EXPERIMENTAL ANALYSIS AND OPTIMIZATION OF MATERIAL CONSUMPTION

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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 its, 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. Much of the work is being done by many Foundry men to reduce specific energy consumption in liquid metal preparation. Operational uncertainties create disincentives for use of recycled materials in metal production. One that greatly influences remelter batch optimization is variation in the raw material composition, particularly for secondary materials. Currently, to accommodate compositional variation, firms commonly set production targets well inside the window of compositional specification required for performance reasons.

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1. INTRODUCTION

The present work deals with some of the steps taken at JPF Metacast, Belgaum. The Foundry are required to reduce material consumption specially in Medium frequency furnace that include improved, scrap charging sequence, furnace, sampling, changes in metal composition etc. This has resulted in reduction of specific material consumption and significantly monetary savings.

2. INDUCTION FURNACE METAL CONSUMPTION

There are many metals used in one melt of induction furnace, which is around 500kgs. Different composition can be used of metal and its additives to get different grades of metal. JPF Metacast produces mainly three grades of metal, those are SG iron, pulley grade and ordinary grade, which are based on customer requirements.

The table 1 shows different addition of metal to form the required grade. The actual process varies slightly, for the component numbered 620 and 637 the amount of metal melted is around 485 kg, as the metal required for the above mentioned components is around 406 kg. The extra metal is melted due to loss of metal while pouring and melting.

The figure 1 shows the component. There are certain experiments conducted before manufacturing of this component.

Fig 1 Component

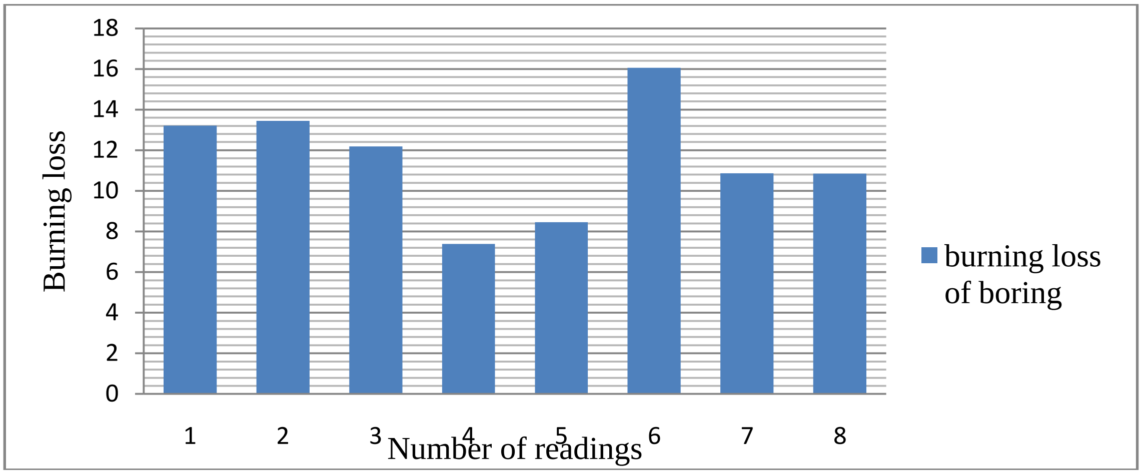
Table 1 Grade wise metallic mix for 500 kg

Sl no	Components	SG iron	Cast iron	
			Pulley grade	Ordinary grade
1	Pig iron	160 kg	100 kg	80 kg
2	MS scrap		140 kg	70 kg
3	Returns	160 kg	100 kg	150 kg
4	Boring		160 kg	200 kg
5	CRC (punching scrap)	180 kg		
6	CPC (Graphite fines)	7 kg	5.7 kg	3.8 kg
7	Silicon		3.6 to 3.8 kg	2 kg
8	Manganese		1.5 kg	0.8 kg
9	Chromium		1.8 kg	
10	Magnesium	3.4kg /250 kg		
11	Copper			
12	Inoculation	0.2%		0.15 to 0.2 %

Table 2 Metal consumption with boring

Sl no	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Units	250	256	254	252	255	258	254	258
MS scrap	140	140	140	140	140	140	140	140
Pig iron	60	60	60	60	60	60	60	60
Boring	200	200	200	200	200	200	200	200
Returns	70	71.5	60	70	70	70	70	70
Additives	13.72	13.72	13.72	13.72	12.32	13.72	12.32	12.32
Total wt	483.72	485.2	473.72	483.7	482.3	483.7	482.3	482.3
Return wt	13.8	14	10	42	35.5	0	23.9	24
Metal wasted	63.92	65.22	57.72	35.72	40.82	77.72	52.42	52.32
Bunch wt	406	406	406	406	406	406	406	406
Burning loss	**13.214**	**13.44**	**12.184**	**7.384**	**8.463**	**16.07**	**10.87**	**10.85**

The burning loss is calculated by using below mentioned formula. Higher the burning loss more will be the melting losses. These losses also effect the energy consumption of the induction furnace. The graph 1 shows the set of eight readings which shows variation in burning losses.



Graph 1 – Burning losses of current process

2.1 Calculations

- Total weight = MS scrap + pig iron + boring + returns + additives
- Bunch weight = the bunch weight of each 620 or 637 component is 203 kg
- Metal wasted = Total weight – bunch weight – return metal weight
- Burning losses = metal wasted / total weight of metal * 100
- Standard deviation(s or σ) =

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2} \quad (1)$$

X = $(x_1 + x_2 + \ldots xn) / (n-1)$ (2)

From equation 2, mean can be calculated. All the values of Burning loss from table 2 are considered as x1, x2----xn.

X = 11.56 %

From the above mean value, average of 11.56 % of burning loss was developed by sample of eight readings.

σ = 2.8 %

The above value shows the deviation of the burning loss from its mean value

That is, from the mean value of 11.56%, there is a ± variation of 2.8 %.

2.2 Improvement in Metal Consumption

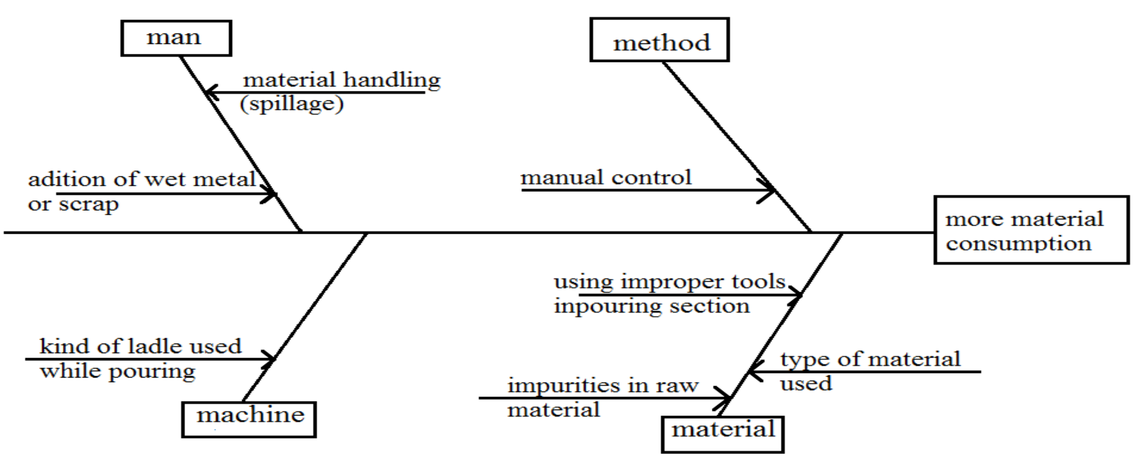


Fig 2 Fish bone diagram (Cause and effect diagram) for material consumption

3. FIRST EXPERIMENT CONDUCTED ON METAL CONSUMPTION

In the early process, it was noted that the burning loss of melting was very high. In that process MS scrap, returns and boring were main constituent of the charge melted. Some changes were made in composition of the metal to be melted. Boring was eliminated, and returns were added around 270 kg for every melt. This change was made because, boring contained many impurities like mud, oil etc. It is difficult to separate mud and other impurities from boring, which also consumes labour hours. Presence of unwanted material in boring also increases the melting loss of the induction furnace. Though boring melts faster than the other metals, presence of impurities in boring increases the time consumed for one melt.

Fig 3 Boring

Figure 3 shows the boring, in this experiment all compositions are kept same except that the boring has been eliminated and is compensated by adding extra returns.

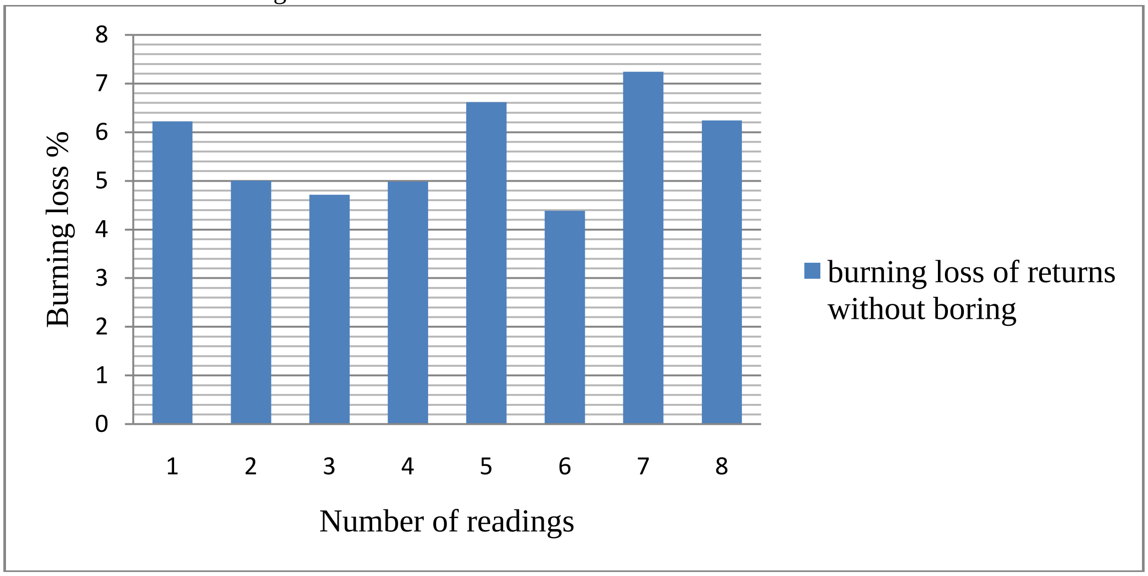
Returns is the metal got from runner, riser and other gating systems; these cannot be used directly for melting, as the return metal contains sand particles adhering to it. The returns extracted from the mould are shot blasted, by using blasting machine. The blasting machine forces a small diametric shots along with high pressured air, which when hits the metal, makes sand and other inclusions to be removed.

Fig 4 Return metal

Table 3 First composition change

Sl no	1	2	3	4	5	6	7	8
Units	253	254	252	256	251	250	256	258
Ms scrap	140	140	140	140	140	140	140	140
Pig iron	60	60	60	60	60	60	60	60
Returns	270	270	270	270	270	270	270	270
Additives	12	13.82	13.82	13.82	13.82	13.82	13.72	12.32
Total wt	482	483.82	483.82	483.82	483.82	483.82	483.72	482.32
Return wt	46	53.6	55	53.7	45.8	56.6	42.7	46.2
Metal wasted	30	24.22	22.82	24.12	32.02	21.22	35.02	30.12
Bunch wt	406	406	406	406	406	406	406	406
Burning loss	6.2241	5.006	4.7166	4.9853	6.6182	4.3859	7.2397	6.2448

The table 3 shows the composition of the experiment conducted in order to reduce the burning losses to as minimum as possible



Graph 2 Burning losses without boring

3.1 Calculation

- Total weight = MS scrap + pig iron + returns + additives
- Bunch weight = the bunch weight of each 620 or 637 component is 203 kg
- Metal wasted = Total weight – bunch weight – return metal weight
- Burning losses = metal wasted / total weight of metal * 100
- Standard deviation(s or σ) =

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2} \quad (1)$$

X = (x1 + x2 + ...xn) / (n-1) (2)

Therefore from equation 1 and 2

X = 5.677 %

From the above mean value, average of 5.677 % of burning loss is developed by sample of eight readings.

σ = 1.03 %

The above value shows the deviation of the burning loss from its mean value

That is, from the mean value of 5.677 %, there is a ± variation of 1.03 %

By this experiment, it can be seen that the percentage of burning loss has been reduced drastically

4. SECOND EXPERIMENT CONDUCTED ON METAL CONSUMPTION

In the first experiment, though the burning losses were reduced to an extent, but still burning losses were high. In the below figure it can be seen that there are sand inclusion in the metal, as the sand has high melting temperature and metal has lower melting point than sand, the sand doesn't melt in the induction furnace and consumes unnecessary electrical energy.

Fig 5 showing sand inclusion in return metal

Shot blasting process is also of no use in removing these sand inclusions. This type of sand inclusion can be reduced by while preparing mould, mould paint is applied for better surface finish, this mould paint can be applied at the riser portion of the mould, so that molten metal remains separated from mould surface this can reduce sand inclusions in metal. The riser portion is rough and uneven. The roughness of the riser portion of the mould should be reduced before the application of mould paint.

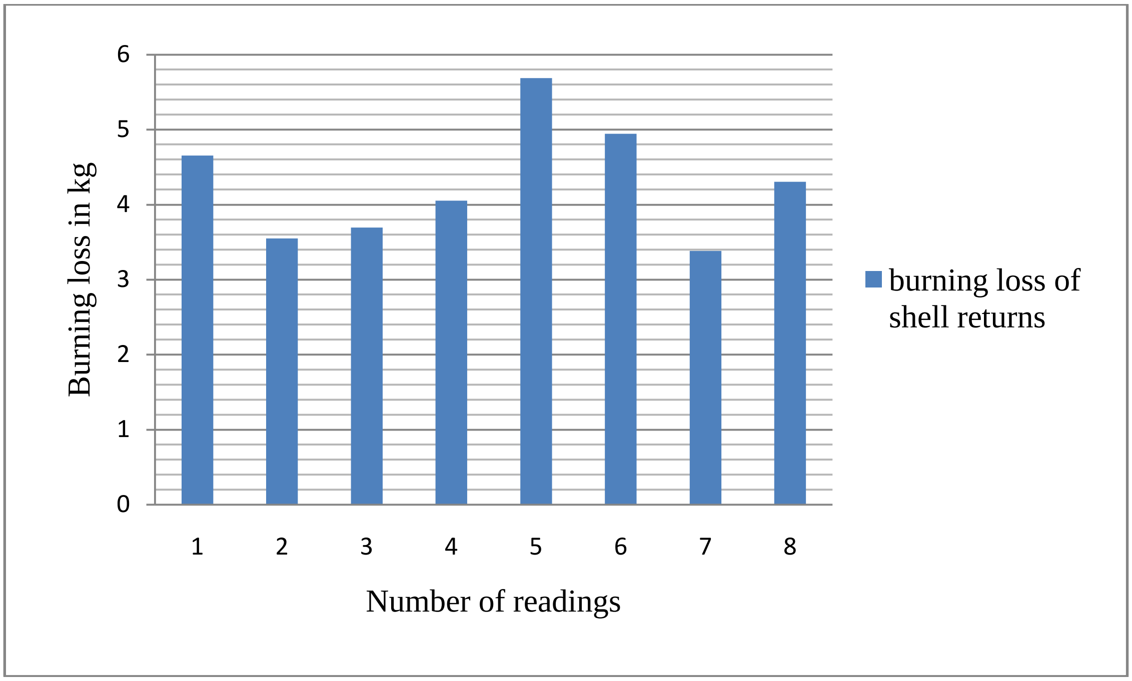
Fig 6 Shell return metal

In this experiment instead of normal returns, shell returns were used. The shell return is almost pure metal with no or very less sand inclusions.

Table 4 Second composition change

Sl no	1	2	3	4	5	6	7	8
Units	249	255	253	257	259	253	255	254
MS scrap	140	140	140	140	140	140	140	140
Pig iron	60	60	60	60	60	60	60	60
Shell returns	270	270	270	270	270	270	270	270
Additives	13.72	12.32	12.32	13.72	13.72	13.72	12.32	13.72
Total wt	483.72	482.32	482.32	483.72	483.72	483.72	482.32	483.72
Return wt	55.2	59.2	58.5	58.1	50.2	53.8	60	56.9
Metal wasted	22.52	17.12	17.82	19.62	27.52	23.92	16.32	20.82
Bunch wt	406	406	406	406	406	406	406	406
Burning loss	4.6556	3.5495	3.6946	4.0561	5.6892	4.945	3.3836	4.3041

The table 4 shows the composition of the experiment conducted in order to reduce the burning losses to as minimum as possible. Shell returns are got from shell casting process, and sand employed in this process is Green sand. As the packing density of the green sand is high compared to CO2 sand, the casting and returns got from this process are of much better surface finish. Producing castings by using green sand process is slow process, therefore CO2 process is mainly employed for faster production.



Graph 3 Burning losses with shell returns

4.1 Calculation

- Total weight = MS scrap + pig iron + shell returns + additives
- Bunch weight = the bunch weight of each 620 or 637 component is 203 kg
- Metal wasted = Total weight – bunch weight – return metal weight
- Burning losses = metal wasted / total weight of metal * 100
- Standard deviation(σ) =

$$s = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(x_i - \overline{x})^2} \qquad (1)$$

$$\bar{x} = (x1 + x2 + \ldots\ldots xn) / (n-1) \qquad (2)$$

There from equation 1 and 2

$\bar{x}$ = 4.284 %

From the above mean value, average of 4.284 % of burning loss is developed by sample of eight readings.

σ = 0.78 %

The above value shows the deviation of the burning loss from its mean value

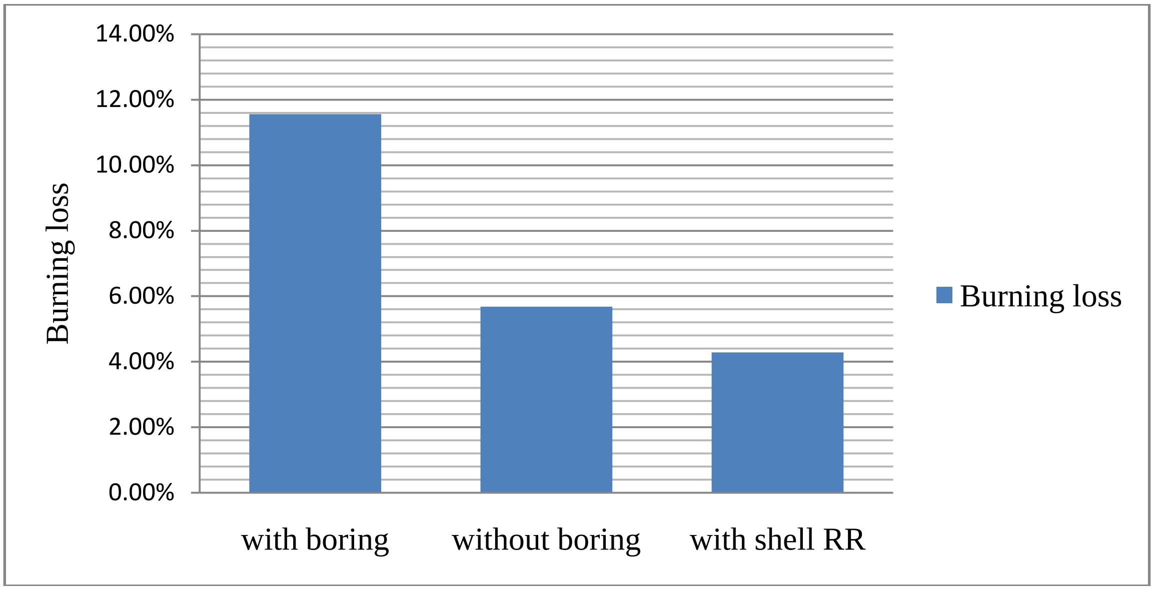
That is, from the mean value of 4.284 %, there is a ± variation of 0.78 %

By this experiment, it can be seen that the percentage of burning loss has been relatively reduced.

5. SUMMARY OF METAL CONSUMPTION

Table 5 Summary of metal consumption

	with boring	without boring	with shell RR
Average burning loss	11.56%	5.68%	4.28%
Standard deviation	2.80%	1.03%	0.78%



Graph 4 Summary of burning loss

Table 4 and graph 3 shows the relative reduction in burning loss. By the experiments conducted it is possible to reduce the burning losses from an average of 11.56 % to an average of 4.2 %.

The limit of burning loss set in JPF Metacast is around 3 %. There are other unaccounted loss of metal such as spillage of metal while pouring in to mould and ladle, the wetness of metal and many other factors.

6. CONCLUSIONS

- The initial consumption of metal was high. The average burning loss earlier was 11.56%. In the first experiment, the burning loss was reduced to the average of 5.68%. In the second experiment, the burning loss was reduced to 4.28%.
- The burning loss generated now is also high, as the maximum burning loss which is to be got is 3%.
- Different composition of metals can be used without altering the grade of metal, so as to reduce the burning losses to minimum as possible.
- Spillage of metal also incorporates the burning loss, as the burning loss is derived from loss of metal before pouring and after pouring, therefore it is very much necessary to reduce the spillage of metal while it is melted form.

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