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Modification in Manufacturing Process of Sinter Plant Roll Liner used for Coke Crushing

P. Pavani, C. Naga Kumar, M. Prasanthi, Y. Renuka
Assistant Professor
Vidya Jyothi Institute of Technology

ABSTRACT:

In Sinter Plant, sinter is used as charge for Blast Furnace. Sinter is a conglomeration of coke fines, dolomite fines, lime stone fines, constitutes 80% of the charge for Blast Furnace in which the coke is crushed in rollers known as Bottom Roll crushers consisting of a roll liner mounted in its hub. Vertical castingprocess with single piece pattern and bottom gating system is employed to manufacture this roll liner and there is more time involved in turning operation due to the draft allowance provided, thus the machining cost also increases. Horizontal casting process with split piece pattern and parting line gating system is introduced, so that the draft allowance to be provided is reduced and in turn the machining time and cost are also reduced, as a result the mass of the casting metal and cost reduces.The work involves the calculation of design parameters with the help of empirical relations and the modeling and of horizontal casting process using modeling software CATIA V5.

KEYWORDS: Casting, Sinter, Roll Liner, Manufacturing

INTRODUCTION

The function of the Sinter Plant is to supply the blast furnaces with sinter, a combination of blended ores, fluxes and coke which is partially 'cooked' or sintered. In this form, the materials combine efficiently in the blast furnace and allow for more consistent and controllable iron manufacture. Materials enter the sinter plant from storage bins. The moisture content of the coke is measured in the strand roll feed hopper and used to trim the secondary water flow rate. The mix permeability is also measured and used to modify the amount of water required

In Coke Crushing plant, the uneven sizes of coke are crushed into a fine size range of 0 to 10 mm. For the purpose of crushing coke rollers are used known as Bottom Roll Crushers. A set of 4 Rollers as 8 units are arranged with two rollers at the top and two rollers at the bottom. The coke is charged to the top rollers and fine coke of required size exits from the bottom rollers. This process of coke crushing is a continuous process and hence the rollers subject to wear continuously. Hence there is a need to replace these rollers at regular intervals.Bottom Roll Crusher consists of a roll liner mounted on its hub as shown in figure.

Figure1 Roll Liner mounted on its hub

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As the process of coke crushing is a continuous process the roll liner will be subjected to wear continuously and every time this roll liner is to be replaced at regular intervals. Casting is a process in which molten metal flows bygravity or other force into amould where it solidifies in theshape of the mould cavity. The term casting is also applied tothe part that is made by this process.

EXPERIMENTAL METHODS:

PROCESSING:

In Horizontal casting process, Splitpiece pattern is used to prepare the mould in the moulding flask.One half of the pattern is placed in the drag part and the other half of the pattern is placed in the cope.

CORE:

The core along with core prints is placed in the mould. Core prints are the extension given to the core to support the core in the mould. The length of the mould is 780 mm & the Diameter is 930 mm.

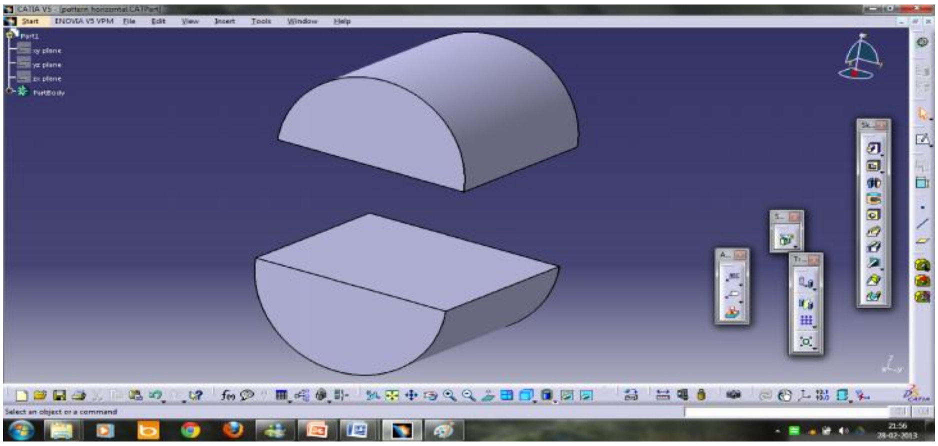

Figure 2: Split piece pattern for horizontal casting process model in CATIA

GATING SYSTEM DESIGN

One of the objectives of the gating system design is to fill the mould in the smallest time. The time for complete filling of a mould termed as pouring time, is a very important criterion for design. Too long a pouring time requires a higher pouring temperature and too less a pouring time means turbulent flow in the mould which makes the casting defect prone. There is thus an optimum pouring time for any given casting.

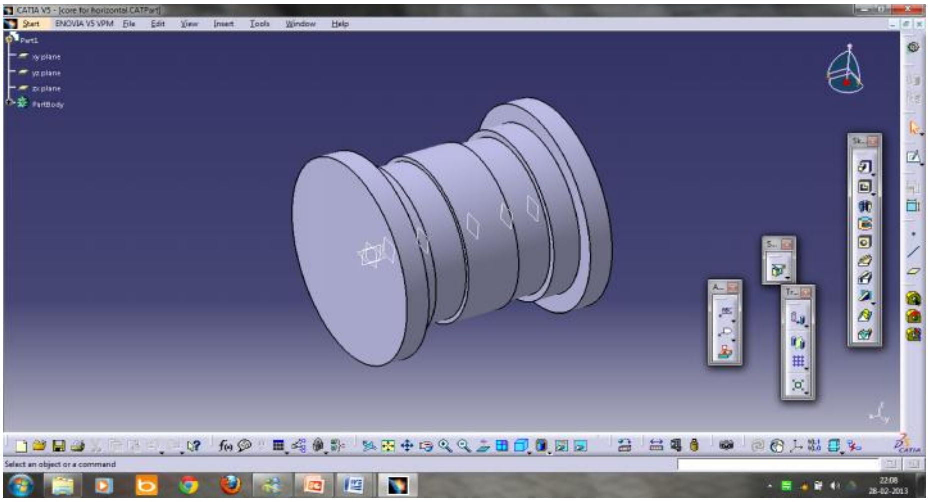

Figure 3: Model of core and core prints

Pouring time = K x $\sqrt[3]{\text{AveragecastthicknessXmassofpouringmetal}}$

Where, K = Constant which depends on thickness of casting.

For thickness > 90 mm, K = 1.9

Average cast thickness = $\frac{1 \quad +8}{2}$= 95 mm.

Mass of pouring metal = 1.4 X mass of the metal required for casting.

Mass of metal required for casting = (Volume of casting) X (Density of steel)

$=\frac{\pi}{4}(d_1^2 - d_2^2)$ h X density of steel

$=\frac{\pi}{4}(930^2 - 700^2)$ X 720 X 7800 X 10^{-9}

= 1653 Kgs.

Mass of pouring metal required = 1.4 X (mass of metal required for casting)

= 1.4 X 1653

= 2315.04 Kgs.

Pouring time = K x $\sqrt[3]{A \qquad hic}$

= 1.9 X $\sqrt[3]{95\ X\ 2315.04}$

= 114.67 Seconds.

Therefore, the time taken by the molten metal to fill the casting = 114.67 seconds.

CHOKE AREA

The choke area can be calculated using Bernoulli's equation as **A =** $\frac{m}{\rho \quad \sqrt{2g}}$

Choke area = $\frac{2 \quad .0}{7 \quad X\ 1 \quad .6\ \ X\ 0.1\ X\sqrt{2\ X\ 9.8}\ \ X\ 0.5}$= 7.934 X 10^3 mm^2

Therefore, choke area to be maintained = 7.934 X 10^3 mm^2

$\frac{\pi}{4}d^2$ = 7.934 X 10^3, d_c = 100.51 mm

Choke diameter = 100.51 mm

The sprues should be tapered down to take into account the gain in velocity of the metal as it flows down reducing the air aspiration.

Sprue diameter at top = 152.273 mm

Spruediameter at choke = 100.51 mm

Sprue base well area to be maintained = 50.179 x 10^3 mm^2

Depth = 2.5 times width of the runner = 145mm

GATING RATIO:

The gating ratio refers to the proportion of the cross-sectional areas between the sprue, runner and ingates and is generally denoted as sprue area: runner area: ingate area. Gating ratios recommended by various theoreticians in the literature vary over a wide range.A non-pressurized gating system, wherein the area of runners and gates is larger than that of the sprue i.e.,1:2:2 or 1:4:4, offers a rapid filling, the low velocity metal stream results in materially reduced mould erosion.

CROSS SECTIONAL AREA OF INGATE:

F = $\frac{G}{0.3\ \ X \quad \sqrt{H}}$

The flow coefficient 'u' represents the inverse value of the resistance offered by the mould and the running system. Values applicable to steel castings are tabulated as below.

Type of mould	Resistance of mould		
	High	Medium	Low
Green sand	0.25	0.32	0.24
Dry sand	0.30	0.38	0.50

Table 1 Values applied to steel castings

$F = \frac{2 \quad .0}{0.3 \ X\,0.5 \ X\sqrt{5 \quad .7 \ X\,1 \quad .6}}$= 171.09 cm^2 ~ 172 cm^2

There are two ingates for the casting and as such cross-sectional area of each ingatewill be 86cm^2.Two runners of rectangular cross section are used with a dimensional proportion of 2:1.

For gating ratio 1: 2: 2

i.e., Sprue area: runner area:ingate area = 1: 2: 2

Therefore, Runner area = ($\frac{i1}{2}$) x 2= 8600 cm^2

Therefore, the runner dimensions of rectangular cross-section with 2:1 proportion will be 150mmwide and 58mmthick.

For gating ratio 1:2:1.5

i.e., spruearea : runner area : ingate area = 1:2:1.5

Therefore, Runner area = ($\frac{i1}{1.5}$) x 2= 11500 mm^2

Therefore, the runner dimensions of rectangular cross-section with 2:1 proportion will be 155mmwide and 75mmthick.

VOLUME CALCULATIONS:

MASS OF THE METAL REQUIRED:

We neglect the internal projections and consider it as a hallow cylinder.

Volume of the hollow cylinder = $\frac{\pi}{4}(d_1^2 - d_2^2)$h

From the figure, outer diameter, d_1 = 930mm, Inner diameter, d_2 = 700mm

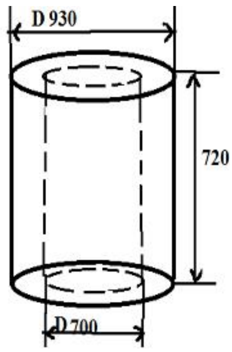

Figure 4

Therefore, total volume of casted part =$\frac{\pi}{4}(930^2 - 700^2)$ x 720= 212 x 10^{6}mm^3

Mass of the metal required = Volume of the metal x Density of the metal
= 212 x 10^6 x 7800 x 10^{-9} (density of steel = 7800 kg/m^3)= 1653.6 Kg.

COST CALCULATIONS:

Considering cost of one kg of steel = Rs.40/- (approx.)
Cost of 1653.6 Kg of steel = 1653.6 x 40= Rs.66, 144/-
Therefore, total cost of casting metal required = Rs.66, 144/-

MACHINING CALCULATIONS:

Cutting speed, $C_s = \frac{\pi}{1}$

C_s = 80 m\min (used in VSP)

$80 = \frac{\pi * 9 \quad * N}{1}$

N = 27.381 rpm

Feed =0.31 mm/rev (according to machine specifications)

For rough castings, depth of cut, d = 5 mm
For single pass, material removed = 10 mm
Hence, Total material to be removed = 30 mm
Therefore, Number of cuts = 3

Time taken for one cut $= \frac{l\epsilon \quad h}{f \quad * N} = \frac{7}{0.3 \ *2 \ .3}$ = 84.82 min

Time taken for 3 cuts = 254.46 min
= 4.241 hours

Machine hour rate = Rs. 2556 /- per hour
Total cost for Turning operation = 4.241 x 2556
Therefore, Total cost for turning operation = Rs. 10,839.996 /-

TOTAL COST CALCULATIONS:

METAL COST:

Considering cost of 1 kg of steel = Rs.40/- (approx.)
Cost of 1653.6 Kg of steel = 1653.6 x 40 = Rs.66,144/- **MACHINING COST:**
Total cost for Turning operation = 4.241 *2556 =Rs.10, 839.996 /-

TOTAL COST:

Total cost of production of single roll liner using horizontal casting process
= Rs. 76,983.996/-

CASTING PROCEDURE:

Moulding flask containing cope and drag is selected to prepare mould of the roll liner.Half part of the pattern is placed in the drag portion, sand is rammed and the pattern is removed.The other half of the pattern is placed in the cope, sand is rammed around it and the pattern is removed.Now, the prepared core is placed in the mould and the entire gating system is made according to design.The casting metal is poured into the mould and allowed to solidify for more than 24 hours.After the casting is solidified it is removed from the mould and necessary finishing operations are carried out to obtain finished casting product. The finished casting product is sent to carry out machining operations to obtain the final required Roll Liner.

NOTABLE AREAS USING CATIA:

CATIA can be applied to a wide variety of industries, from aerospace and defense, automotive, and industrial equipment, to high tech, shipbuilding, consumer goods, plant design, consumer packaged goods, life sciences, architecture and construction, process power and petroleum, and services. CATIA V4, CATIA V5, Pro/ENGINEER, NX (formerly Unigraphics), and Solid Works are the dominant systems.

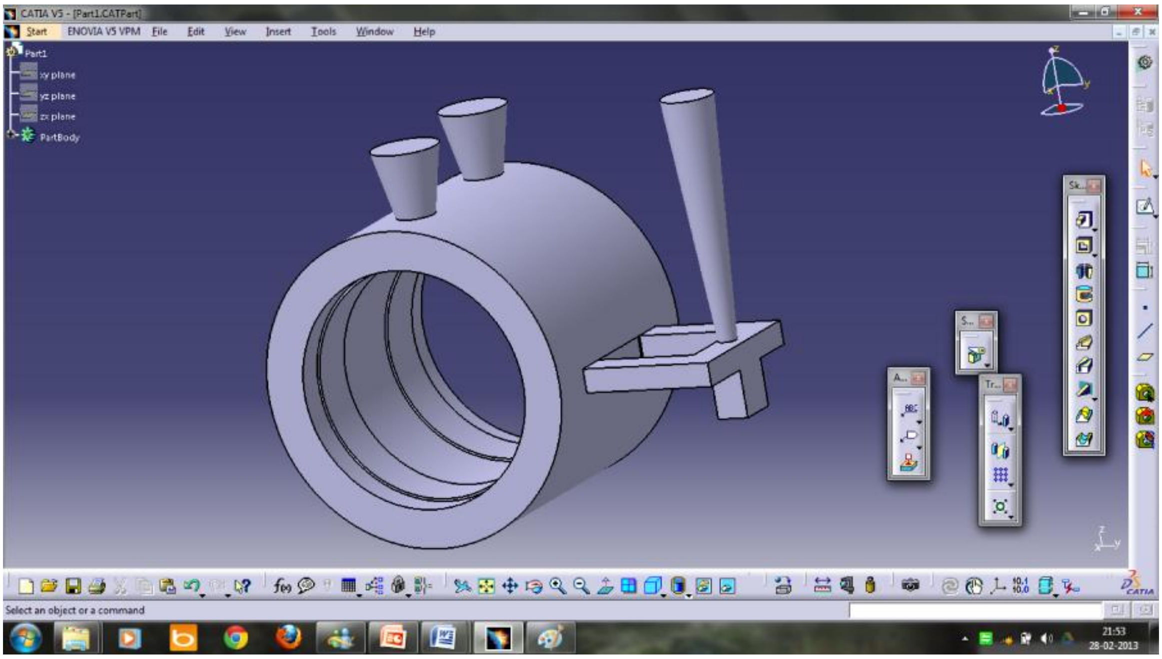

Figure 5: Model of horizontal casting with gating system

RESULTS & DISCUSSIONS:

Economic advantages of horizontal casting process over vertical casting process

Cost saved upon casting metal

For vertical casting = Rs.74, 256/-

For horizontal casting = Rs.66, 144/-

Therefore, cost saved on casting metal= Rs.8112/-

Cost saved upon machining

For vertical casting = Rs. 23,404.578 /-

For horizontal casting = Rs.10, 839.996 /-

Therefore, cost saved on machining = Rs.12,564.582/-

Total cost saved upon production of one roll liner

For vertical casting = Rs. 97,660.578/-

For horizontal casting = Rs. 76,983.996/-

Therefore, cost saved on production of one roll liner = Rs.20,676.582/-

As such 32 roll liners are manufactured annually,

Therefore total cost saved every year = 32 x 20,676.582= Rs.6, 61,650.624 /-

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CONCLUSION:

With the horizontal casting process design, the draft allowance to be provided on the pattern can be reduced. Hence the machining cost involved in the finishing operation can be reduced and casting metal required to be poured into the mould can also be reduced. By changing the gating ratio and its type the defects like hot tears can be eliminated. However elimination of defects can be proved with experiments only.

If we employ this horizontal casting process for the manufacturing of ROLL LINER the total cost of production that can be saved annually is Rs.6, 61,650.624 /- .

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