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Energy Savings in Foundries through Yield Improvement and Defect Reduction in Castings

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Abstract

Energy conservation is an important step to overcome the energy crisis and prevent environmental pollution. Casting industry is a major consumer of energy among all the industries. The distribution of electrical energy consumed in all the departments of the foundry is presented. Nearly 70% of the energy is consumed especially in the melting department alone. Production of casting involves number of process variables. Even though lot of efforts has been taken to prevent defects, it occurs in the casting due to variables present in the process. This paper focuses the energy saving by improving the casting yield and by reducing the rejections. Furthermore, an analysis is made on power consumption for melting in the induction furnace to produce defective castings and improvement in the casting yield. The energy consumed to produce defective castings in all other departments is also presented. This analysis reveals that without any further investment in the foundry, it is possible to save 3248.15 kWh of energy by reducing the rejections as well as by improving the casting yield. The redesign of the feeding system and the reduced major rejection shrinkage in the body casting improved the casting yield from 56% to 72% and also the effective yield from 12.89% to 66.80%.

Keywords: Energy, Casting yield, Feeding system, Defective casting, Melting

1. Introduction

In today's world of competitive global market, quality casting at minimum price is inevitable. Among the various factors contributing the total manufacturing cost, the energy cost contributes a major percentage for the foundries. The melting operation alone consumes nearly more than 70% of the total energy consumed by the foundries compared with all the other operations in the foundry. Generally, electricity cost is gradually increases hence the production cost is also increases. The manufacturing cost is also increasing everyday. For being competitive in the market, it is essential to reduce the manufacturing cost inside the foundries by means of adopting various measures. The energy saving is among the one, which can be achieved by means of increasing the casting yield, reducing scrap level, auditing plant operations, eliminating losses, monitoring the power consumption, controlling the super heating temperature as well as time, quick tapping of the metal from the furnace, use of clean foundry returns, quick control of chemical and metallurgical quality of the molten metal etc. In this paper energy saving without any capital investment was analysed by means of increasing the yield and reducing rejections for a SG iron grade 500/7 casting produced in a medium scale foundry using induction furnace [1-7].

Casting yield is defined as the ratio of the casting weight to the total metal pouring weight. It is a major factor in melting energy savings. The amount of pouring metal required to produce castings is reduced by means of increasing the casting yield. The energy savings can be easily achieved by pouring less metal into the moulds due to weight reduction in runners, less number of risers etc.

The effective yield includes the casting yield and rejections of the castings. This overall improvement in the yield significantly reduces the manufacturing cost besides increase in rejection levels. It is essential for the foundries to reduce defects through process control and increase the casting yield for their survival [8].

2. Methodology

The electrical energy consumed for the production of castings in all the departments of the foundry is shown in fig.1. It is clear from the fig.1 that, in particular melting department alone consumes a major part of the total energy consumed by the foundry. This study focuses on the effect of yield improvement and reduced rejections on the consumption of the electrical energy alone in the melting department. [2-7].

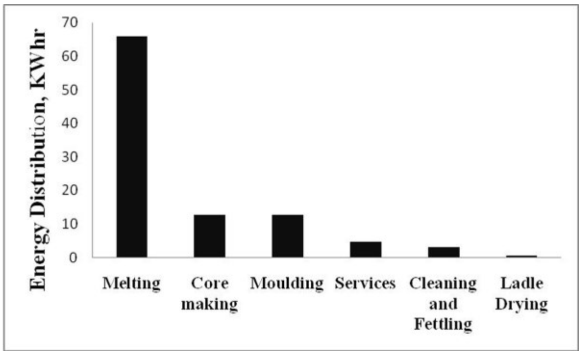

Fig. 1. Energy distribution in foundry

Foundrymen must compare themselves with others to improve their operations [8-15]. The benchmarking data for melting metals using induction furnace is given in the table1.

Table 1.
Bench marking of cast iron with induction furnace

Cast iron	650 kWh /Ton
Power factor	0.98
No.of heats/lining	600 (3 shifts) 500 (2 shifts)

Production of defect free castings is very difficult due to the presence of many variables in the production system. The causes for the rejection may be a combination of several factors rather than one factor. The benchmarking for foundry rejections due to foundry causes is 2%. By implementing the effective rejection control methods, foundrymen must keep their rejections within this limit.

Automobile SG 500/7 casting produced in a medium scale foundry using induction furnace was taken for yield improvement analysis. The drag and cope match plates with the existing feeding system is shown in the Fig 2a and Fig 2b respectively. Rejections in the foundry shop floor for the existing feeding system are 76.97% and the major defect was identified as shrinkage. Hence, the feeding system should be modified to reduce shrinkage defect [16-20].

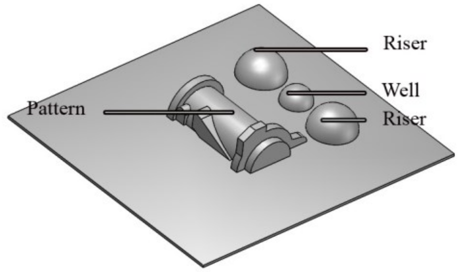

Fig. 2a. Drag pattern - existing design

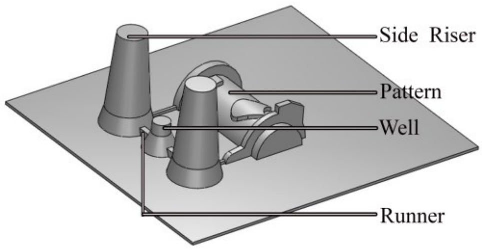

Fig. 2b. Cope pattern- existing design

The feeding system was redesigned with the help of literature [19-20] to improve the casting yield as well to eliminate the shrinkage defect in this body casting. After redesigning the feeding system, two risers were removed (Top riser and One side riser) and a tall tapered side riser alone used instead of two risers in the existing feeding system. The drag and cope match plates with the redesigned feeding system is shown in the Fig 3a and Fig 3b respectively.

Fig. 3a. Drag pattern- modified design

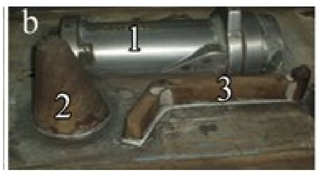

Fig. 3b. Cope pattern - modified design

The cope and drag patterns with components of gating and feeding system are shown in the Fig3a and Fig 3b respectively are,

1. Pattern (Cope)
2. Riser
3. Runner
4. Well
5. Pattern (Drag)

The casting poured with redesigned gating and feeding systems is shown in the fig 4.

Fig. 4. Casting with redesigned feeding system

3. Results and Discussion

The metal is melted in a medium frequency induction furnace. The total metal melted to produce the castings in existing and modified feeding systems is calculated by using casting yield and is given in table2. In this study, losses in the melting as well as pouring are neglected.

Table 2.
Casting yield- energy consumption

Details	Feeding System	
	Existing Design	**Modified Design**
Casting Weight in kgs	17.00	17.00
Pouring Weight in kgs	30.30	23.60
Casting Yield= (Casting weight/Pouring Weight) x100	=(17.0/30.30)x 100 =56%	(17.0/23.60)x100 =72%
Number of Castings Produced	152	180
Liquid Metal Prepared(Melting losses Neglected)	152x30.30 =4605.60 Kgs	180x23.60 =4248.00 Kgs
Average Energy Consumed in Induction Furnace (Foundry where case study was made)	660kWh/ Ton of Liquid Metal Prepared	
Energy Consumed to Melt Metal	=4.605x660 =3039.30kWh	=4.248x660 =2803.68kWh
Energy Consumed/ Casting	=3039.30kWh/152 **=19.9953kWh**	=2803.68kWh/ 180 **=15.575kWh**

The effective yield is calculated by including the rejections also. The improvement in the effective yield significantly reduces energy required for the production of castings. The effective yield and energy consumption for good casting is given table 3.

Table 3.
Effective yield –energy consumption

Details	Feeding System	
	Existing Design	**Modified Design**
Total Number of Castings Produced in Numbers	152	180
Accepted Castings in Numbers	35	167
Rejected Castings in Numbers	117 Major Rejections = Shrinkage 80nos due to improper design of feeding system	13 Major Shrinkage Defect was totally eliminated
Percentage Rejection	=(117/152)x100 =76.97%	=(13/180)x100 =7.22%
Casting Yield in Percentage	56%	72%
Effective Yield=Casting Yield x(100 – Rej%)/100	=56 x (100 - 76.97)/100 =12.89%	=72 x (100 - 7.22)/100 =66.80%
Energy Consumed for the Total Castings Produced	3039.30kWh	=2803.68kWh
Energy Consumed / Good Casting Despatched	=3039.30kWh/35 **=86.837 kWh**	=2803.68kWh/167 **=16.788 kWh**

The electrical energy consumed for the production of rejected castings in all the departments of the foundry for existing and modified feeding systems is shown in the table 4. By considering all the departments in the foundry, the energy consumed for the rejected castings is 3555.85 KWh for the existing feeding system, whereas it is 307.70 KWh for the modified feeding system. Hence by reducing the rejections, the total energy spent to produce rejected castings can be saved [2-14].

Table 4.
Distribution of energy for rejections

Sections	% Energy consumed	Energy consumed in kWh	
		Existing Design	**Modified Design**
Melting	65.8	2339.76	202.48
Core making	12.8	455.15	39.38
Moulding	12.7	451.59	39.08
Services	4.8	170.68	14.77
Cleaning and Fettling	3.2	113.78	9.84
Ladle Drying	0.7	24.89	2.15
Total	100	3555.85	307.70

4. Conclusions

The distribution of electrical energy consumed in all the departments of the foundry is presented and the melting department consumes nearly around 70% of the total energy consumed in the foundry. Defects occur in the castings even though lot of efforts has been taken to prevent them due to variables present in the production system. This paper reveals that energy can be saved either by improving the casting yield or by reducing the rejections or by the combination of both. The existing design feeder system used in the automobile body casting with rejections of 76.97% consumed a total energy 3555.85 kWh whereas the modified feeding system consumed only 307.70 kWh of energy. In addition, the casting yield improved from 56% to 72% and the effective yield also improved significantly from 12.89% to 66.80% by using the modified feeding system.

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