ENERGY EFFICIENCY IMPROVEMENTS IN MELTING FURNACES

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Background
The power required in heating and melting of metals in all types of metallurgical units is the main area in which 60% to 75% of the total power is used in the unit. Hence any energy conservation activity should concentrate in the melting area so that considerable amount of energy is saved. This paper discusses various units like the steel plants and foundries where metal is melted and suggestions are given where energy conservation measures can be applied to save considerable amount of energy. The paper covers the foundry operation in more detail as foundries are mostly in the SME sector and in larger numbers. It is also suggested that units requiring molten iron can relocate to a nearby place where a blast furnace is located so that molten metal can be transferred to the point thereby saving almost 350 to 450 units of electrical power per MT of casting made.

Introduction
The alarming situation of CLIMATE CHANGE has resulted in attracting the immediate attention by every individual and company towards optimising the scarce recourse. The production of electricity by thermal based units itself is so low and is associated with the generation of lot of fly ash. Disposal of fly ash is another major problem. The efficiency of cupola as a melting unit is very high and induction furnace as a superheating unit is also very high. Thus by employing the method of DUPLEXING in foundries, the total operation can be made energy efficient. Small activities in a foundry can lead to a considerable saving of energy. Various measures have been suggested which are practical and can be adopted without much investment. This paper deals with them in detail.

Energy Pattern in a Foundry
The energy consumption in various operations of a foundry reveals that the major consumption of electrical energy is in the melting operation.

Energy required for Melting
The theoretical energy required for melting of metals from fundamental calculations is given in Table 1. The actual power being consumed in a foundry is also given. In some cases it may be more than that mentioned in the table. This vast difference is in the operation variables and can be controlled to a large extent by proper planning.
It is clear from the table that the theoretical Energy required for melting iron is only 340kWH per Ton whereas the actual Power required is around 600 to 900 units. This vast difference is due to two factors—one inherent in the principle of melting in an Induction Furnace and the other operational. The inherent reasons in the furnace include the inefficiency in (i) Electrical Bus bar losses, (ii) Eddy Current losses (iii) Refractory losses and (iv) Cooling water losses. The operational losses are largely due to unnecessary and excessive holding of molten metal in the furnace. This will be discussed later in the paper.

**Duplexing**

This operation is to use the melting efficiency of Cupola and superheating efficiency of induction furnace. The net Melting Efficiency by Combining the high efficiency of melt down of Cupola and superheating efficiency of Induction Furnace is called the Duplexing operation. This results in the lowest cost per MT of liquid metal production.

- Cupola as a Meltdown unit is very efficient to the extent of 60 to 70%
- Induction Furnace as a Super Heating Unit is very efficient to the extent of 60 to 70%.

<table>
<thead>
<tr>
<th>Metal</th>
<th>Temp C</th>
<th>Theoretical heat kWh/T</th>
<th>Actual-Gas/Oil kWh/T</th>
<th>Actual-Electric kWh/T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>750</td>
<td>295</td>
<td>1406-2138</td>
<td>500</td>
</tr>
<tr>
<td>Copper</td>
<td>1260</td>
<td>190</td>
<td>1523</td>
<td>334</td>
</tr>
<tr>
<td>Grey Iron</td>
<td>1510</td>
<td>340</td>
<td>801</td>
<td>500</td>
</tr>
<tr>
<td>SG Iron</td>
<td>1649</td>
<td>363</td>
<td>-</td>
<td>606</td>
</tr>
</tbody>
</table>
Duplexing principle combines the high efficiency of melt down of Cupola and super heating efficiency of Induction Furnace resulting in a considerable saving to the Unit.

Casting Rejection
Casting rejection is another major area where considerable amount of energy is wasted. In fact the casting rejection at the final stage has absorbed all energy in various operations of the foundry like moulding, core making, melting and pouring, fettling, shot blasting and sometimes machining. From the energy point of view, a rejection at the machine shop is of high energy content compared to the one at the casting stage. Rejection control in a foundry is a big area and involves the study of the production process at every stage in the foundry. Preparation of Pareto Chart is a short route to identify the high rejection items and selective process standardisation will give quick result. In this method the rejection in every item reduces considerably while the steps taken will improve the general process and helps in the reduction of rejection in all the components. History cards is another effective tool to identify and follow up the performance. In this card the history of a casting is recorded from the pattern stage, methoding stage, moulding process, type of core used, the chemistry and temperature of metal poured to the process adopted in fettling is recorded. The rejection is recorded at each batch production and a PDCA technique will yield improvements at each stage. All the techniques mentioned below can be adopted individually and severally to get the desired result of lower rejection consistently.

- Pareto analysis of rejection
- Classify high rejection few and trivial many
- Study individual item and individual reason
- Actions on reason-will be general in action and helps in overall process improvement-like sand fall, cold shut etc
- Individual item-History Card is very useful

Casting Yield
Casting yield is defined as the weight of casting divided by the total weight of metal poured to the mould. This is generally presented in percentage. This virtually indicates that how much of metal is converted to saleable casting and how much comes back to the foundry as gate, runners, risers etc. Higher the Casting Yield, better is the profitability in the casting. Efforts are always made in improving the Casting Yield by employing better techniques.

- Consider a foundry with 100MT /month
- Select items to cover 40% of high volume items
- Improve the yield by 5%
- Amount saved= 40MT X 5% X 50,000/MT= Rs.100,000 per month
- The net saving for the Foundry is Re.1.00 per kg of the total output of 100MT
- The competitiveness of a foundry is decided by the energy conservation and waste reduction activities.
- One unit of energy saved is equal to three units generated
• Unit having respect for energy will survive the international competitiveness

Some of the techniques are briefly described below:

**Use of aided feeders**
One of the major developments that have taken in reducing the quantity of feeder metal required to produce sound casting is in the development of aided feeders. The aided feeder effectively increases the time of solidification of the feeder so that the feed path is kept open and availability of liquid metal is ensured for a longer time in the riser. There are two types of feeders- insulating feeders and exothermic feeders. The insulating feeder will maintain the heat in the feeder so that the cooling of feeder is avoided and the solidification time of the feeder is extended by a factor of, say, 1.1. An exothermic feeder initially supplies heat to the metal and increases the temperature of the liquid and later acts as insulating feeder and prevents the cooling of the feeder. This extends the time of solidification of the feeder significantly by a factor, say, 1.2. This implies that if a sound casting is produced by the use of 120mm diameter feeder, it is enough to use a 110mm dia insulating feeder or a 100mm diameter exothermic feeder. Thus the weight of feeder reduces considerably and the Casting Yield improves drastically.

**Use of Ceramic Foam Filters**
The use of ceramic foam filter to increase the casting yield is rarely used and is many a times considered as a secondary effect and the primary reason for use is removal of inclusions. In fact the use of ceramic foam filter has improved the yield drastically and may be that this advantage has not been thought of as the primary effect by the use of ceramic foam filters. It has been established that use of ceramic foam filters makes the molten metal flow laminar. Thus use of ceramic foam filters results in dual benefit of reducing the velocity and turbulence to make the flow laminar and the other effect is the removal of inclusions to produce clean castings. Earlier designs of gating with a longer stepped runner bar can be easily be replaced by a shorter and almost near the casting with a foam filter so that the efficiency of filtration is drastically improved and the weight of runner bar is reduced. Serious study has to be made in each component to improve the yield by employing Ceramic Foam Filters.

**Review of Gating and Feeding system, Use of softwares for methoding**
A very important step in this direction of improving the Casting Yield is systematically studying the present Gating and Feeding systems, subject it to approval by the use of software available and to make improvements. This is long drawn exercise in a existing foundry whereas the method helps in standardisation in a new foundry.

**Technical Training and upgradation**
Involvement of personnel at all levels in the operation of a foundry is very important. Continuous training in newer technologies and processes is very essential in the implementation of all schemes.