6 DISCUSSION

The present metal to coke ratio of 1: 4 or 1:5 is the normal practice in use at the Government Factory. This gives higher unit cost of the cast products. The correct refractory selection and the oxygen enrichment can be positively affected to increasing metal to coke ratio and decreasing the cost of the cast products. These two improvements tend to reduce coke consumption and enhance the energy efficiency.

Coke provides the energy for melting and super heating of the Cast iron. The amount of chemical energy release by burning of coke will determine the reaction between coke and gases O_2, Co_2 and H_2 O. The main barrier of the reaction is ash produced by the burning.

Coke Oxidation by gases:

An exothermic reaction

$$C_{coke} + O_2 \quad CO_2 \qquad \Delta H^0 = -33.6\ KJ/g^0C$$

An Endothermic reaction of gasification by CO_2 and H_2O

$$CO_2 + C_{coke} \quad 2CO \qquad \Delta H^0 = +13.56\ KJ/g^0C$$

$$H_2O + C_{coke} \quad H_2 + CO \qquad \Delta H^0 = +\ 9.99\ KJ/g^0C$$

The above exothermic reaction is the main energy supplier to melt the cast iron. The heat of combustion of coke carbon is -33.6KJ/g^oC at 250^0C. Coke reacts with Oxygen 105 times faster than with CO_2 or H_2O. Coke is so reactive with O_2 at above 850 ^0C the reaction is governed by the rate of oxygen diffusion to the coke surface. (American Foundry socity Cupola Hand Book, 1999)

The oxygen enrichment supplies more oxygen at elevated temperature to increase the diffusion rate and accelerate the exothermic reaction. It will give more energy for better melting. Metal to coke ratio decides the spout temperature and the carbon pick up. Low metal to coke ratio gives high spout temperature and the steel content in the metal charge can increase. High metal to coke ratio gives low spout temperature and low carbon pickup. Oxygen enrichment increases the metal to coke ratio. It is possible to increase it to 20% by 3% of oxygen enrichment.As shown in Table 5.8, the metal to coke ratio increases by 38.3% as a result of the total improvement.

The metal rate is determined by the metal to coke ratio and rate of combustion is governed by oxygen driving force. 3% oxygen enrichment gives 20% increase of wind rate. It rise the flame temperature and increase the melt rate. 3% oxygen enrichment will reduce approximately 20% of coke consumption and increase the melt rate proportionately. The 20% more metal can melt by same coke when 1% of oxygen enrichment. As shown in Table 5.6, melt rate is increased by 27%

Metal to coke ratio and combustion condition in cupola are directly related to the temperature inside the chamber. The continuous supply of the oxygen will results in the increase in temperature unless the coke supply is adjusted. Therefore a specified value of taping temperature and melt rate can be manipulated by metal to coke ratio and oxygen enrichment. The combustion temperature and melt rate can be maintained in an economical way due to oxygen enrichment .Silicon losses is also minimized by oxygen enrichment. Another advantage is the reduction of the additives such as ferrosilicon by 50% with oxygen enrichment. The oxygen enrichment reduces the capital investment in pollution control system, man power, and raw material and scrap losses.

The analysis of the cast iron product before and after improvement and the results of the trials indicate how the improvement took place.

According to the table 5.9 the average improvement can be describe as below.

Average saving

Coke Saving : 586.6 Kg

Increase in Melt Rate: 247 Kg/Hr

Increase in spout Temperature: 56 ^{0}C

Increase in Coke to metal Ratio: 1:4.636 to 1:7.66

The typical experimental figures after tuyere injection of oxygen enrichment are,

Coke saving 4-15%, Melt rate increase 30% +, Spout temperature increase 20 -60^{0}C
According to the results of the improvement, it tallies with the typical experimental valve except the coke saving. This can occur due to the quality of the coke and the influence of proper refractory selection.

The carbon and silicon enriched pig iron is expensive material. But lower grade cast iron scraps can be used by oxygen enrichment. The temperature and the heat transfer will increase due to oxygen enrichment. Then the thermal efficiency of the combustion zone also increases. Therefore steel scraps can easily be melting. The net results will be the reduction in cost of the cupola charges.

Time and temperature are the main factors for erosion of cupola lining. The increase in spout temperature can increase the wear of cupola lining. When temperature is kept at the normal level by reducing the blast rate or the coke charge the lining erosion can minimized. By oxygen enrichment the above result can be achieved.

Sintering ability and the lining thickness of the refractory brick are the important parameters for the energy saving. Thick lining wastes energy and reduces the cupola volume. Thin lining wastes the heat energy. The long sintering cycle of the refractory consume more heat energy for initial heating. Improper lining causes premature failure.
The customized bricks as shown in Figure 4.2(b) can be purchased from the manufacture on order. The furnace volume was increased; hence metal output needs low energy consumption. The analyzing of the result of Table 5.3 and Table 5.4 is shown that the correct selection of cupola lining is increased the volume of cupola from 0.37m^3 to 0.46m^3.Hence coke consumption is reduced by 18.9% and wastage is reduce from 7.5 – 5.9 %. Output is increased by 19.5%.

The improvement results were shown the reduction in coke consumption, increase in spout temperature and increase in melt rate. It was influence the quality of the casting and the reduction in cost. The low quality charging raw material and coke can be used for quality cast products by introducing oxygen enrichment. It is another advantage to cost reduction. The oxygen in blast air will be the prime driven force to reduction of coke consumption and increase in melt rate in cast iron products. Therefore oxygen is the cost saving tool by allowing in decreases of charged coke, partially substituting lower cost anthracite for more expensive foundry coke, replacing pig iron with less expensive metal charge and decreasing ferroalloy requirement. The varying of oxygen level in blast air provides with an extremely flexible tool to controlling the cupola operations in spite of occasionally unforeseen changes in the quality of coke and metallic charge, humidity and temperature.

The cupola lining is directly involved in unit cost. The abrasion, spalling, chemical, mechanical and temperature effect are the main factors that effect in repairing of the cupola linings. The correct selection of refractory in each section of the cupola was reduced the maintenance cost and unit cost of the products. The above improvements cause a reduction in the unit cost of production from Rs.300.00 as at present to Rs. 220.00. This was benefited to the reduction in the overall cost of the all casting products of the Government factory.

The present trend of the cast iron demand in the local market is lower due to the new arrival of ductile iron in to the Sri Lankan market.In beginning of the ductile iron era the cost of the product is 1/3 of the cast iron and now it hits to 3 time of the cast iron product. The main reason is the poor quality in cast iron products in the Sri Lankan market. Most of the ductile iron products are imported to the local customer for their requirement of cast iron products. The reduction in the cost and improving the quality of casting will increase the demand in cast iron products in the Sri Lankan market.

7 CONCLUSIONS

Oxygen enrichment and correct refractory selection was enhanced the energy efficiency and quality improvement of the cast products of cold blast cupola. The lining of cupola with different types bricks in various zones reduced the number of annual repairing sequence from 6 to 4 hence reduce the cost by 38%. The 1% of oxygen enrichment increased the melt rate by 43%. As a result the cost of the cast iron products of conventional coal blast cupola at Government factory reduced by 27 % and increased the metal to coke ratio is from 4:1 up to 7:1.

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