DESIGN FACTOR OPTIMISATION APPLIED TO CASTING OF DEAD WEIGHT OF GINNING PRESS

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ABSTRACT

The gating system refers to those channels through which the metal flows from the ladle to the mould cavity. The use of a good gating system is even more important if a casting is produced by a gravity process. One of the key elements to make a metal casting of high quality is the design of a good gating system. It could be even worse, if the molten material is a sensitive metal for receiving damage during the filling, because of dross and slag formation. If poor gating techniques are used, invariably, lower casting quality is achieved, because of damage on the molten metal received during the flow through the gating system. The purpose of this study is to identify the problem associated with gating system for the manufacturing of ginning dead weight which is used for their machineries at Jadhao Steel Alloys, Amravati. The typical casting defects were identified in which the shrinkage defect, blow holes, pin holes, gas holes, sand inclusion and miss run defects etc. are prominent. As the total percentage of defect being around 25-30 % of the total casting produced. It means total % of rejection is around 25-30% which is very high and not acceptable. After careful investigation of the casting process, it was found that all the above defects can be considerably reduced by using a proper gating system. Hence optimization of gating system is considered as a main topic of investigation. According to deep study and analysis of existing gating system used by industry, it was found that old gating ratio was incorrect and after gating system calculations it was found that the total of weight of gating system is very high that has to reduce considerably. After careful observation and analysis of existing gating system used by industry, it was decided to make necessary changes in the design and dimension of gating system. By using proposed gating system, the experiment has been carried out at Jadhao Steel Alloys, Amravati. The result found after experimentation are very sound and productive.

Keywords: Casting, Gating System, Dead Weight & Ginning Press.

1. INTRODUCTION

1.1 Gating system:

The term gating system includes all the passage ways through which molten metal enters in to the mould cavity. The gating system is made up of a) Pouring basin b) Sprue c) runner bar d) In-gate e) riser

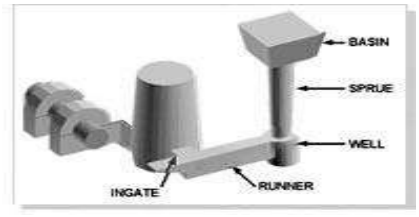


Figure 1.1.1: 3D Gating system

The design of gating system is important and the main requisites of gating system are;

i. The gating should be so designed that it avoids the mould or core erosion by reducing metal velocity within the cavity and avoiding direct impingement on mould walls or cores.

ii. The flow of metal to the mould cavity should occur with as minimum as possible turbulence, because if turbulence is excessive, the aspiration of mould gases will occur which will oxidize the mould metal.

iii. The flow of molten metal must be laminar so as to reduce the casting defects like shrinkage, porosity, blow holes, gas holes, miss-run, sand inclusion etc.

1.2 Functions of a gating system:

The entry section of a gating has two functions: (i) To supply liquid metal free of entrapped gases, slag and eroded sand. (ii) To establish a hydraulic pressure head, that will force the metal through the rest of the gating system and into the casting. Distribution section has five functions: (i) To decrease the velocity of the metal stream. (ii) To minimize turbulence, both in the gating system as well as in the mould cavity. (iii) To avoid mould and core erosion. (iv) To establish the best possible thermal gradient in the casting. (v) To regulate the rate of flow of metal into the mould cavity.

In addition to these, the gating system should be of such simple design as to facilitate moulding, particularly with mechanical methods, at the same time involving minimum fettling cost and affording maximum casting yield. Many of these requirements and functions are conflicting with each other. Effort should be to harmonize these so as to create conditions conducive to the production of a defect free casting.

2. PROBLEM IDENTIFICATION

During our industrial visit at Jadhao Steel Alloys, Amravati it was found that so many types of steel casting jobs are produced. The typical casting defects observed like Shrinkage, Blow Holes, Pin Holes, Gas Holes, Sand Inclusion, Miss-run etc. are prominent. It was found that industry was facing the problem of rejection particularly for ginning weight steel casting used as dead weight for their machineries. Following table shows the inspection report for ginning weight at quality desk.

Table No. 2.1: Inspection report by using existing gating system

Job Qty.	Shrinkage	Blow Holes & Gas Holes	Sand Inclusion	Miss-Run	Total	Percentage of Rejection
20	3	2	-	1	6	30%
20	1	1	1	2	5	25%
20	1	1	1	1	4	20%
20	2	2	1	-	5	25%
20	2	1	-	2	5	25%

After observation of inspection report and discussion had with GM production Jadhao Steel Alloys, Amravati regarding with the percentage of rejection and various casting defects observed for the manufacturing of Ginning weight which is use as a dead weight for ginning machine it was decided to follow actual procedure of casting manufacturing in relation with the gating system used. In order to reduce percentage of rejection and casting defects, it was decided to study and analysis of existing Gating System used by industry.

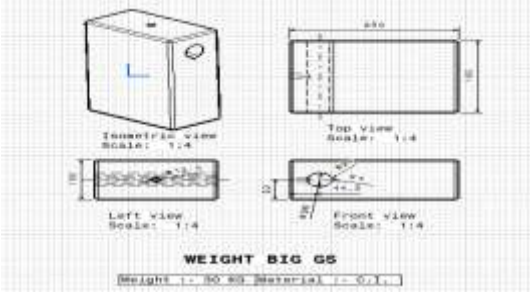
3. STUDY AND ANALYSIS OF EXISTING GATING SYSTEM

The main objective of this study is to follow standard casting procedure in relation with standard gating system as per researcher's research in the field of casting technology. As per the discussion had with GM at Jadhao Steel Alloys, Amravati regarding with casting defects and percentage of rejection for the manufacturing of ginning dead weight, it was observed that all the above defects can be considerably reduced by using a proper gating system. Hence optimization of gating system is considered as a main topic of investigation.

3.1 Ginning dead weight:

Ginning dead weight used as a dead weight for ginning machine which is agro based machine. To provide extra load on machine during vibration of ginning machine in order to remove cotton seeds from cotton fibre.

Figure 3.1.1: Dimensional drawing of ginning weight



3.2 Design, dimensions, gating ratio & calculations of existing gating system:

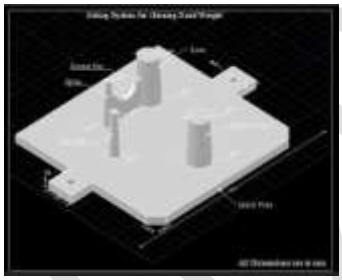


Figure 3.2.1: Design & dimension of existing gating system

- Total volume of gating $= 6.51 \times 10^{-4}\ m^3$
- Total weight of gating = Total volume of gating × density
  $= 6.51 \times 10^{-4} \times 7.2 \times 10^{3}$
  $= 4.68$ kg
- Gating ratio:

The rate of flow of molten metal through the sprue is a function of the cross-sectional areas of the sprue, runners and in gates. Gating ratios recommended by various theoreticians in the literature vary over a wide range. The Dimensional characteristics of any gating system can be generally expressed in terms of gating ratio. Following table shows the gating ratio of existing gating system.

Table No. 3.2.1: Gating area with dimension (Gating Ratio) for existing gating system

Sr. No.	Part	Existing Gating System Dimensions (mm)	Existing Gating Area (mm^2)
1	Sprue	D1 = 20 & D2 = 25	491
2	Runner	L = 60, H = 65 & T = 23	920
3	In-gates	L = 30, H = 15 & W = 40	1050
		L = 30, H = 5 & W = 40	
Gating ratio becomes 1 : 1.87 : 2.13			

But as per standard gating ratios suggested by many researchers for grey cast iron are 1 : 2 : 1, 1 : 2 : 0.5, 1 : 4 : 1 & 2 : 7 : 1. It is seen that obtained gating ratio does not match with standard gating ratios as per researchers in foundry technology.

4. PROPOSED GATING SYSTEM

According to deep study and analysis of existing gating system it was found that industry has used improper gating system. The result found after calculation and analysis of existing gating system are very typical in which, gating ratio 1 : 1.87 : 2.13 which does not match with standard gating ratio as per researcher's research in foundry technology. The further result after calculation of existing gating system are, the weight of gating system is around 4.7 Kg. which is very high it has to reduce considerably. Along with this calculation it was found that the flow pattern for existing gating system is laminar. On the basis of above results found for existing gating system it was decided to made necessary changes in the dimensions of runner and in gates with riser in order to maintain standard gating & to reduce the total weight of gating system in order to improve total productivity.

4.1 Gating ratio and its calculation for proposed gating system:

According to changes in the dimensions of existing gating system, the followings calculations are made in order to maintain standard gating ratio. With these calculations for proposed gating system gating ratio will be equal to

- Cross sectional area of sprue = 491mm^2
- Cross sectional area of runner = 1000 mm^2
- Cross sectional area of in gates = 505 mm^2 (Therefore 491: 1000: 505 = 1 : 2.03 : 1.02)

Hence it was found that proposed gating ratio, becomes (1 : 2.03 : 1.02) which is matched with std. gating ratio i.e.1 : 2 : 1 as per researchers research in foundry technology.

Table No. 4.1.1: Gating area with dimension for existing & proposed gating system

Section	Existing Gating Volume (m^3)	Existing Gating Weight (kg)	Proposed Gating (m^3)	Proposed Gating Weight (kg)
Sprue	4.19×10^{-5}	301.68×10^{-3}	4.19×10^{-5}	301.68×10^{-3}
Runner	6.712×10^{-5}	483.264×10^{-3}	7.2956×10^{-5}	0.5252
In gates	72×10^{-6}	518.4×10^{-3}	14.4×10^{-6}	103.68×10^{-3}
Riser	5×10^{-4}	3.6	2.034×10^{-4}	1.4646
Total		4.68		2.398

Hence it has proved that the weight of gating system reduces from 4.70 kg to 2.40 kg which is most economical for manufacturing industry in mass production.

4.2 Comparative analysis for flow pattern and velocity in between proposed and existing gating system:

Table No 4.2.1: Comparative analysis of flow pattern in between proposed and existing gating system

Section	Flow pattern (Re < 2000, Laminar / Re > 4000, Turbulent) for existing gating system	Mean velocity for existing gating system (m/sec)	Flow pattern (Re < 2000, Laminar / Re > 4000, Turbulent) for existing gating system	Mean velocity for existing gating system (m/sec)	Flow Pattern
Sprue	580 < 2000	4.214 m/sec	580 < 2000	4.214 m/sec	Lamina
Runner	108 < 2000	1.3756 m/sec	103 < 2000	1.3040 m/sec	Lamina
In	141 < 2000	3.5877 m/sec	265 < 2000	6.7270 m/sec	Lamina
Riser	96 < 2000	0.6966 m/sec	246 < 2000	1.7845 m/sec	Lamina

The above comparative analysis for flow pattern and mean velocity in between existing and proposed gating system produced flow pattern is laminar through all typical section of existing and proposed gating system with typical variation in mean velocity because of changes in the dimension of existing gating system. In

order to reduce various casting defects by using existing gating system this flow pattern analysis plays an important role during manufacturing of Ginning Dead Weight.

5. EXPERIMENTAL RESULTS, ANALYSIS AND DISCUSSION

By using proposed gating system, the experiment has been carried out at Jadhao Steel Alloys, Amravati. The result found after experimentation are very sound and productive. By using standard gating ratio as per ISO, it was found that the total weight of gating system reduced from 4.68 kg to 2.39 kg with reducing total percentage of rejection from 25% - 30% to 7.5% - 10%, With % of yield increases from 86% to 92%, with productivity increases from 42% to 74%, with keeping flow laminar through all sections of gating system which is most essential to reduce casting defects.

5.1 Inspection Report

Table no 5.1.1: Inspection report by using proposed gating system

Job quantity	Blow holes	shrinkage	Gas holes & pin holes	Sand inclusion	Misrun	Total	% of defects
20	-	-	-	1	1	2	10%
20	-	-	-	-	-	-	-
20	-	-	1	-	-	1	5%
20	-	-	-	1	1	2	10%
20	1		-	1		2	10%
20	-	-	-	2	-	2	10%
Average percentage of rejection is around 5% to 10%							

5.2 Actual weight of existing & proposed gating system

Table No 5.2.1: Comparison for Actual weight of existing & proposed gating system

Section	Existing Gating Volume (m^3)	Existing Gating Weight (kg)	Proposed Gating (m^3)	Proposed Gating Weight (kg)
Sprue	4.19×10^{-5}	301.68×10^{-3}	4.19×10^{-5}	301.68×10^{-3}
Runner	6.712×10^{-5}	483.264×10^{-3}	7.2956×10^{-5}	0.5252
In gates	72×10^{-6}	518.4×10^{-3}	14.4×10^{-6}	103.68×10^{-3}
Riser	5×10^{-4}	3.6	2.034×10^{-4}	1.4646
Total		4.68		2.398

According to necessary changes in the design & dimension of existing gating system it was found that the proposed gating ratio matched with standard gating ratio & the total weight of gating system reduced from 4.7 kg to 2.4 kg. This is most economical for every manufacturing industry in mass production.

5.3 Bunch weight analysis for existing and proposed gating system

Table No. 5.3.1: Bunch weight analysis for existing gating system

Sr. No.	Batch No.	Average bunch weight (kg)	Casting weight (kg)	Gating weight in (kg)	Percentage of yield (%)
1	GW/2014/10	34.65	29.8	4.85	86
2	GW/2014/10	34.72	29.92	4.8	86.17
3	GW/2014/10	34.71	30.1	4.61	86.71
4	GW/2014/10	34.59	29.92	4.67	86.49
5	GW/2014/10	34.69	29.88	4.81	86.13
6	GW/2014/10	34.75	29.93	4.82	86.12
7	GW/2014/10	34.67	29.9	4.77	86.24
8	GW/2014/10	34.85	30.18	4.67	86.59
9	GW/2014/10	34.58	29.98	4.6	86.69
10	GW/2014/10	34.66	30.1	4.56	86.84
Average		34.687	29.971	4.716	86.398

The average weight of casting found 29.971 kg with average bunch weight of casting found 34.687 which produced average percentage of yield 86% with average weight of existing gating system 4.716 kg.

Table No. 5.3.2: Bunch weight analysis after experimentation by using proposed gating system

Sr. No.	Batch No.	Average bunch weight (kg)	Casting weight (kg)	Gating weight in (kg)	Percentage of yield (%)
1	GW/2014/04	32.8	30.6	2.2	93.29
2	GW/2014/04	32.44	29.8	2.64	91.86
3	GW/2014/04	32.1	29.9	2.2	93.14
4	GW/2014/04	32.48	30.18	2.3	92.91
5	GW/2014/04	32.55	30.1	2.45	92.47
6	GW/2014/04	32.62	30.19	2.43	92.55
7	GW/2014/04	32.38	29.9	2.48	92.34
8	GW/2014/04	32.62	30.18	2.44	92.51
9	GW/2014/04	32.46	29.98	2.48	92.35
10	GW/2014/04	32.51	29.94	2.57	92.09
Average		32.4	30	2.4	92.55

The bunch weight analysis by using proposed gating system produced the average weight of casting found 30 kg with average bunch weight of casting found 32.40 which produced average percentage of yield 92% with average weight of existing gating system 2.4 kg. The typical bunch weight analysis in between existing and proposed gating system produced percentage of yield increases from 86% to 92% which is most economical for manufacturing industry.

CONCLUSION

The typical changes in design and dimension of gating system play crucial role during manufacturing of casting product. After observation, inspection and analysis of every factor of gating system it has found that, the small change in the dimension of gating system results large effects on the production cost. The target or motto of project is to reduce casting Defects, to reduce % of rejection and to reduce weight of gating system in order to achieve maximum productivity which is most essential for every manufacturing industry. The result found after experimentation are very sound and productive by using standard gating ratio as per researcher's research in foundry technology, it was found that the total percentage of productivity improved from 42 % to 74 % by reducing weight of gating system from 4.68 kg to 2.39 kg with reducing total percentage of rejection from 25 % - 30 % to 7.5 % - 10 %, with increasing % of yield from 86 % to 92 % with keeping flow laminar through all sections of gating system which is most essential to reduce casting defects.

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