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Feeding and Gating System Design and Simulation of Flange Roller of Hydrators for Yield Melioration

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Abstract

The aim of this paper is showing the advantage of simulation technology in Casting. Casting simulation technique is widely used in foundries and casting industries. Casting simulation simulates the real casting phenomenon and gives a virtual casting process as molten metal flow in mould cavity with respect to time and direction. This paper explains the methods and techniques of feeding & gating system uses to increase the yield of casting in the company. On the basis of the own research it can be stated, that introducing the simulation software bring the great changes in the company, for example: product improvement by prevention of defects, increasing of effectiveness and efficiency in the processes, reduction in timing, proper utilization of material, grater quality, less cost to fulfill defects.

Keywords—Runner, Riser, Sprue, Sprue base, Gating System, Caine's method, Crack, Simulation

1 Introduction

Simulation simulates the real casting phenomenon using a computer program. It consists of set of mathematical equations. Casting process simulation has become an invaluable tool in the production of economical and high performance cast components. Its application by experienced and knowledgeable operators leads to reduced castings defects, casting yield improvement, and reduced trial and error iteration in development of a casting's optimization. Increasingly casting simulation being used as a collaborative tool between component designers and casting producers to reduce lead times, to develop casting friendly component designs, and to produce better castings. [11]

Quality improvement: Improvement in quality improves the reliability of casting and reduces the excess cost of defective casting and other resources cost. The quality improvement can be obtained from simulation. [7]

Yield improvement: With simulation technique, the casting process and method is optimized in short time. And also the casting process is optimized there will be very lesser wastage thus it results in yield improvement, reduces the effective melting cost per casting, and increases the net production capacity. [4]

Rapid development: Simulation of casting is virtual process so there is no scrap material and other wastages. Casting through virtual trials eliminates the wastage of production resources, and gives opportunity to foundry to take high order.

1.1 About Product: Flange Roller for Hydrator

Flange Roller is with flange rings that are non-separable units, designed for application where there are axial loads, but no lateral (axial) support surfaces. The flange rings accommodate these axial loads, which are included when shafts are not horizontal or aligned properly. Depending on the design of the supports rollers, the flange rings are pressed-on or loose. [8]

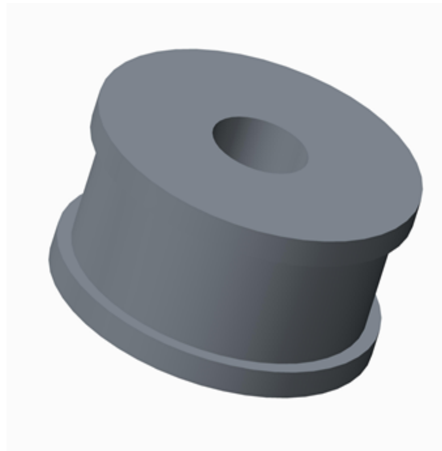
Product Description:

- Product Weight:- 862.85 kg
- Material:- EN-24 STEEL
- Tensile Strength:- 1.982×10^3 N/mm^2
- Density:-7850 kg/m^3
- Hardness :-220 BHN [8]

Chemical Composition:

- Carbon 0.36-0.44
- Manganese 0.45-0.70
- Silicon 0.15-0.35
- Sulphur 0.035 max
- Phosphorus 0.04max
- Nickel 1.30-1.70
- Chromium 1.00-1.40
- Molybdenum 0.20-0.35 [10]

Product Image of Flange Roller of Hydrator:



2 Methodology

- Method used is "Clain's Method".[1]
- Due to accurate performance we decided to use Caine's method for designing top riser.
- Performed simulation using Pro-Cast software. [11]

2.1Calculation of Freezing Ratio and Riser Volume:

- Volume of Casting = 109918722.30 mm^3
- Surface Area of Casting = 1865023.365 mm^2
- Solidification time, $t_s = K\left(\frac{V}{SA}\right)^2$

$$= 1.43\times10^4\left(\frac{109918722.30}{1865023.365}\right)^2$$
$$= 49.85 \text{ sec}$$

- Freezing ratio, $X = \frac{a}{Y-b} + c = \frac{0.10}{Y-0.03} + 1$ (1)
- Freezing ratio, $X = \frac{(SA/V)casting}{(SA/V)riser} = \frac{0.01696}{1.25\pi D^2/0.25\pi D^3}$
  $= 3.3945\times10^{-3}$ D (2)
- Y= Riser Volume/Casting volume
  $=\frac{0.25\pi D^3}{109918722.3}$
  $=7.1416\times10^{-9}D^3$ (3)
- Putting the value of X (from eq.2) and Y (from eq.3) in eq.1

We get diameter of riser, D = 377.7249 mm [4][6]
Riser Volume, $V_r = 4.230546\times10^7$ mm^3

2.2 Comparing it with existing system:

- Riser Dia. = 406.4 mm
- Riser Height = 304.8 mm
- Riser volume = 3.95×10^7 mm^3[8]

- After comparing the data related to total riser volume we can say that total riser volume is sufficient.

2.3 Calculation for Gating System:

- **Pouring Time of Molten metal:**

Pouring Time $=(2.4335 - 0.3953\times \log W)\times\sqrt{W}$ [2]
Where, W = Mass of Casting (Not including Riser)
= 862.85 kg
So, Pouring Time $=(2.4335 - 0.3953\times \log 862.85)\times\sqrt{862.85}$
= 37.39 sec

- **Mass Flow Rate:**

Mass flow Rate = $\delta A_1 v_1$
= 33.121726 kg/s

- **Effective Height of Sprue:**

Effective height $= H - \frac{C}{2} = 74.465 - \frac{C}{2}$
= 561.1175 mm
Where, H = total height of casting cavity and riser
C = height of casting cavity

- **Chock Area:**

Chock Area $=\frac{W}{\delta tc\sqrt{2gh}}$
$=\frac{862.85}{7000\times37.39\times0.90\times\sqrt{2\times9.81\times0.56117}}$
$= 1.104\times10^{-3}$ m^2
Where,
W= Weight of Casting,
δ = Density of Metal,
t = Metal Pouring Time,
g = gravity acceleration = 9.81 m/s,
c = efficiency co-efficient for bottom gating

- **Pouring Basin:**

Pouring Basin Height = $74.467 - 56.1175$
= 18.345 cm
=183.45 mm

- **Velocity at Top of Sprue:**

$V_1^2 - V_0^2 = 2gh_1$ [13]
Here, $V_0 = 0$
So, $V_1 = \sqrt{2\times9.81\times0.18345}$
$V_1 = 1.81971$ m/s

- **Velocity at Chock:**

Same as above equation,
$V_2 = \sqrt{2\times9.81\times0.74467}$
= 3.822 m/s

- **According to Volume Flow Rate**,

(Volume)$_{input}$ = (Volume)$_{output}$
$V_1A_1 = V_2A_2$
We have the values of v_1, v_2 and A_2
So, A_1 =2224.0937 mm^2

Now, Area $A_1 = \frac{\pi}{4} \times d_1^2$

$d_1 = 53.228$ mm

- Chock Area $A_2 = \frac{\pi}{4} \times d_2^2$

  $d_2 = 37.4998$ mm ≈ 40 mm

Gating Ratio = 2.04:1:0.97

- **Sprue Well Calculation:**

  Sprue Well Area = 5×Chock Area

  = 5×1103.9

  = 5519.5 mm^2

  So, Sprue Area $= \pi r^2 = 5519.5$ mm^2

  So, r = 41.92 mm

  So, d = 83.85 mm

  Sprue base well Height = Sprue base well Diameter

  So, H = 83.85 mm

- **Ingate calculation:**

  $A = \pi r^2 = 0.97 \times 1103.9$

  r = 18.46 mm

  So, Gate Diameter d = 36.92 mm ≈ 40 mm

- **Yield Calculation:**

  $$\text{Yield} = \frac{V_c}{V_c+V_r}$$

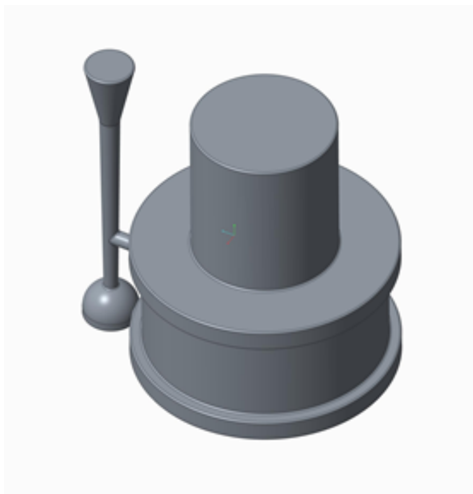
  $$= \frac{10.9918722\times10^7}{(4.230546+10.9918722)\times10^7}$$

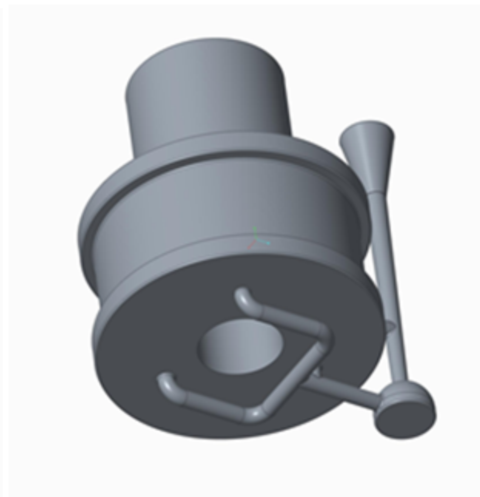
  = 72.19 %

The yield or efficiency of a casting is defined as the weight of the casting divided by weight of total amount to be poured [6]. Risers can add a lot to the total weight being poured. So it is important to optimize the size and shape. Here 72% yield shows that the size of risers and gating system are optimum and hence the less metal wastage in other than casting part. [7]

- **Comparing with existing Gating data:**
  - Sprue diameter : 50.8 mm
  - Sprue Height : 513.54 mm
  - Gating Diameter: 38.1 mm [8]

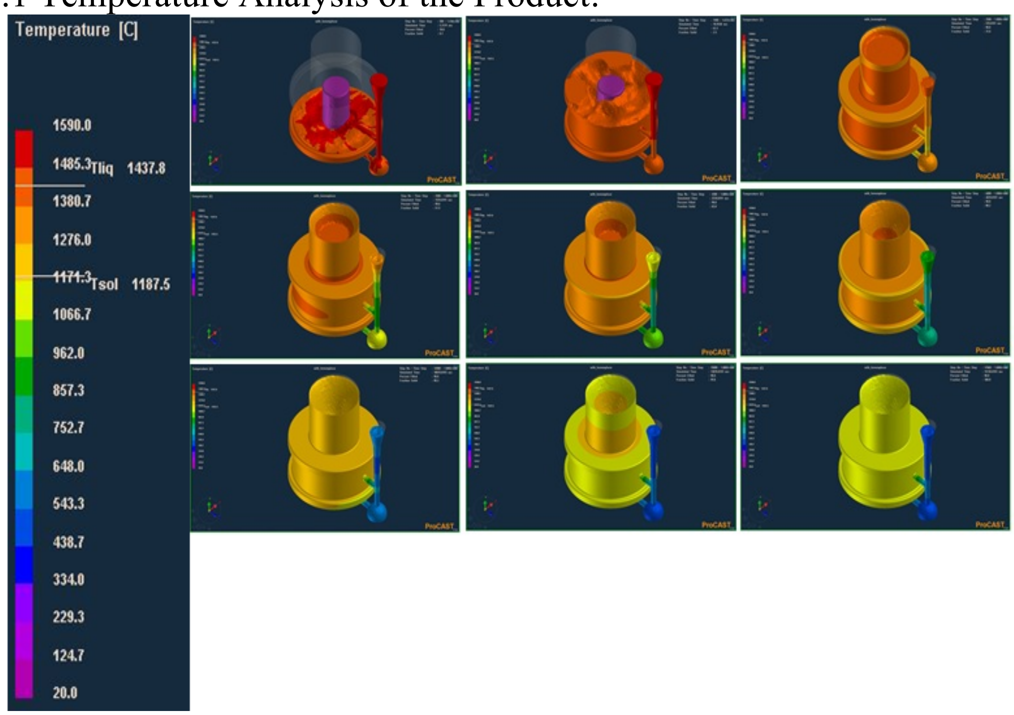
3 Riser and Gating System



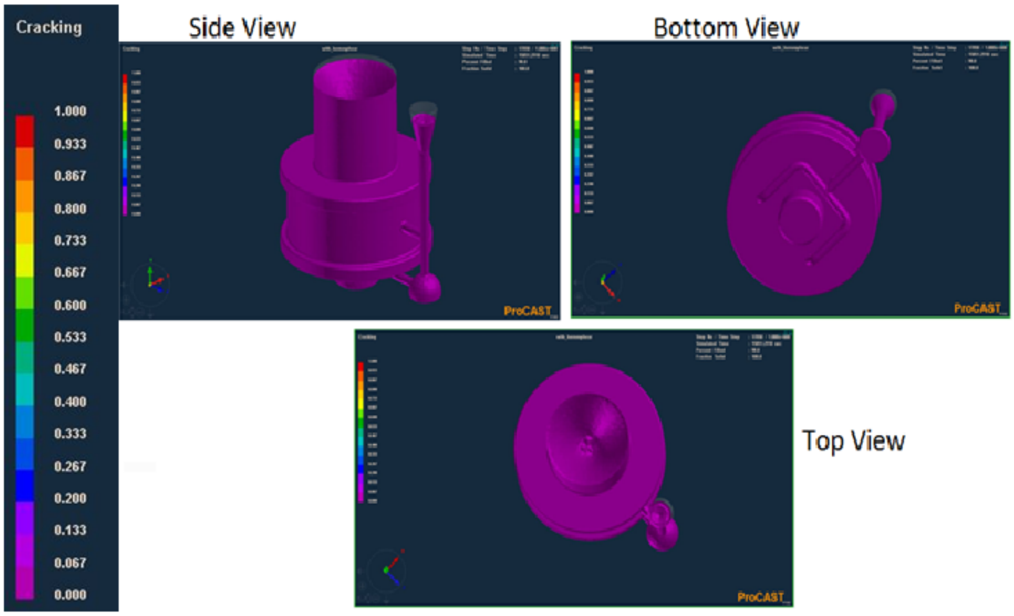


4 Result

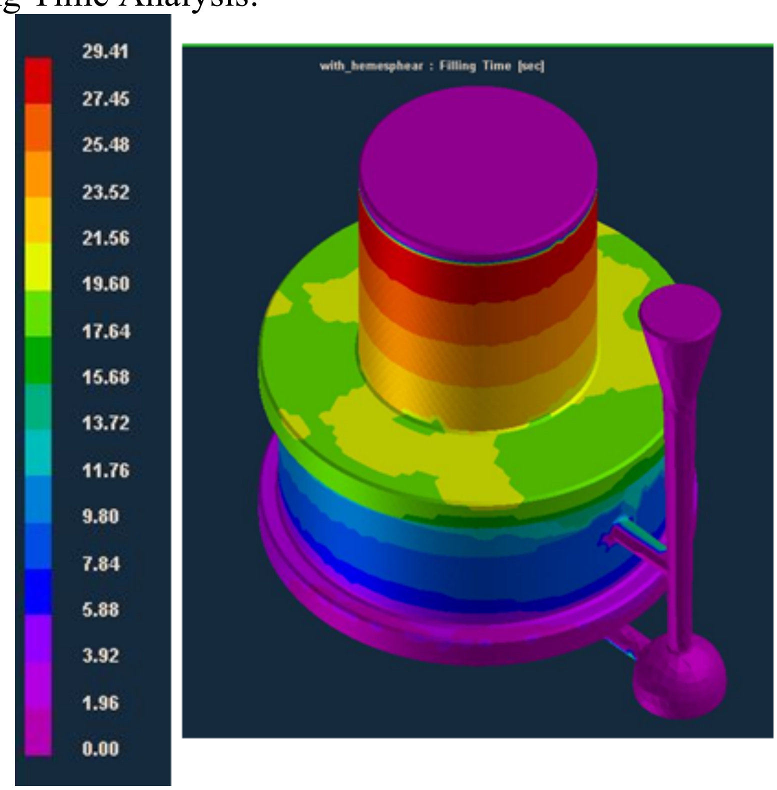
4.1 Temperature Analysis of the Product:



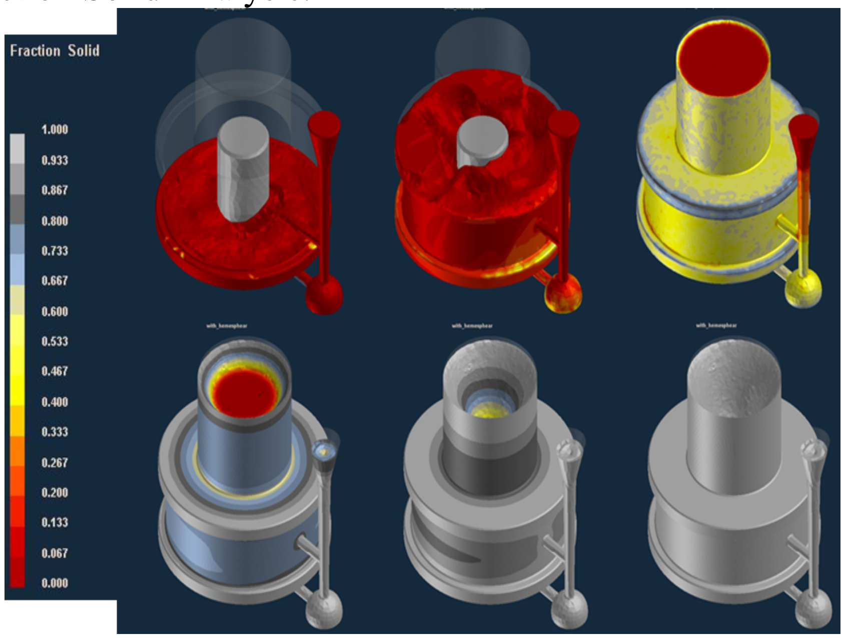
4.2 Cracks in Re-design System:



4.3 Filling Time Analysis:



4.4 Fraction Solid Analysis:



4.5 Final Product image:

5 Conclusion

After referring different reference books and number of examples of complex shaped product we made calculation for feeding &gating system design for Flange Roller of Hydrator. According to calculation and suggestion of industry, we decided to place risers with exothermic sleeve as illustrated in optimal solution to achieve following benefits like comparatively higher yield, Favorable temperature gradient, suitable for industry's methodology and easy removal of risers

In Future, the obtained result will be implemented in real time to produce defect free casting of similar products.

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