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To Study Energy Conservation in Foundry by Using Process Parameters

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ABSTRACT

In this paper analysis of energy conservation in foundry is carried out by using process parameter .& these parameters gives the information about Energy audit gives detailed information about utilization of energy in various sections and identifies areas of improvement. In this paper Material and graphical representation is considered.

I.INTRODUCTION

Foundry is one of the most energy intensive metallurgical industries. The major part of the energy consumed in Foundry is in the melting units. Energy also contributes to the major cost input to the production of castings. Besides it, high energy consumption is upbringing the threat of climate change and global warming. Therefore it becomes very much necessary to look into various means by which energy consumption in melting units can be minimized considerably.

Various sections of foundry namely pattern making, moulding, melting, core making, compressed air etc. consume energy in the form of electricity or through burning of fuel. Among these largest amount of energy to the tune of 65 – 70 % of the total foundry energy is consumed in melting operation. As the Foundries are growing with mechanization and automation, the requirement of energy is also increasing day by day. Looking into today's scenario, it becomes very essential for a foundry industry to look for means which can bring down the energy consumption in melting operation significantly by efficient and optimal running of furnaces. Plenty of work is being done by Foundry industry in this direction where the ultimate aim is to reduce specific energy consumption in liquid metal preparation

II. ENERGY CONSUMPTION AND ENERGY AUDIT

Energy consumption tells about energy is used for melting of metal which in the form of heat and electricity. Energy audit gives detailed information about utilization of energy in various sections and identifies areas of improvement. Many researchers [3, 5, 8-11] focused on energy consumption and audit.

Arasu and Jeffrey [3] proposed thatenergy accounting is necessary to determine where and how energy is being consumed and how efficient is the energy management system. They explained that energyaccounting method should define the areas of high energy use, energy waste and should point out areas in which energy saving can be accomplished. To arrive at the energy consumption pattern is the main part of the energy audit process. Energy pattern can be used to understand the way energy is used in a foundry and helps to control energy cost by identifying areas where waste can occur and where scope for improvement may be possible. Arasu and Jeffrey [3] observed that the specific energy consumptionis reduced with increased capacity utilization as shown in fig. 2.1

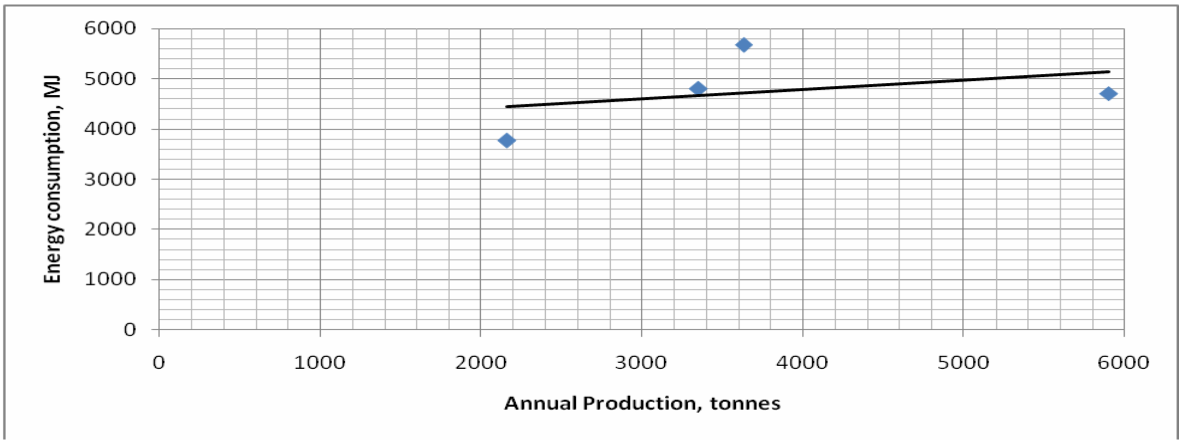

Fig 2.1 Linear Regression Model for Energy Consumption [3]

Patange and Khond[5] focused on proper energy management system it would be necessary to choose an efficient furnace that must be satisfy demand of foundry. Although high energy expenses are a significant concern for metal casters, many foundries are using melting technologies with poor energy efficiency. They found that amount of heat put into the furnace, the thermal efficiency refers to the percentage of that heat that actually melts the metal and the power to the furnace was varied very frequently due to empty space in the crucible, excess charge, and sample analysis delay. Maintain a high power factor, which will lead to reduced demand, better voltage, high system efficiency as well as rebates from the electricity supplying company.

Makarov et al. [8]calculated data for the relation between the energy technological parameters and the electric energy consumption. They suggested measures took to decrease the consumption of energy resources for the

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manufacture of electric furnace steel in electric furnaces operating with scrap,hot briquetted iron, and pellets and in electric furnaces operating with scrap and liquid cast iron.

Bhattacharjee and Vasudevan [9] did energy audit at cupola furnace and calculated heat input, heat losses. They had given recommendation for improvement in cupola furnace which include operating practice used for charging, the dimension of cupola well depth, tueyere area and shaft height. They suggested retrofitting of existing conventional unit with divided blast would result in a coke saving of 25 %.

Yuanyuanet al.[10] did Analysis on energy consumption situation and energy saving potential in casting production; they found that energy consumed is mainly in the form of coal, coke, electricity, fuel oil and gas. Energy saving and emission reduction should focus mainly on quality promotion, rejection decrease and waste reduction, by means of near net shaping, computer technology, new materials technology, advanced melting, forming techniques and equipment, smoke, dust and slag control and materials recycling. They have given recommendation for integration and innovation with modern management, advanced technology and equipment.

Peasleeet al. [11]gives results of energy consumption measurements at steel foundries using induction and electric arc furnace. They have performed some industrial experiments in isothermal holding of liquid steel in induction furnaces under different power inputs were used for evaluation of the real values of heat losses by radiation from liquid steel and conductivity through lining.Peaslee [11] observed that 67.6% energy was required to melt and main heat loss was to cooling water for coil. Their results are shown in Figure 2.5.

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Fig. 2.2Sankey-Diagram of Energy Flowfor Induction Furnace

III.EXPERIMENTAL WORK

To arrive at the energy consumption pattern is the main part of the energy audit process. Specific energy consumption is the energy consumed per ton of liquid metal produced. Energy management is the strategy of adjustingand optimizing energy, using systems and proceduressoas to reduce energy requirements per unit of outputby keeping constant or reducing total costs of producingthe output from these systems. The term energymanagement can be considered as consisting of threebasic steps - planning, execution and control. The collection of data has made use of metering facilities for energy consumption in different sections/ equipment's. Optimizing capacity utilization is largely dependent on factors such as production planning capabilities and increasing the number of equipment options available for production. Methodology of energy consumption studies and process flow explained in figure 3.1

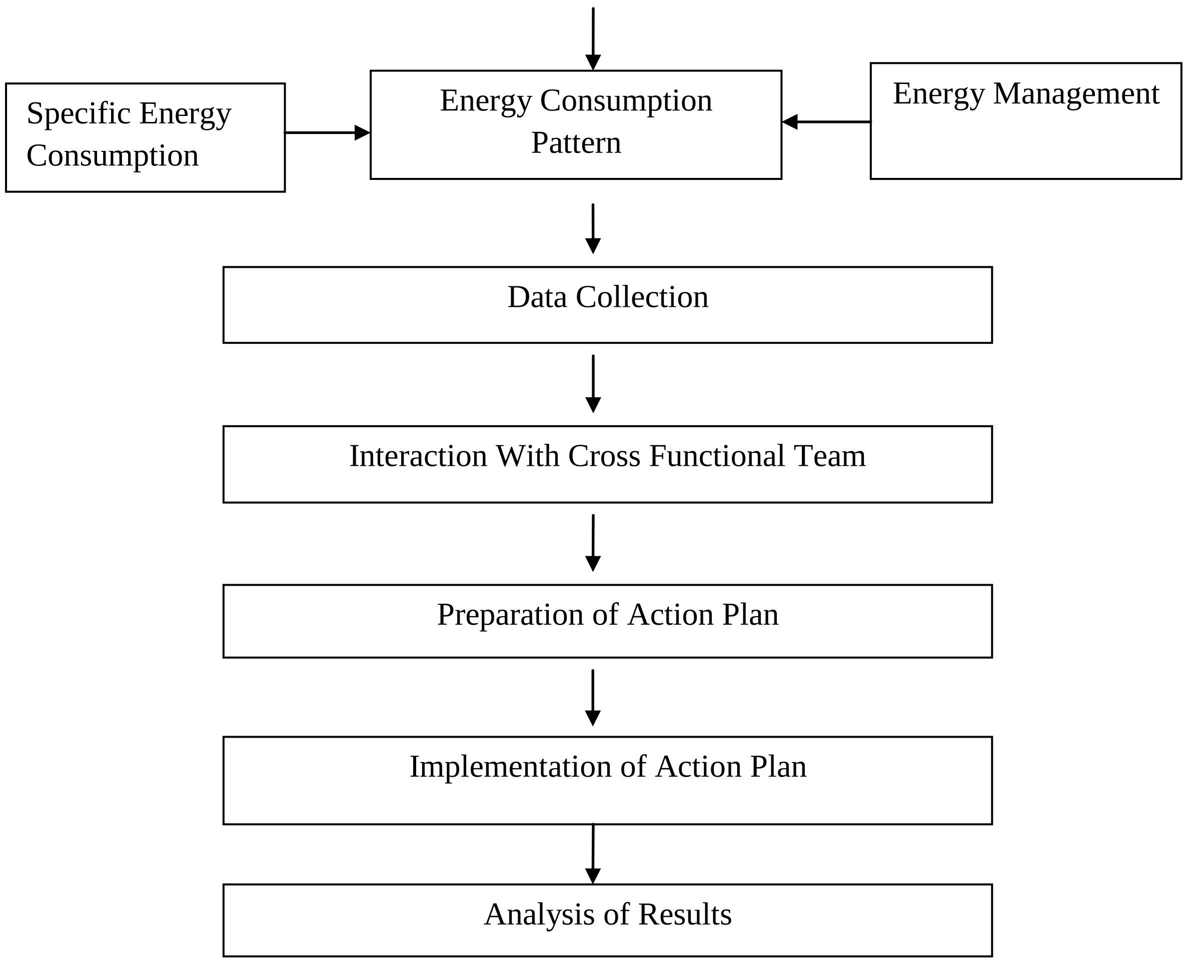

Fig.3.1 MethodologyforEnergy Consumption Studies [3]

3.1 Energy Consumption

In C.I. foundry two induction furnace having melting capacity of 2.8 ton each used for melting. Metal melted is gray cast iron and spheroidal graphite iron. Furnace consumes 74.45% of total energy.

Table3.1Energy Consumption in C.I. Foundry for Induction Furnace

Sr.No.	Consumption	Units(kWh)	Percentage
1	Furnace	364808	74.45
2	New line	77778	15.87
3	Old Foundry	10425	2.1276

4	Cooling Pump	31262	6.38
5	Other	5701	1.16

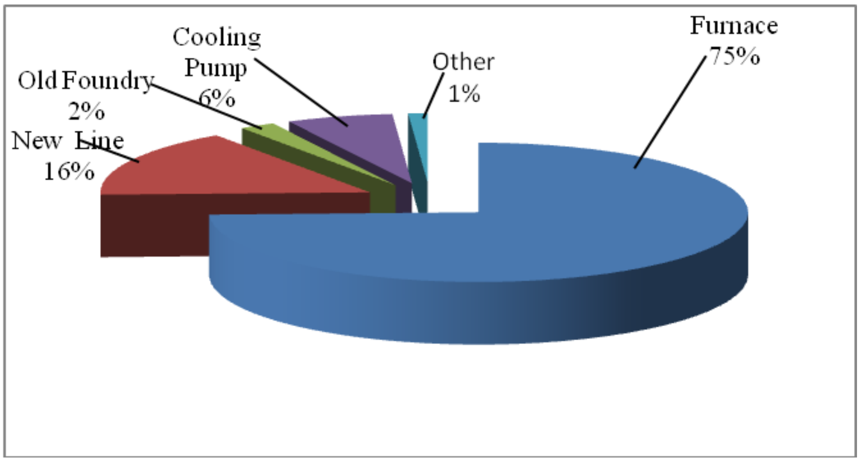

Fig. 3.2Energy Consumption in C.I. Foundry for Induction Furnace

Among these largest amount of energy to the tune of 65 – 75% of the total foundry energy is consumed in melting operation. Cycle time required for melting operation is also important parameter. It is depends upon power input, raw material and activities related cycle time such as charging, de-slagging, composition adjustment. For induction furnace energy efficiency depends on the effectiveness of lining material and cooling system. Holding of material reduces furnace lining life consumes more power this happens because of breakdown in the production line and improper scheduling of furnace. For cupola furnace energy efficiency depend upon air flow rate through blower, size variation in coke and raw material, synchronization between induction furnace and cupola furnace for duplexing operation.It was decided to focus on furnace area in order to reduce energy consumption.

3.2 Heat Loss Calculation

In order to find the heat model of the furnace, we use the heat balance equation of the furnace for consideration. The pattern of heat balance equation is as follows.

Heat input = Heat output + Heat loss

Upon considering the heat losses (heat), they consist of the heat losses from transferring the heat from furnace wall to the coil, the heat losses from radiation at the furnace, heat losses from the heat induction of the cooling water system, and other heat losses. The mechanism for the heat losses depends on the temperature and upon considering the heat losses (electricity). The characteristics of the losses depend on the volume of electricity and resistance [24]. Table 3.3 shows that materials used for furnace charging.

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Heat input = 1700 kW

Table 3.2Materials for Furnace Charging

Sr.No.	Material	Weight(Kg)
1	Runner Riser of cast iron	1270
2	M.S. Scrap	525
3	Pig Iron	1100
4	Ferrosilicon	20
5	Ferromanganese	5
6	Petroleum Coke	18

M= Mass (Kg)

L= Latent heat (kJ/kg)

Cp= Specific heat capacity (kJ/Kg K)

Mw= Flow rate of cooling water (kg/sec)

Cpw= Specific heat capacity of water (kJ/KgK)

T1= Temperature of liquid cast iron (K)

T2= Temperature of solid cast iron (K)

Δt = Melting time (sec)

R= Heat resistant of furnace lining (kW/K)

ε= Emissivity of ramming mass

σ= Stefan Boltzmann constant = 5.669 x e-8 W m−2 K−4

Heat given to Cast Iron

$$QCI= \frac{M \times L}{\Delta t} + \frac{M \times Cp \times \Delta T}{\Delta t} \qquad \text{.. (3.1)}$$

$$QCI = \frac{1270 \times 209}{3600} + \frac{1270 \times 0.5 \times 1480}{3600}$$

QCI = 334.78 kW

Heat given to M.S. Scrap

$$QMS= \frac{M \times L}{\Delta t} + \frac{M \times Cps \times \Delta T}{\Delta t}$$

$$QMS = \frac{525 \times 272}{3600} + \frac{525 \times 0.682 \times 1480}{3600}$$

QMS= 186.85 kW.

Heat given to Pig iron

QPI= $\frac{M \times L}{\Delta t} + \frac{M \times Cps \times \Delta T}{\Delta t}$

QPI= $\frac{1100 \times 209}{3600} + \frac{1100 \times 0.54 \times 1480}{3600}$

QPI= 308.06 kW.

Heat given to Ferrosilicon, Ferromanganese and Petroleum = 18.74 kW.

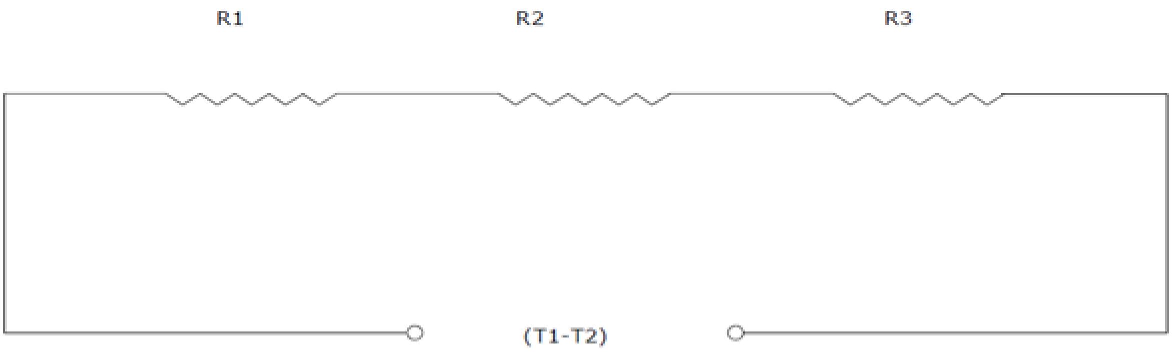

Fig. 3.3 Resistance Analogy of Furnace

Q conduction = $\frac{(T1-T2)}{\sum R}$ ………………………………………..………. (3.2)

Q conduction = $\frac{1460}{0.008938}$

Q conduction=163.33 kW

Heat loss due to radiation

Q radiation = ε × A × σ × (Ti4-To4) ………………………………………………….. . (3.3)

Q radiation = 0.45× 3.14× 0.3472× 5.667× 10-8× (15004-404)

Q radiation= 48.8617 kW

Heat loss to cooling water $= Mw \times Cpw \times \Delta t$…………………………………..…… (3.4)

$= 7.5 \times 4.2 \times 13$

$= 409.5$ kW

Heat loss in generator panel and capacitor bank = 119 kW

Unaccounted heat loss = 110 kW.

Most of energy supplied is utilized for melting of metal i.e. for sensible and latent heat. Heat loss through furnace wall is calculated by considering resistance analogy. Heat loss from furnace include conduction loss, radiation loss, heat gained by cooling water, loss in generator and capacitor bank. Also there is significant loss of energy considered as unaccounted heat loss.

3.3 Quality of Raw Material

- Quality of raw material is not good.
- Foundry return raw material having sand mass attached with it.

During the melting process, slag is generated from oxidation, dirt, sand and other impurities. Slag can also be generated from the scrap, erosion and wear of the refractory lining, oxidized ferroalloys and other sources. In a coreless induction furnace, slag normally deposit along the upper portion of the lining or crucible walls and above the heating coils.Almost every vessel that holds or produces liquid iron is lined with refractory materials and is susceptible to refractory erosion by slag. In other circumstances, slag can combine with refractory materials to form accretions that hamperproduction. The consequences of refractory problems, loss of production and the cost to replace the refractory can be serious. Thus, extending the life of a refractory lining is an important consideration.

Fig. 3.4Raw Material Used for Furnace Charging.

Iron oxide is present in large amounts in many of the slag found in foundry vessels and furnaces. Unfortunately, iron oxide is among the best solvents for refractories, and in particular it is a very good solvent for silica refractories. The vulnerability of refractories to FeO attack can be roughly judged by the amount of refractory that will dissolve in pure FeO. As seen in Table 3.4, at 1500oCMgO is the least soluble and silica is the most soluble.

Table 3.3Solubility of Oxides in FeO at 1500oC

Sr. No.	Refractory Material	Percentage
1	Al2O3	11
2	MgO	5
3	SiO2	40

IV.CONCLUSION

Present work shows that furnace is most energy consuming factor, almost 65-70 % of total energy consumed in melting division. Action plans are made by observing all processes carefully. Experiments are performed using clean raw material and bundled steel instead of unclean scrap and loose steel resulted in lower units per ton.

V.ACKNOWLEDGEMENTS

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