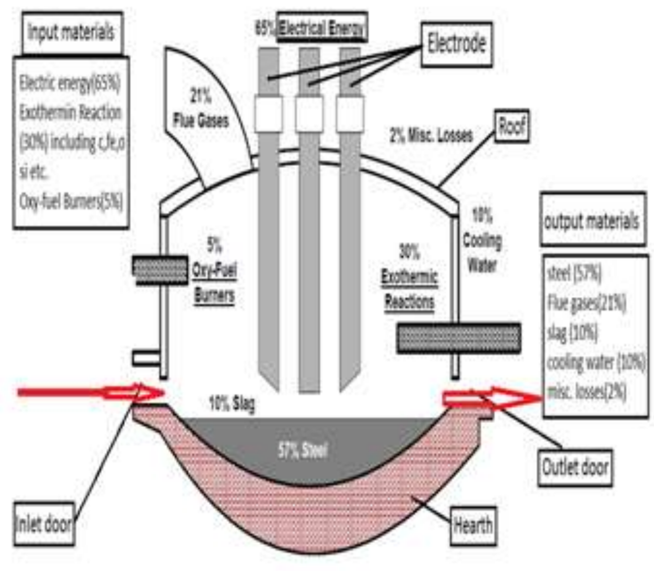
Electric arc furnace (EAF) is a furnace that heats charged material by means of an electric arc. An electric arc furnace is heated up to 1600ºC by electricity that is generated through electrodes [7]. Generally, two types of a furnace (a) Indirect arc furnace- In the indirect-arc furnace, an arc is struck between two carbon electrode and heat is transferred to the charge by radiation. Indirect arc furnaces are of fairly small capacities and do not develop steelmaking temperature readily. (b) Direct arc furnace- Direct arc furnace current flows from the electrode to the charge and heat transferred from arc to the charge primarily by radiation but of the heat is also generated in the charge itself [6]. Approximately 438 million ton/year of liquid steel (31% of the world's total) are produced by using the electric arc steelmaking process in the world. In Turkey, approximately 70% of total steel are produced by EAF. This presents that about 20 million tonne steel are produced by EAF method [8].Steel scrap is the principle raw material.In basic furnaces slag formers like limestone, fluorspar, sand, and quartzite are used to form a slag to refine the metal [13].The basic concept of direct reduction iron (DRI) dates back to some 3000 years, but the first commercial plant became operational in 1952 in Sweden. In India, the pioneering work was done by National Metallurgical Laboratory Jamshedpur and Tata steel Ltd Jamshedpur. The first commercial-cum-demonstration plant was established using coal-based technology during 1980's by Sponge Iron India Limited. In the year 1989 ESSAR steel made a beginning in the production of sponge iron through gas based technology [12].

MATERIALS AND METHODS

In fig.1 shown in inlet and outlet stream of materials. In inlet stream steel scraps, coke, natural gas and an electrode are main components. In outlet streams steel, slag, dust and off gases.

In fig 2 shown in inlet and outlet streams of materials. To supply Electrical energy is 65% of total energy other materials are also provides. In outlet streams steel (57%), slag (10%) and off gases (21%). Our aim is how to utilize off gases.





RESULTS AND DISCUSSION

Formulae:(a) Mass Balance

The mass balance analysis was carried out for an EAF with a capacity of 70 tonne. The amounts of materials fed into the EAF and each material out coming from the EAF should be determined. After determining the amount of each charged material, the chemical composition of all the materials is gathered as measured at the plant or taken from the relevant literature [7].

$$\Sigma m_{inlet} = \Sigma m_{exit}$$

$$\Sigma m_{in} = \Sigma m_{SS} + m_{CPC} + m_{DRI} + m_{DOLO}$$

$$\Sigma m_{exit} = \Sigma m_{LS} + m_{SLAG} + m_{SGASES} + m_{DUST}$$

In below table inlet and outlet amount of material into Electric Arc Furnace (EAF) has been discussed. As we can see outlet liquid steel is 68125 kg, which is 77.3% of inlet total metal. Slag and off gases of heat are 21.6% of total metal. This chart is very useful for the purpose of calculating the efficiency of the process [8].

	Material going into EAF			Materials going out of EAF		
S.N	**Substance**	**Amount kg**	**% of Total Amount**	**Substance**	**Amount kg**	**% of Total Amount**
1	Steel scrap	40160	45.5	Liquid Steel	68125	77.3
2	Hot Metal	23625	26.8	Slag	16010	18.2
3	DirectReducedIron	14670	16.6	Off Gases	3012	3.4
4	CalcinedPetroleum Coke	1190	1.4	Dust + Excess carbon	966	1.0
5	Dolomite+ Electrode	8468	9.6			
	Total	88113	100	**Total**	88113	100

Table: 1 Mass balance obtained after operation

(b)Energy Balance

Energy (heat) balances give a general quantitative idea of an electric arc furnace as a thermal-energetical unit. These balances are derived from the law of conservation of energy according to which the total input of energy must be equal to energy output. It is true for the entire unit and for each of its zones.

Energy input = Energy output

$$E_{DRI} + E_{HM} + E_{SS} + E_{CPC} + E_{CH} = E_{LS} + E_{SLAG} + E_{VC} + E_{OFFG} + E_{TL} + E_{OTH}$$

This is a reference date for energy balance. We have to weconsumes the electric energy is 240 KWh/ton, which is 48.84 % of total metal [8].

S.No	**Energy input**	**Symbol**	**KWh/ton**	**% of Total Energy**
1	Electric Energy	E_{EE}	240.3	48.84
2	Direct Reduced Iron	E_{DRI}	73.80	15.00
3	Hot Metal	E_{HM}	42.80	8.96
4	Steel Scrap	E_{SS}	60.80	12.30
5	Chemical Oxidation (Including Dolomite, Electrode)	E_{CO}	51.00	10.30
6	Calcined Petroleum Coke	E_{CPC}	23.10	4.60
	Total		491.8	100.00

Table: 2 Heat Balance of 70 ton Electric Arc Furnace

In order to make the mass balance and energy balance, firstly all materials entering the system are calculated on a component basis. The necessary information was provided from an iron and steel producing company. Secondly, the mass values of liquid steel leaving the furnace considering its alloying elements were compared with input materials on an elementary basis. This comparison helps us to determine the mass values of substances going into the chemical reactions. In this way, the compounds that form slag, stack gases, and dust were found. These compounds were consistent with the measurements taken in the plant. Due to the fact that the company does not have data on the ratio of the compounds present in the dust and slag, the necessary information is obtained from a similar study. Electric arc furnace steelmaking is assuming an increasingly large role in steel production,with the use of larger quantities of scrap substitutes and a scrap of different levels of quality. Thus the goal is to improve the economic and technicalindices of the furnaces, despite the difficulties and limitations connected with the use of this new type of charge. In improving charging and melting operations and furnace equipment, certain basic requirements must be met:

1. Maximum use must be made of the available energy (electrical and internal) during the heat;
2. The use of electric power and carbon in the furnace must be optimized;
3. The time the arc is off due to cold-charging must be made as short as possible;
4. The steelmaking process must be made safe and environmentally clean.

CONCLUSION

Based on the results, obtained from development of energy conservation for heat integration in electric arc furnace, possibilities of its implementation and also a comparison of the modified system with the existing process on the basis of energy consumption.The salient conclusions are listed below:

Heat Integration technique can be effectively applied to electric arc furnace to generate a different energy conservation process which can lead to an efficient use of energy.

1.The waste gas generated through this work is 14.2 % less in comparison to another Electric Arc Furnace.
2. The average amount of energy that can be saved in the present study in terms of coke is 72.4 KWh/ton.

There is a huge amount of energy wasted in Electric Arc Furnace (EAF) industry which can be reused by application of proper scheme. Preheating the inlet materials is one of the feasible schemes which could be applied in order to decrease energy consumption and increase productivity. In this scheme, flue gas energy is transferred to a neutral gas through a heat exchanger and then the hot gas is used to preheat the inlet materials held in the system. Simulation of the preheating process how that using this technique electrical energy can be saved up to 14.2 % and furnace productivity can be increased up to 13%. There is good potential to further increase in saving by increasing the inlet gas temperature.In this, preheating of feed material is carried out using waste gas. In the modified system of the electrical arc furnace, total consumption of energy is 419.4 KWh/ton in place of 491.8 Kwh/ton, which is 14.2 % less than that of another electric arc furnace.

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