[Sunil et al., 3(5), May 2018



INTERNATIONAL JOURNAL OF RECENT TECHNOLOGY SCIENCE & MANAGEMENT

"Design and Optimization of Perfect Gating System for Uniform Solidification

Rate of Given Component"

Sunil Yadav¹, Vaibhav Jain², Vikas Sharma³ Krishna Waghe⁴ ¹PG, Scholar, Dept. of Mechanical Engineering, MIT, Indore, MP, India ^{2,3}Assistant Professor, Dept. of Mechanical Engineering, MIT, Indore, MP, India

ABSTRACT

The main purpose of today's manufacturing industries is to produce low cost, high quality products in short time. Casting is manufacturing process in which component of machine made by solidification of molten metal in a specific cavity to form a predesigned shape. There are so many parameter are involve in casting process like allowances, surface finish and defects in component. This all effects are controlled by achieving uniform solidification rate throughout the process. For this uniform solidification a proper method of casting and gating should be designed. So in this research work a large sized component is designed, analyzed and manufactured through lost foaming casting process for zero drafting allowances and minimum machining allowances with best surface finish.

Keyword: Sand, Pattern, Casting, Cavity, Mold, LFCP

I. INTRODUCTION

As I reviwed the effect of defferent methods of casting in my previous paper [4] and find a appropriate method of casting which is Lost Foam casting will be best suitated for large sized component ccasting. In this Lost foam casting technique (LFC) is known by different generic and propriety names like lost foam, evaporative pattern casting,

evaporative foam casting, full mold, etc. Similar to the full mold process, in this process the pattern evaporates when the metal is poured into the mold. Lost foam casting is a type of metal casting process that uses expendable foam patterns to produce castings. Expanded polystyrene foam is used which melts when molten metal is poured into the mold.

Application: Lost foam casting is used mostly for automotive applications. Cast iron, aluminum alloys, steels, nickel and in some cases stainless steel and copper alloys are cast in this process. The flexibility of LFC is useful in making complicated casting assemblies for automotive parts like cylinder heads, weldments etc. This simple and inexpensive method is used in hobby foundry work.



Figure 1.1 Lost Foaming Casting



[Sunil et al. , 3(5), May 2018

II. OBJJECTIVE OF WORK

The objective of research work is to produce low cost, high quality products in short time using latest technologies like ProCAST analysis software. In casting process suitable method and design are responsible for perfect casting of component. But for testing alternative design by manufacturing it's taking time and lots of money, so instead of manufacture for each time we can use casting analysis software and test over it and find the optimum solustion which reduces wastage of Material, time and money for such large sized component. Once the design is functionined properly on software then only we manufactured physically.

So objective of this project is to design and optimize casting through computer and then manufacture component physically. The specification of component is mentioned in figure 2.1 below.



Figure 2.1 Large Sized Casting Bed

III. METHEDOLOGY

Methodology for project as follows



http://www.ijrtsm.com@International Journal of Recent Technology Science & Management



[Sunil et al., 3(5), May 2018

IV. DESIGN CALCULATIONS

4.1 Bed Plate size (6000 X 2000 X 250 mm)

```
Pouring Time (t)
```

Casting weight less than 450 kg (1000 Ibs)

 $t = K(0.95 + T/0.853)\sqrt{w}$ Sec

Where

K= Fluidity factor dependent on equivalent carbon T= Average casting thickness (inches) w= Weight of casting (Ibs), (maximum 450 kg or 1000 Ibs) for 4.0 eq. carbon, K=0.85 to be taken T=3.2 inches w=11270 kg (24846.09 lb) $t = 0.85(0.95 + 3.2/0.853)\sqrt{11270}$ t = 54.10 Sec

4.2 Rate of rise of metal:

Height of Casting h=271 mm

Height of Casting in mm Rate of rise of metal $R_{R} = \frac{1}{2}$

$$R_R = \frac{271}{54.10} = 5 \ mm/Sec$$

Note: Rate of rise of metal should be

- 6-10 mm/sec for wall thickness of 40mm or more •
- 10-20 mm/sec for 10-40 mm wall thickness
- In Jash Engineering Limited(for gate) taken 6mm/sec •

4.3 Pouring Rate

It is denoted by "R"

$$R = \frac{Casting Weight in kg}{Pouring Time in Second}$$
$$R = \frac{11270}{54.10} = 208.317 \ kg/Sec$$

4.4 Mean Effective Head

•	For top gating :	$H_{st} = H$
•	For bottom gating :	$H_{st} = H - (C/2)$
•	For parting line gating:	$H_{st} = H - (P^2/2C)$

Where,

H = Head of Metal in Sprue C = Height of Casting P = Distance between gate and top of the Casting H =height of casting + height of moulding box H=271+200 = 471 mm $H_{st} = H - (C/2)$ $H_{st} = 471 - (271/2)$ $H_{st} = 335.5 \text{ mm} (33.55 \text{ cm})$

4.5 Choke Area

$$A = \frac{W}{C_x D_x T \sqrt{2gh}} mm^2$$

Where,

A = Choke area (mm²)

http://www.ijrtsm.com@ International Journal of Recent Technology Science & Management

THOMSON REUTERS

[Sunil et al. , 3(5), May 2018

- T = Pouring time (Sec)
- D = Density of molten metal (kg/mm³)

g = Acceleration due to gravity (mm/sec)

- H = Effective metal height (sprue height in mm)
- C = Effective factor which is a function of gating system used (friction factor = 0.83)

4.6 Total Gate Area

1

It is denoted by A_g

$$A_g = \frac{R}{0.31\mu\sqrt{H_{st}}} \ cm^2$$

Where,

R = Pouring rate (kg/sec)

 $H_{st} =$ Mean effective head (cm)

 μ = Velocity loss

Coefficient Note:

 μ = 0.4 for high loss CO_2 mould , complicated gating system

 $\mu = 0.5$ for green sand casting $\mu = 0.6$ for short gating system, dry sand moulds

208.317

$$A_{g} = \frac{1}{0.5\sqrt{33.55}} cm^{2}$$

$$A_{g} = 71.95 cm^{2} = 72 cm^{2} (Approx)$$

4.7 Cross-sectional area of each gate

Area of Gates =
$$\frac{A_g}{Numbers \ of \ Gate} \ cm^2$$

Width : Thickness = 4:1

For grey iron castings, the thickness of gate will depend on the pouring temperature of metal

T 11 4 1	a .		C	•	
Table 4 1	(tate	thickness	tor	nouring	temperature
14010 1.1.	Oute	unekness	101	pouring	temperature

Sr. no	Pouring Temperature	Gate Thickness
1	1480 ⁰ C	3 mm
2	1380 ⁰ C	6 mm
3	1315 ⁰ C	12 mm

Gate should be connected at the thinnest section of the casting. Gate length(runner to casting) : 1-2 times the gate width Branch off gate from the runner at right angle

Area of Gates =
$$\frac{72}{26} = 2 \ cm^2$$

Width : Thickness = 4 : 1 = 25 :10 (40mm x 12mm) modified

4.8 Cross-sectional area of runner

Runner Area = 2.25 times Total Gate Area Note:

- Shorter runner requires large area of cross-section, longer area may have smaller cross-section area.
- Design the runner cross-section so that the height is 2-3 times of width.
- Bottom of both- the runner and the gate(s)-may be located in the cope. If the gate should be in drag part of runner (equal to depth of the gate) should also be in the drag.

http://www.ijrtsm.com@International Journal of Recent Technology Science & Management

THOMSON REUTERS

[Sunil et al., 3(5), May 2018

Runner Area = 2.25×71.95 = 161.88 cm^2 = 16188 mm^2 = $16188/3 = 5396 \text{ mm}^2$ Wxh = $60x90 = 5400 \text{ mm}^2$

4.9 The sprue bottom area and diameter Area-diameter of sprue bottom = $1.33A_g = 1.33 \times 71.95$

 $= 95.69 \text{ cm}^2$

(Circular sprue is preferred), Area of circle

$$A = \pi r^{2}$$

$$A = 3.14 \text{ x } r^{2}$$

$$95.69 = 3.14 \text{ x } r^{2}$$

$$r^{2} = 95.69/3.14 = 30.46$$

$$r = 5.52 \text{ cm} = 55 \text{ mm}$$

4.10 The sprue top area and diameter

Area of sprue at pouring basin = (sprue area at the bottom)x $\mu_c x$ (Hs/Hp)

Where , $\mu_c = 0.7$ Hs = Height of sprue

Hp = Height of pouring basin

For short sprue : Area of sprue at top = $2 \times Area$ at bottom of sprue Diameter at pouring basin is 1.5 to 2 times of sprue at bottom side

= 1.5 x 55 = 82.5 mm Top Diameter = 82 mm

4.11 The dimension of sprue base

Diameter of sprue base = 2x(diameter of sprue bottom) Height of base = Height of runner

4.12 Dimensions of pouring basin

Capacity of pouring basin $(kg) = K \times R$

Where,

K = constant (7.5 for casting upto 1500 kg and 6.0 for casting above 1500 kg) R = Pouring rate (kg/sec)

Capacity of pouring basin $(kg) = K \times R$

= 6 x 208.317 = 1249.9 kg

Table 4.2: Pouring basin dimensions:

No. of Sprue	L	W	Н
1	1.5	1	0.7
2	1.6	1	0.7

For no. of sprue 1 L=1.5=600 mm =0.6 m W =1=400 mm =0.4 m H=0.7=230 mm= 0.23 m

> Volume = L x W x H = $0.6 x 0.4 x 0.23 = 0.0552 m^3$ Total Mass = 0.0552 x 7300 = 402.96 kg

V. ANALYSIS OF GATING SYSTEM USING PROCAST

5.4 Gate Design

3D model has been prepared for Pattern casting machine using CAD modeling software, Creo. A Two gate-bed plate model has been modeled first.

http://www.ijrtsm.com@International Journal of Recent Technology Science & Management

ISSN : 2455-9679 Impact Factor : 2.865



Figure 5.1: Two Gated-bed Plate model



Figure 5.2: Import Mesh File in Procast



Figure 5.3: Mesh Mould



Figure 5.4: Casting material Selection FEGG25



Figure 5.6: Simulation of Pouring Metal on Mould



Figure 5.5: Mould material Selection As green Sand



Figure 5.7: Temperature Distribution & Soldification



[Sunil et al. , 3(5), May 2018

ISSN : 2455-9679 Impact Factor : 2.865

While we observe solidification rate in two gate system we find that a metal is not solidify uniformaly and a large are is left that cause scaling defect in casting. And due to this a machining allowance needed. So now we need to optimize gating system for uniform solidification.

VI. OPTIMIZATION OF GATING SYSTEM

As we discussed about solidification rate is how much important for low cost high quality & less Time consuming casting, so in order to obtain uniform solidification rate we need to optimize gatting system now we design a three gate mould and analys on proCAST.



Figure 5.1: Three Gated-bed Plate model



Figure 6.2: Mesh Mould

The Control Testion Actives Targe Provident Resear 5-2 Flow Targe Control Testion Actives Targe Provident Resear 5-2 Flow Targe Control Testion Actives Targe Provident Resear 5-2 Flow Targe Control Testion Actives Targe Provident Resear 5-2 Flow Targe Control Testion Actives Targe Provident Resear 5-2 Flow Targe Control Testion Actives Targe Provident Resear 5-2 Flow Targe Control Testion Actives Targe Provident Resear 5-2 Flow Targe Control Testion Actives Targe Provident Researce 5-2 Flow Targe Control Testion Actives Targe Control Te



Figure 6.3:Flow Simulation



Figure 6.5: Temperature Distribution & Soldification



ProCAST

0.600 0.533 0.467 0.400 0.333 0.267 0.200 0.133 0.067



[Sunil et al. , 3(5), May 2018

VII. RESULT & DISCUSSION

As we analysized both type of gatting system we get the good results in Three gate system. ProCast also give Temperature distribution at each steps. For using this temperature changes mentioned in Figure 7.1 and Figure 7.2 we can understand the rate of solidification.



Temperature Distribution at Different Postion in Each Step

Figure 7.1: Temperature Distribution & Soldification for Two Gate System



Temperature Distribution at Different Postion in Each Step

http://www.ijrtsm.com@ International Journal of Recent Technology Science & Management

THOMSON REUTERS

[Sunil et al. , 3(5), May 2018

8.1 Conclusion:

VIII. CONCLUSION & FUTURE SCOPE

In Results It has been clear that in three gate system temperature curves are close to each other which shows that solidification are uniform and also the casting simulation technology has become an essential tool for casting defect troubleshooting and optimization method. It improves quality product without shop-floor trials. With the use of optimization techniques gating system of the casting are improve and increase the yield percentage of the casting. This would result reduction in cost and material saving. Many design rules, are developed over the years through experience and study. But For wide spread application, simulation programs must be easy to use, fast, and reliable. This can been achieved by integrating method design, solid modeling, simulation techniques. The Simulation software has proven its reliability and accuracy in predicting internal defects which help to reduced shop floor trials, and optimization using a single software program.

8.2 Future Scope:

Advanced lost foam casting processes (Pressure Assisted Solidification and Vacuum Assisted Mold Filling) have demonstrated the capability to improve mechanical properties, especially fatigue performance, for aluminum alloys and improve casting cleanliness, which reduces scrap, for ferrous alloys.Advantages of LFCP that have not been fully utilized are

1) freedom from gray iron "skin" formation in ductile and compacted graphite iron and

2) elimination of hot tearing for high strength, cast aluminum alloys.

So in Future Pressure Assisted Solidification and Vacuum Assisted Mold Filling can be used to Improve results

REFERENCES

- Rupinder Singh, Sunpreet Singh, Gurpartap Singh, "Comparison of Investment Castings Prepared With Wax and ABS Patterns." 3rd International Conference on Materials Processing and Characterisation (ICMPC 2014), Procedia Materials Science 6, 2014, 851 – 858.
- Rupinder Singh, Sunpreet Singh, Vishal Mahajan, "Investigations for Dimensional Accuracy of Investment Casting Process after Cycle Time Reduction by Advancements in Shell Moulding." 3rd International Conference on Materials Processing and Characterisation (ICMPC 2014), Procedia Materials Science 6 (2014) 859 – 865
- Sunil Yadav, Vaibhav Jain "Alternative Casting Methods for Large Sized Component over Sand Casting Methods: A Review" International Journal of Recent Technology Science & Management (IJRTSM) Vol.3, Issue-3, March 2018, pp 19-24
- 4. D.Caulk "Analysis of Mold Filling in Lost Foam Casting of Aluminum", International Journal of Metalcasting, January 2009, Volume 3, Issue 1, pp 7–25.
- M. khodai, S.M.H. Mirbagheri, "Behavior of Generated Gas in Lost Foam Casting.", International Journal of Materials and Metallurgical Engineering Vol:5, No:2, 2011 Pp 151-155.
- 6. S. Shivkumar, "Modeling of temperature losses in liquid metal during casting formation in expendable pattern casting process", Vol. 10, Materials Science and Technology, 1994, PP. 986-992.
- Helder Pinto, F. J. G. Silva, "Optimisation of die casting process in Zamak alloys." 27th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM2017, 27-30 June 2017, Modena, Italy, Procedia Manufacturing 11, 2017, 517 – 525.
- Bhupendra j. Chudasama "Solidification Analysis and Optimization Using Pro-Cast" International Journal of Research in Modern Engineering and Emerging Technology (IJRMEET) ISSN: 2320-6586 Vol.1, Issue 4, May13, pp 9-19.
- 9. Ravi, B. (2000). Computer Aided Design And Analysis For Zero Defects, International Conference on Aluminium, p. 1-6.
- 10. Rabindra Behera, Kayal, S. Sutradhar. G. (2001). "Solidfication behaviour and detection of Hotspots in Aluminium Alloy castings: Computer Aided Analysis and experimental validation", International Journal of Applied Engineering Research, ISSN 09764259.