Effects of Improved Gating System by Using Standard Gating Ratio

Shashank V. Gulhane[#1], A. D. Shirbhate[*2]

[#1] *Asst. Professor, Department of Mechanical Engineering*
GWCET, Nagpur, India
[#2]*Professor, Department of Mechanical Engineering*
PRMIT&R, Badnera, Amravati, India

ABSTRACT: One of the key elements to make a metal casting of high quality is the design of a good gating system. The gating system refers to those channels through which the metal flows from the ladle to the mold cavity. The use of a good gating system is even more important if a casting is produced by a gravity process. 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. 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. 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 at M/s Jadhao Steel Alloys, Amravati in which the shrinkage defect ,blow holes, pin holes, gas holes, sand inclusion and misrun defects etc. are prominent. The total percentage of defect is 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. By using standard gating ratio as per ISO, it was found that the total percentage of productivity improved from 42% to 74% by reducing total 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 % of yield increases from 86% to 92%, with keeping flow laminar through all sections of gating system which is most essential to reduce casting defects.

Keywords – Gating Ratio, Gating System, Jadhav Steel Alloys, Casting Defects, Productivity.

INTRODUCTION

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 the following parts: - a) Pouring basin b) Sprue c) Runner bar d) In gates e) Riser

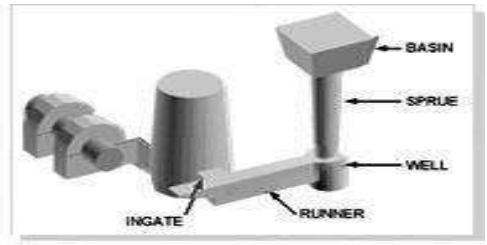

Fig. 1. Gating system 3D

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

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

IMPORTANCE OF GATING SYSTEM

The design of gating system is as important as rise ring of a steel casting. It is well known that improper gating practice can result in defects like , ceroxide, inclusions, cold shuts, misruns, hot tears, local shrinkages, and gas cavities in a steel casting. A gating system should be pre-designed and incorporated in method drawing as is the case of rise ring and not left to the discretion of the molder.

CONSTITUENTS OF GATING SYSTEM

A gating system for steel castings can be broadly divided into: - The entry section – consisting of the pouring basin, sprue and sprue base. The distribution section consists of the runners and in gates.

FUNCTIONS OF A GATING SYSTEM

The entry section of a gating has two functions:-

a) To supply liquid metal free of entrapped gases, slag and eroded sand.

b) To establish a hydraulic pressure head, this will force the metal through the rest of the gating system and into the casting.

The distribution section has three functions:-

a) To decrease the velocity of the metal stream, to minimize turbulence, both in the gating system as well as in the mold cavity.

b) To avoid mold and core erosion, to establish the best possible thermal gradient in the casting.

c) To regulate the rate of flow of metal into the mold cavity.

In addition to these, the gating system should be of such simple design as to facilitate molding, 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.

PROBLEM IDENTIFICATION

During our industrial visit at M/s 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, Misrun 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 I: Inspection report for GW. By using existing gating system

Job Qty	shrinkage	Blow holes & gas holes	Sand inclusion	Misrun	Total	% 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%**
20	**1**	**3**	**1**	-	**5**	**25%**

Average percentage of rejection is around 25% to 30%

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.

STUDY AND ANALYSIS OF EXISTING GATING SYSTEM

The study and analysis of existing Gating System and Proposed Gating System for the manufacturing of Ginning Dead Weight at Jadhao Steel Alloys Amravati. 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 discussions with Mr. G. M. (PROD.) 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.

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 fiber

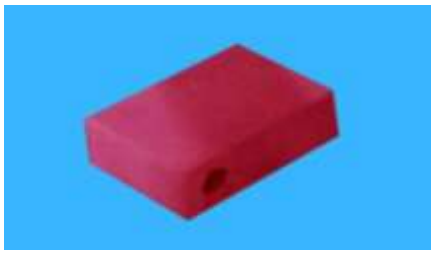

Fig. 2. Ginning Weight

DIMESIONAL DRAWING OF GINING WEIGHT

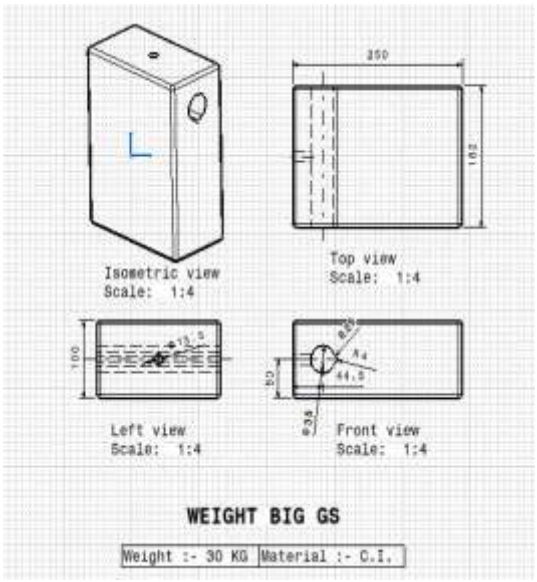

Fig. 3. Dimensional Drawing of Ginning Weight

DESIGN & DIMENSION OF EXISTING GATING SYSTEM

As per the discussion had with G. M. (PROD.) 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. In order to reduce casting defects it was decided to follow deep study and analysis of existing gating system.

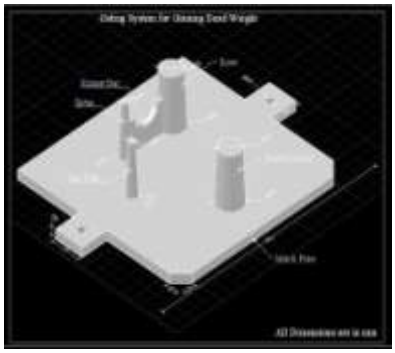

Fig. 4. Design and Dimension of Existing Gating System

Total volume of gating = 6.51×10^{-4} m3
Total weight of gating = Total volume of gating × density
= $6.51\times10^{4}\times7.2\times10^{3}$
= 4.68 kg

GATING RATIO AND ITS CALCULATIONS FOR EXISTING GATING SYSTEM

The typical gating system made by industry found typical casting defects which has increased percentage of rejection and which has affected productivity. In order to reduce percentage of rejection it was decided to follow standard gating ratio as per ISO in foundry technology.

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.

TABLE II: Gating area with Dimension 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, L=30, H=5,W=40	1050

Gating ratio becomes 1:1.87:2.13

But as per standard gating ratio suggested by many researchers (i.e. 1:2:1, 1:2:0.5, 1:4:1, 2:7:1) for grey cast iron. Hence obtained gating ratio is not matched with standard gating ratio as per researchers in foundry technology.

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 is not matched 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 ratio as per researchers research in foundry technology. Necessary changes in the dimensions of runner and in gates with riser proposed in order to maintain standard gating ratio as per researchers in foundry technology and to reduce total weight of gating system in order to improve total productivity.

TABLE III: Gating area with Dimension for existing & proposed gating system

Section	Existing gating volume in (m3)	Existing gating weight in (kg)	Proposed gating in (m3)	Proposed gating weight in (kg)
Sprue	$4.19\ X10^{-5}$	$301.68X10^{-3}$	$4.19\ X10^{-5}$	$301.68X10^{-3}$
Runner	$6.712\ X10^{-5}$	$483.264\ X10^{-3}$	$7.2956X10^{-5}$	0.5252
In gates	$72\ X10^{-6}$	$518.4X10^{-3}$	$14.4X10^{-6}$	$103.68X10^{-3}$
Riser	$5\ X10^{-4}$	3.6	$2.034\ X10^{-4}$	1.4646
TOTAL		4.68 kg		2.398 kg

GATING RATIO AND 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 changes 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

TABLE IV: Gating area for existing & proposed gating system

Sr. No	Part	Existing Gating System Dimensions (mm)	Proposed Gating System Dimensions (mm)	Existing Gating Area (mm^2)	Proposed Gating Area (mm^2)
1	Sprue	D1= 20 , D2= 25	D1= 20, D2= 25	491	491
2	Runner	L= 60, H= 65, T= 23	L= 60, H= 65, T= 25	920	1000
3	In gates	L=30 H=15,w=40, L=30, H=5, W=40	L=20, H=12,w=30 ,L=5, W=20,H=5	1050	505
Gating ratio becomes (1:1.87:2.13)(1:2.03:1.03)					

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

FLOW PATTERN ANALYSIS IN BETWEEN PROPOSED & EXISTING GATING SYSTEM

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. In order to reduced casting defects and percentage of rejection it was decided to check flow pattern for the proposed gating system. Following are the calculations made to check molten metal flow pattern for the individual section of proposed gating system.

TABLE V: Comparative analysis of flow pattern in between proposed and existing gating system

Section	For Existing Gating System		For Proposed Gating System		Flow pattern
	Reynolds Number	Mean Velocity in m/s	Reynolds Number	Mean Velocity in m/s	
Sprue	580	4.214	580	4.214	Laminar
Runner	108	1.3756	103	1.3040	Laminar
In gates	141	3.5877	265	6.7270	Laminar
Riser	96	0.6966	246	1.7845	Laminar

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.

EXPERIMENTAL RESULTS, ANALYSIS AND DISCUSSION

By using proposed gating system the experiments 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.

INSPECTION REPORT

TABLE VI: Inspection Report by using proposed gating system

Job Qty	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%							

ACTUAL WEIGHT OF EXISTING & PROPOSED GATING SYSTEM

TABLE VII: Comparison for Actual weight of existing & proposed gating system

Section	**Existing gating volume in (m3)**	**Existing gating weight in (kg)**	**Proposed gating in (m3)**	**Proposed gating weight in (kg)**
Sprue	$4.19 X10^{-5}$	$301.68X10^{-3}$	$4.19 X10^{-5}$	$301.68X10^{-3}$
Runner	$6.712 X10^{-5}$	$483.264 X10^{-3}$	$7.2956X10^{-5}$	0.5252
In gates	$72 X10^{-6}$	$518.4X10^{-3}$	$14.4X10^{-6}$	$103.68X10^{-3}$
Riser	$5 X10^{-4}$	3.6	$2.034 X10^{-4}$	1.4646
TOTAL		**4.68 kg**		**2.398 kg**

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.

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.

BUNCH WEIGHT ANALYSIS

TABLE VIII: Bunch Weight analysis after experimentation by using proposed gating system

Sr. No	Batch No.	Bunch weight in Kg	Casting weight in Kg	Gating weight in Kg	% yield
1	GW/2012/04	32.800	30.600	2.200	93.29
2	GW/2012/04	32.440	29.800	2.64	91.86
3	GW/2012/04	32.100	29.900	2.2	93.14
4	GW/2012/04	32.480	30.180	2.3	92.91
5	GW/2012/04	32.550	30.100	2.45	92.47
6	GW/2012/04	32.620	30.190	2.43	92.55
7	GW/2012/04	32.380	29.900	2.48	92.34
8	GW/2012/04	32.620	30.180	2.44	92.51
9	GW/2012/04	32.460	29.980	2.48	92.35
10	GW/2012/04	32.510	29.940	2.57	92.09
Average		**32.40**	**30**	**2.4**	**92**

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.

TABLE IX: Bunch Weight Analysis for existing gating system

Sr. No	Batch No.	Bunch weight in Kg	Casting weight in Kg	Gating weight in Kg	% yield
1	GW/2011/10	34.650	29.800	4.85	86.00
2	GW/2011/10	34.720	29.920	4.8	86.17
3	GW/2011/10	34.710	30.100	4.61	86.71
4	GW/2011/10	34.590	29.920	4.67	86.49
5	GW/2011/10	34.690	29.880	4.81	86.13
6	GW/2011/10	34.750	29.930	4.82	86.12
7	GW/2011/10	34.670	29.900	4.77	86.24
8	GW/2011/10	34.850	30.180	4.67	86.59
9	GW/2011/10	34.580	29.980	4.6	86.69
10	GW/2011/10	34.660	30.100	4.56	86.84
Average		**34.687**	**29.971**	**4.716**	**86%**

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. 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.

COST ANALYSIS IN BETWEEN EXISTING AND PROPOSED GATING SYSTEM TO MEASURE TOTAL PRODUCTIVITY

This cost analysis in between existing and proposed gating system produced percentage of productivity increases from 42% to 74% which is most essential for every manufacturing industry.

TABLE X:-Cost Analysis by using existing gating system

Sr. No	Heat No.	Casting Produced	Bunch Weight of each casting	Pure weight of each casting	Weight of gating	Total weight of bunch casting	No of casting accepted	No of casting rejected	Total weight of accepted casting	Total weight rejected casting	Total weight of gating	Total production cost	Refund cost due to rejection and gating	Total price of accepted casting	Productivity in Rs.	Percentage of total productivity
		A	B	C	D = B - C	E = A x B	F	G	H = C x F	I = C x G	J = A x D	K = E x @ Rs. 45	L = (I+J) x @ Rs. 30	M = H x @ Rs. 45	N = M - L	O = N/K
1	GW/10/11	20	34.65	29.8	4.85	693	15	5	447	149	97	31185	7380	20115	12735	40.83%
2	GW/10/11	20	34.72	29.92	4.8	694.4	14	6	418.88	179.52	96	31248	8265.6	18849.6	10584	33.87%
3	GW/10/11	20	34.71	30.1	4.61	694.2	16	4	481.6	120.4	92.2	31239	6378	21672	15294	48.99%
4	GW/10/11	20	34.59	29.92	4.67	691.8	15	5	448.8	149.6	93.4	31131	7290	20196	12906	41.34%
5	GW/10/11	20	34.69	29.88	4.81	693.8	16	4	478.08	119.52	96.2	31221	6471.6	21513.6	15042	48.17%
6	GW/10/11	20	34.75	29.93	4.82	695	14	6	419.02	179.58	96.4	31275	8279.4	18855.9	10576.5	33.85%
7	GW/10/11	20	34.67	29.9	4.77	693.4	15	5	448.5	149.5	95.4	31203	7347	20182.5	12835.5	41.13%
8	GW/10/11	20	34.85	30.18	4.67	697	15	5	452.7	150.9	93.4	31365	7329	20371.5	13042.5	41.78%
9	GW/10/11	20	34.58	29.68	4.6	691.6	15	5	446.7	148.9	92	31122	7257	20236.5	12979.5	41.75%
10	GW/10/11	20	34.66	30.1	4.56	693.2	16	4	481.6	120.4	91.2	31194	6348	21672	15324	49.12%
Average		**20**	**34.687**	**29.971**	**4.716**	**693.74**	**15.1**	**4.9**	**452.918**	**146.832**	**94.92**	**31218.3**	**7234.56**	**20368.44**	**13133.9**	**42.04%**

TABLE XI:-Cost Analysis by using proposed gating system

Sr. No.	Heat No	Casting Produced	Bunch Weight of each	Bare weight of each	Weight of gating	Total weight of bunch	No of casting accepted	No of casting rejected	Total weight of accepted	Total weight rejected	Total weight of gating	Total production cost	Refund cost due to rejection	Total price of accepted casting	Productivity in Rs.	Percentage of total productivity
		A	B	C	D = B-C	E = A x B	F	G	H = C x F	I = C x G	J = A x D	K = E x @ Rs. 45	L = (I+J) x @ Rs. 30	M = H x @ Rs. 45	N = M - L	O = N/K
1	GW/04/12	20	32.8	30.6	2.2	656	18	2	550.8	61.2	44	29520	3156	24786	21630	73.27%
2	GW/04/12	20	32.44	29.8	2.64	648.8	18	2	536.4	59.6	52.8	29196	3372	24138	20766	71.12%
3	GW/04/12	20	32.1	29.9	2.2	642	19	1	568.1	29.9	44	28890	2217	25564.5	23347.5	80.81%
4	GW/04/12	20	32.48	30.18	2.3	649.6	18	2	513.06	60.36	46	29232	3190.8	23087.7	19896.9	68.06%
5	GW/04/12	20	32.55	30.1	2.45	651	19	1	571.9	30.1	49	29295	2373	25735.5	23362.5	79.74%
6	GW/04/12	20	32.62	30.19	2.43	652.4	18	2	543.42	60.38	48.6	29358	3269.4	24453.9	21184.5	72.15%
7	GW/04/12	20	32.38	29.9	2.48	647.6	18	2	538.2	59.8	49.6	29142	3282	24219	20937	71.84%
8	GW/04/12	20	32.62	30.18	2.44	652.4	18	2	543.24	60.36	48.8	29358	3274.8	24445.8	21171	72.11%
9	GW/04/12	20	32.46	29.98	2.48	649.2	19	1	569.62	29.98	49.6	29214	2387.4	25632.9	23245.5	79.56%
10	GW/04/12	20	32.51	29.94	2.57	650.2	18	2	538.92	59.88	51.4	29259	3338.4	24251.4	20913	71.47%
Average		**20**	**32.496**	**30.077**	**2.419**	**649.92**	**18.3**	**1.7**	**547.366**	**51.156**	**48.38**	**29246.4**	**2986.08**	**24631.47**	**21645.39**	**74.01%**

DISSCUSSION

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. 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 average total percentage of rejection for existing gating system is around 25% to 30% of total casting produced. The average total percentage of rejection for proposed gating system is around 7.5% to 10% of total casting produced. This major change in the average percentage of rejection plays an effective role on production cost. 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.

The number of factors influencing the gating design is numerous. But out of all these factors can be considered as a important one. According to deep study and analysis It was decided to follow standard gating ratio as per ISO suggested by many researchers in the field of casting .In order to maintain standard gating ratio It was found that old gating ratio was incorrect. After gating system calculation it was found that the total weight of gating system is very high, that has to considerably reduce. After careful observation and analysis it was decided to make necessary changes in the design and dimension of gating system.

By using proposed gating system the experiments has been carried out at Jadhao Steel Industry, 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 percentage of productivity improved from 42% to 74% by reducing total 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 % of yield increases from 86% to 92%, with keeping flow laminar through all sections of gating system which is most essential to reduce casting defects.

CONCLUSION

The typical changes in design and dimension of gating system play a 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 4.68kg 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.

To design a gating system for steel casting standard gating ratio plays a crucial role during manufacturing. In ordered to reduce casting defects & percentage of rejections, typical optimization technique must be follow. Design of typical elements of gating system must be produced optimum weight of gating system. Flow pattern analysis is very important in order to check molten metal flow pattern is laminar or turbulent during casting with optimum velocity of molten metal in order to reduce various casting defects. To optimize the gating system for steel casting percentage of yield and percentage of productivity must be improve.

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Appendix

Photo copies for types of defects observed by using existing gating system






Experimentation Images