Design of Gating and Feeding System for Drag Chain Link and Simulation for Yield Reclamation

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Abstract

Casting is one of the direct method of manufacturing process in which the desired geometry of component is obtain by pouring liquid material into mould where flaws are mainly sourced from either insufficient mould characteristics or gating system. Casting defects are mainly produced due to ineffective gating and feeding system, which can be enhance by proper gating system design and simulation. Simulation gives optimal solidification parameter for specific casting component and eliminate any defect way before doing actual casting hence it saves both money and time. Here an attempt is to design a gating and feeding system for Drag chain Link.

Keywords: *Design of Gating and Feeding system, sprue, Caine's method*

INTRODUCTION

The quality demand made on casting has increased sharply in recent years and are becoming still more stringent. Foundries are faced by the need to produce high grade casting, but nonetheless to produce them economically. To do this, experimental casting, especially for individual casting or small runs before mass production, are uneconomical.
Quality of casting can be improves the reliability of casting and reduces the excess cost of defective casting and other resources cost. Simulation of casting is done with using a computer program which consists of set of mathematical equations. P.D. Chauhan, Mohit Anuvadiya, Vivek Chauhan proposed the methods & techniques of feeding and gating system design to increase the yield of casting. [14]

ABOUT PRODUCT: DRAG CHAIN LINK

Drag Chain Link is mostly used in conveyer for transporting heavy material in industry. Drag chain link can withstand heavier loads(Figure-1).

Product Description
Product Weight:- 28.65 kg, Material:- 1%Cr steel IS-4896 Grade-1, Yield Strength:- 680 N/mm^2 , Density:-7830 kg/m^3, Hardness :-250-300 BHN

Chemical Composition
Carbon: 0.45-0.55, Manganese: 0.50-1.00, Silicon: 0.75 max, Sulphur: 0.060, Phosphorus: 0.060, Chromium: 0.80-1.2.

Fig. 1: Drag Chain Link

Fig. 2: Product Defect

In this product there is a crack defect observed during the casting(Figure-2).

METHODOLOGY

Caine's method is used to find the accurate performance of gating and feeding system. Pro-cast software is used for performing simulation and further analysis.

Calculation of Freezing Ratio And Riser Volume:

- Volume of casting = 3649940 mm^3
- Surface area of casting = 381607 mm^2
- Solidification time, $t_s = K\left(\frac{V}{SA}\right)^2$ [6]

$$= 1.43 \times 10^4\left(\frac{3649940}{381607}\right)^2 \quad = 130.8 \text{ sec} \quad \ldots(1)$$

- Freezing ratio, $X = \frac{a}{Y-b} + c$

$$= \frac{0.10}{Y-0.03} + 1 \quad \ldots(2)$$

- Freezing Ratio, $X = \frac{(SA/V)\ casting}{(SA/V)\ riser}$

$$= \frac{0.10455}{(1.25\pi D^2/0.25\pi D^3)\ riser} \quad = 2.091\times10^{-2}\ D \quad \ldots.(3)$$

- Y = Riser volume/ Casting volume

$= \frac{0.25\pi D^3}{3649940}$ $= 2.1518 \times 10^{-7}\ D^3$ ….(4)

- Putting the value of X(From eq.3) and Y(From eq.4) in eq.2, diameter of riser,D = 88.25 mm
- Riser Volume, V_r = 538884.43 mm^3
- It is decided to divide the total riser volume into three parts and out of three two are small riser with equal volume and one is big riser.
- So, Big riser volume = 339625.8 mm^3
- Diameter = 70 mm
- Height = 88.25 mm
- 2 small riser volume = 58290.87 mm^3
- Diameter = 29 mm
- Height = 88.25 mm

Comparing with the Existing System

Four riser Diameter = 51 mm

Height = 70 mm

Calculation for Gating System:

- **Pouring Time of Molten metal:**

Pouring Time $= (2.4335 - 0.3953 \times \log W) \times \sqrt{W}$ [6]

Where, W = Mass of Casting (Not including Riser) = 28.65 kg

So, Powering Time= $(2.4335-0.3953\times\log28.65)\times\sqrt{28.65}$ = 9.94 sec

- **Effective Height of Sprue:**

Effective height $= h - \frac{p2}{2c}$ $= 70 - \frac{35^2}{2\times70}$ = 61.25 mm

Where, h = height of sprue,
C = height of casting cavity,
P = height of mold cavity in cope

- **Chock Area:**

$$\text{Chock Area} = \frac{W}{\delta t c\sqrt{2gh}} \quad [6]$$

$$= \frac{28.65}{7850\times9.94\times0.90\times\sqrt{2\times9.81\times0.070}} = 348.11 \text{ mm}^2$$

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 part gating

- **Pouring Basin:**

Pouring Basin Height = $70 - 61.25$ = 8.75 mm

- **Velocity Calculation:**
- **Velocity at Top of Sprue:**

$v_2^2 - v_1^2 = 2gh_1$ Here, $v_1 = 0$
So, $v_1 = \sqrt{2 \times 9.81 \times 0.00875}$ $V_1 = 0.414$ m/s

- **Velocity at Chock:**

Same as above equation, $v_2 = \sqrt{2 \times 9.81 \times 0.070}$ = 1.17 m/s

- **According to Volume Flow Rate,**

$(\text{Volume})_{\text{input}} = (\text{Volume})_{\text{output}}$ [6]
$v_1A_1 = v_2A_2$
We have the values of v_1, v_2 and A_2

So, $A_1 = \frac{1.17\times348.11}{0.41}$ = 985.40 mm^2

Now, Area $A_1 = \frac{\pi}{4} \times d_1^2$, d_1 = 35.42 mm

- **Chock Area A2 = $\frac{\pi}{4} \times d_2^2$, d2 = 21.05 mm**
- **Sprue well Calculation:**

Sprue well area = 5 × chock area = 5 × 348.11 = 1740.55 mm^2
So, Sprue area $= \pi r^2$ = 1740.55 mm^2, r = 23.53 mm, so, D = 47.07 mm
Here Sprue base well height = Sprue base well diameter,So, H = 47.07 mm

- **Ingate Calculation:**

A = πr^2 = 348.11, r = 10.52 mm
So, Gate Diameter = 21.05 mm

- **Yield Calculation:**

$$\text{Yield} = \frac{V_c}{V_c+V_r} = \frac{364.994\times10^4}{(364.994+53.8884)\times10^4} = 77.13\ \%$$

- **Comparing with existing data:**

- Sprue Diameter = 50.8 mm
- Sprue Height = 70 mm
- Gating Width = 40 mm
- Gating Height = 15 mm

Riser And Gating System

Figure-3 shows drag chain link with riser and feeding system as per new calculated design data.

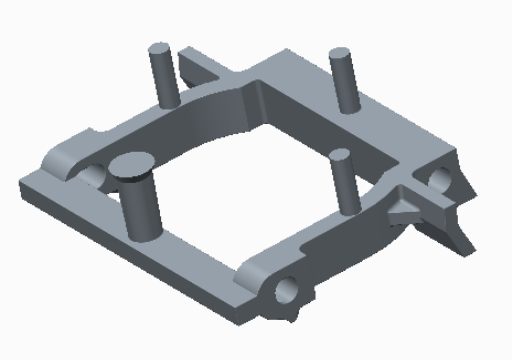

Fig-3. Product image with new Gating and Feeding system Design

RESULT

After calculating data for gating and feeding System we have design this system for drag chain link and we have done Temperature analysis and Fraction solid Analysis of this design. Temperature analysis and fraction solid analysis shows that the new design is defect free and improving the yield by 10 pecentage.

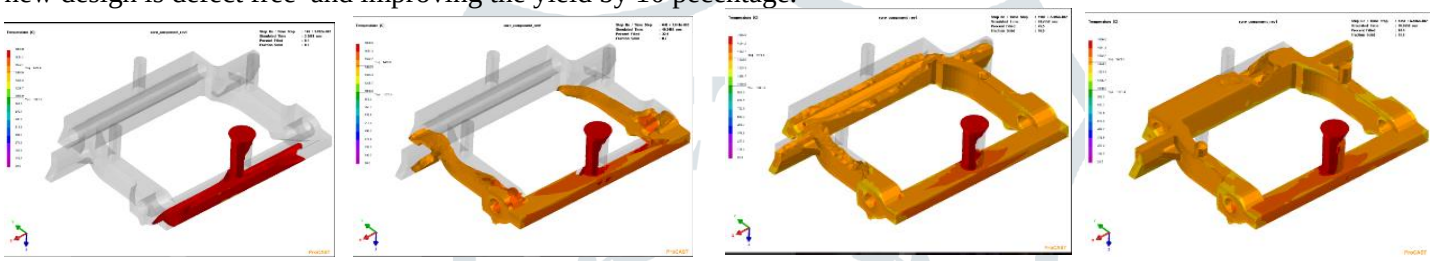

Fig-4. Temperature Analysis of the Model

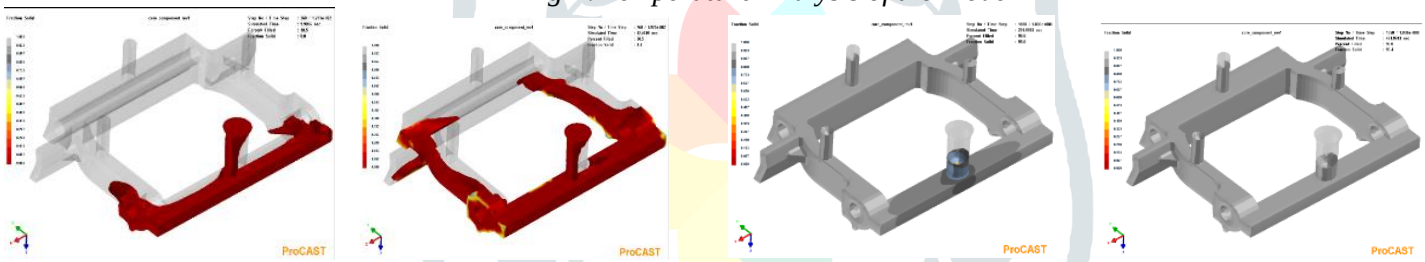

Fig.5 Fraction solid Analysis

CONCLUSION

After referring different reference books and number of examples of complex shaped product an attempt is to make calculation for feeding and gating system design for Drag Chain Link. According to calculation and suggestion of industry it is decided to place three risers, out of it one should be of large diameter riser and two should be of small diameter riser to achieve following benefits.: Comparatively higher Yield, Favorable Temperature Gradient, Suitable for industry's methodology and easy removal of Riser. Table-1 shows the comparison of existing data with the new design data.

Table: 1 Comparison of existing data with the new design data

Existing Data	New Design Data
➢ **Gating dimensions:** • Sprue = Dia.= 50 mm Height = 70 mm • Runner= width = 40 mm Height = 10 mm • Ingate = width = 40 mm Height = 10 mm	➢ **Gating dimensions:** • Sprue = Dia.= 47 mm Height = 95 mm • Runner= width = 40 mm Height = 30 mm • Ingate = width = 40 mm Height = 30 mm
➢ **Riser diameters :** • 4 riser of equal size • Diameter of Riser = 50 mm Height of riser = 70 mm	➢ **Riser diameters :** • Diameter of Big Riser = 70 mm • Height of the Big Riser = 88.25 mm • Diameter of 2 small Riser = 29 mm • Height of 2 small Riser = 88.25 mm

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REFERENCES

1. P. N. Rao, Manufacturing Technology (Volume-1), Tata McGrawHill, Second Edition,2002.
2. R. Wlodawer, Directional Soldification of Steel Castings, Pergamon Press, First Edition.
3. J. R. Brown, Foseco Ferrous Foundryman's Handbook, Butterworth-Heinemann , First Edition,2000.
4. M. Blair, Feeding and Risering Guidelines for Steel Castings, Steel Founders' Society of America.
5. P. Beeley, Foundry Technology, Butterworth-Heinemann, SecondEdition,2001
6. O.P.Khanna, foundry techonology
7. Metal Casting from web-source: www.themetalcasting.com
8. Product manufactured by Suryadeep Alloy Steel Casting pvt.Ltd. from websource: www.suryadeepalloy.com
9. T.V.Rammana Rao, Metal Casting Principles and practice, New Age International (P) Ltd.
10. Metal Properties from Web source: www.steelexpress.co.uk
11. Pro Cast software information from web source:www.esi-group.com
12. Principles of Metal Casting" by Heine R.W.,Loper C.R. and Rosenthal P.C.
13. Fundamental of Metal Casting by Mukharjee P.C.
14. P.D.Chauan, Mohit Anuvadiya, Vivek Chauhan, Feeding and Gating System Design and Simulation of Flange Roller of Hydrators for Yield Melioration . ICRISET2017-BVM Engineering College ,Kalpa Publications in Engineering, vol. 1 pp. 548 to 556.