Improvement in Energy efficiency of melting furnace- a case study

Dr D S Padan

Foundry, Tata Motors Ltd. Jamshedpur -10

9234500367 (M)

e-mail: devinder.padan@tatamotors.com

Abstract

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. Plenty of work is being done by Foundrymen to reduce specific energy consumption in liquid metal preparation.

The present paper talks about some of the major steps taken at Tata Motors,Jsr, Foundry to reduce electric energy consumption specially in Medium frequency furnace that include improved lining material, scrap charging sequence, furnace operation, sampling, innovation in metal tapping and transfer, changes in production scheduling etc. This has resulted in reduction of specific energy consumption by about 50 KWH per MT of liquid metal , thus achieving a benchmark level of 525 KWH per MT and an annualized saving of more than Rs 1 Crore.

Key words: Specific energy, medium frequency furnace

Introduction

Foundry is one of the most energy intensive metallurgical industries. 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. On the other hand today the whole world is frightened of climate change and global warming due to CO_2 generation from burning of fuel as source of energy or for producing electricity. Looking into today's scenario, it becomes very essential for a Foundrymen to look for means which can bring down the energy consumption in melting operation significantly by efficient and optimal running of furnaces. This will not only reduce the cost of energy but also add to revenue thru sale of carbon credits. Plenty of work is being done by Foundrymen in this direction where the ultimate aim is to reduce specific energy consumption in liquid metal preparation. In the same line TML GI Foundry consisting of induction furnaces has worked a lot. The present paper deals with energy efficiency improvement measures specifically to induction melting of grey iron with some of the actions taken at TML Foundry recently which has given fantastic result.

Measures to improve energy efficiency of melting furnace

Type of furnace

Commonly two types of melting furnaces are used in Foundries- Cupola and induction furnace. Up gradation of cupola with Divided blast arrangement has given substantial saving in energy through reduction in coke consumption. In Induction melting, medium frequency furnace is found to be more energy efficient as compare to line frequency furnace. The salient feature of medium frequency furnace is its high rate of power input resulting less melting time. It can be run as batch type where full metal of a heat can be tapped out and the next heat can be started with solid charge making it more energy efficient than line frequency furnace.

Furnace lining

Lining material, thickness and its sintering play important role in energy saving. Thick lining reduces furnace volume and hence the metal output resulting high specific energy consumption. Thin lining, though it improves the power density, promotes heat loss from the side wall. Lining material with high thermal conductivity causes more heat loss. Lining material with long sintering cycle time consumes much energy for the first heat to get ready. Improper lining causes premature failure. Therefore it is important to do lining as prescribed by the furnace manufacture to get optimum result for energy consumption. Use of pusher block to remove old lining in place of manual breaking contributes in reducing cycle time of lining hence overall specific energy per MT of liquid metal.

Scrap charging

Size of scrap is an important parameter in reduction in energy consumption. The scrap charge should be as dense as possible. Lesser the air pocket between scrap pieces, more is the power density, higher the heat conductivity, faster melting with least energy consumption. It is better to use small pieces of scrap to get optimum result. Weighment of scrap in every heat to maintain proportion of charge mix is required for consistency in quality as well as energy consumption. Scrap should be free from rust, sand etc. to avoid formation of more slag causing heat delay hence high energy consumption. Scrap should be charged continuously as the melting proceeds. Continuous charging helps in preheating the scrap at the top. For off days furnace should not be left empty rather it should be charged to full level to utilize heat content of the furnace.

Power input

Furnace should be run at maximum power since beginning. There are some misconception of running furnace at low tap initially and then gradual increase to higher tap. Maximum power input increases rate of melting and hence reduces cycle time of a heat. Power factor to be maintained near to one. Drop of voltage from the source also to be monitored for better energy efficiency.

Deslagging and sampling

As the furnace is full with molten metal and has attained temp 1350 -1400 Oc deslagging should be done. Prior to it slag removing tools should be brought near to furnace and kept ready. Complete removal of slag is necessary to avoid slag deposition on lining with time reducing furnace volume and hence the metal output. After deslagging sample should be taken and sent to chemical laboratory. Use of Carbon equivalent instrument gives faster estimation of bath composition hence shortens the heat time.

Superheating of bath

Unnecessary superheating of metal to high temperature costs to energy significantly. Depending on final pouring temperature of a component and temperature loss during transfer of metal to pouring zone, superheating temperature should be decided. In every heat metal bath temperature should be measured and monitored to get optimum energy saving.

Transfer of metal

Once metal is ready for tapping there should not be single minute delay in it. Metal carrying ladles either hanging on crane or vehicle should be absolutely ready. After the tapping there should not be any obstruction in movement of ladle. It is to be ensured that transfer ladle is adequately preheated. It is better to take out metal completely in one go for early start of next heat. In case of line frequency furnace at least 2/3 rd heel metal to be maintained in furnace for faster melting of scrap in next heat.

Buffer stock

Due to product mix of light and heavy castings, situation arises when rate of metal consumption is less than the rate of metal generation. In such situation there is all chances of metal held up in furnace causing wastage of energy. It is better to have a holding furnace as buffer stock in between melting and pouring to avoid such situation. Holding of metal also helps in consistency of metal chemistry and temperature through homogenization of metal with some variation coming from melting furnace.

Production scheduling

Appropriate production plan should be made for equalizing the metal load in all shifts. Non uniform distribution of production cause under utilization of furnace in a particular shift, metal held up etc consuming high energy unnecessary. Shop should work on pull theory. Production planning should be such that he rate of metal consumption is higher than the rate of metal generation.

Preventive maintenance

A well defined preventive maintenance schedule with frequency to be made and adhered to avoid unwanted in between breakdowns of furnace. Besides furnace, PM schedule to be made and followed for other equipments connected to furnace eg crane, scrap charger etc.

Use of tools like TPM, Kaizen, 5 'S'

Total productive maintenance (TPM) has become very popular tool in reduction of breakdowns drastically. Out of 8 pillars of TPM, autonomous maintenance usually done by operator himself helps significantly in up keeping of equipments. Kaizen helps in following various processes sequentially. 5 'S' helps in better housekeeping and safety at the working floor. These tools ultimately contributes significantly in reducing the heat time and hence reducing the specific energy consumption.

Human

Human activity plays very important role in melting operation. Due to comparatively hotter area of work, by nature some people are reluctant to follow the process sequentially and timely which affects the out put of the furnace adversely. Motivation to them by area in charge helps in improving the situation. Change of working area or rotation can help to achieve the best performance with maximum output. Training and retraining on energy saving techniques, getting maximum out put from furnace is required.

Practice followed at TML Foundry

TML Foundry consists of Medium frequency furnace of capacity 5MT and power rating of 4 MW. Material used for lining is silica based. Height of bottom and lining wall thickness are 9"and 4" respectively. Sintering cycle as prescribed by OEM is followed which takes about 14 hrs. Scrap of size 8-10 inches is used. Weighed charge is put in furnace continuously by mobile charger. Initially steel scrap is added along with carbonaceous material later clean Foundry return is added along with ferro silicon. Charge ratio is maintained in every heat. Furnace is run at maximum power right from the beginning. Time to time poking is done to avoid any bridging of scrap at the furnace top. After the scrap is melted to full level of the furnace, complete deslagging is done at metal temperature reaching to 1400 OC approx. Subsequently CE is checked and sample is sent for chemical analysis. Super heating is done near to 1500 Oc. Temperature is checked in each and every heat to monitor superheating. Once metal is ready tapping is done.

Some recent improvements in melting operation

Use of two metal transfer vehicles in place of one vehicle to tap metal from furnace

5-5.5 MT Metal is tapped from furnace in two parts using ladle mounted on vehicle. Earlier one vehicle was used two times for complete tapping of metal. One ladle transfer from the furnace takes about 5 minutes. Hence the furnace waits for 5 minutes to tap second ladle. Now two vehicles are used one after another to tap metal. With this, the total tapping time has reduced and furnace availability has increased by about 90 minutes a day which gives 1 additional heat.

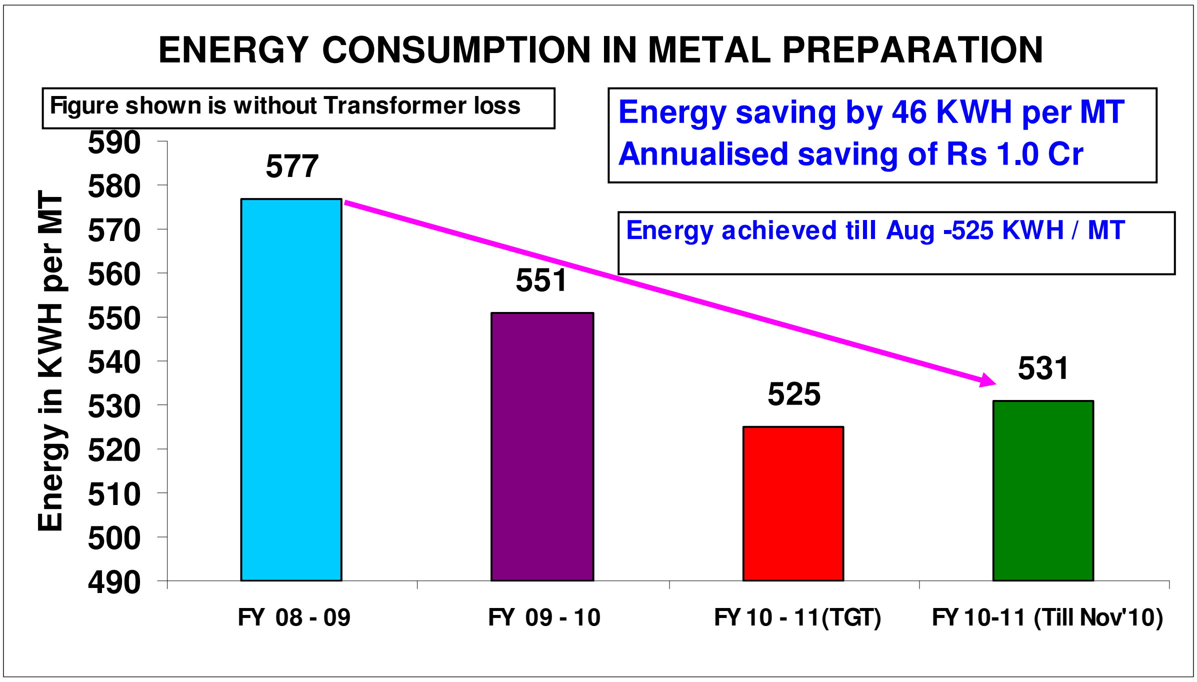
Keeping furnace lining free of slag

Slag generated during melting has tendency to stick on the furnace wall. This reduces volume of furnace hence reduces metal out put per heat. Superheating of metal is done at higher temperature and held for few minutes. This inhibits slag to deposit on the furnace lining keeping furnace clean with full volume.

Equal distribution of production load in three shifts

Production is carried out in three shifts. Earlier production plan was not equally distributed in all three shifts consistently. It ranged from 50 – 80 MT per shift. By implementation of kaizens in various areas of core shop for increase in productivity and smooth supply of cores, Day's tonnage production is distributed in all three shifts almost equally as 70-80 MT per shift. This has increased metal out put as well as reduced energy consumption considerably.

The melting operation as described above and the steps taken recently in order to reduce specific energy consumption in metal preparation has shown significant result by lowering the energy consumption by 50 KWH /MT approx. with a saving of 1 crore per annum. Graph below shows the trend of specific energy consumption in metal preparation achieved at TML Foundry.



Conclusion

Time has come to save energy for the global benefit. We as Foundrymen can contribute to it significantly by saving energy in Foundry practice especially in melting operation. Lot of scope for energy saving can be found by putting little thoughts in every step of melting process. Measures for improvement in energy efficiency in melting operation along with few examples are shared herewith which can be suitably applied to other Foundries to get maximum overall benefit.