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Gating Design Modification Using 3D CAD Modeling and Casting Simulation for Improving the Casting Yield

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ABSTRACT

A well designed gating system is essential to obtain defect free sound casting which is the basic requirement of the customer. For economical casting gating, should have minimum volume and consume less metal. Initially gating system components are designed using past experience and judgment of patternmaker. Using trial and error method after various iterations, sound casting is obtained, this process is time consuming as well as wastage of resources in each trial. As gating is cut off and recycled it must consume minimum metal. If it consuming more metal the associated cost such as recycling cost, transport cost, re-melting cost will be higher and results in lower casting yield and lower productivity.

In this paper casting of brake disc is analyzed and studied to solve the problem of lower casting yield due to over designed gating system components. To overcome this problem gating system is redesigned based on gating rules, gating design procedure, theoretical knowledge, casting simulation and practical considerations. The various gating systems are designed for the casting and 3D CAD models of this designs are made and simulated using casting simulation program Autocast-X flow plus. After analyzing the simulation results, if desired results are not obtained, then the changes are made in the design and 3D CAD model and simulated again, the procedure is repeated until the desired results are obtained so as it will give the sound quality casting with the higher casting yield, profit and productivity.

Keywords-casting simulation, 3D CAD modeling, gating system, sound casting

1. Introduction:

As the foundries are primary suppliers to the automobile industries also casting is widely used as one of the economical method of manufacturing automobile components. Although lots of research has been carried out in foundry technology, yet achieving optimal utilization of material, energy and other resources is a big challenge to Indian as well as Global foundries.

The main objective of a gating system is to lead clean molten metal poured from ladle to the casting cavity, ensuring smooth, uniform and complete filling which results into the sound defect free casting. As the is secondary component of casting, it should be minimum in volume so as it must consume less metal and the casting yield is higher, which makes the process economical. To achieve this goal, the gating should be properly designed so as to work properly and efficiently. If gating is overdesigned it will reduces the actual casting yield, if it is undersized or not designed properly it would results into the various flow related defects such as cold shunt, misrun, blow holes, slag and sand inclusion. Hence proper design of gating system is essential for sound casting with higher yield.

2. Problem definition:

The initial gating system of brake disc is giving the defect free casting but the gating components such as sprue, sprue well, gates and risers are having higher volume hence when poured metal solidifies it consumes more metal, as this components are secondary components of casting this are cut-of from actual casting and re-melted. Higher volume of these gating system components reduces the actual yield hence process becomes uneconomic and less profitable.

For increasing the yield of casting, the gating system and its components are redesigned so as they must consume minimum metal also they produce the defect free casting. As casting yield increases the productivity increases and also re-melting and recycling costs are reduced.

2. 1 Assessment of the initial yield:

The current gating system used is unpressurised, multi gating system used to feed the bunch of 8 brake disc casting. The liquid metal poured for the given casting is 90 kg per mould box. From that the weight of good casting obtained is 64. 80 and rejected scrap for recycling is 25. 20 kg, from that calculated yield is 72%. The gating system is having the weight i. e. 9. 70 kg excluding riser weight. Hence here is chance to reduce the weight of gating system for the improving the actual casting yield.

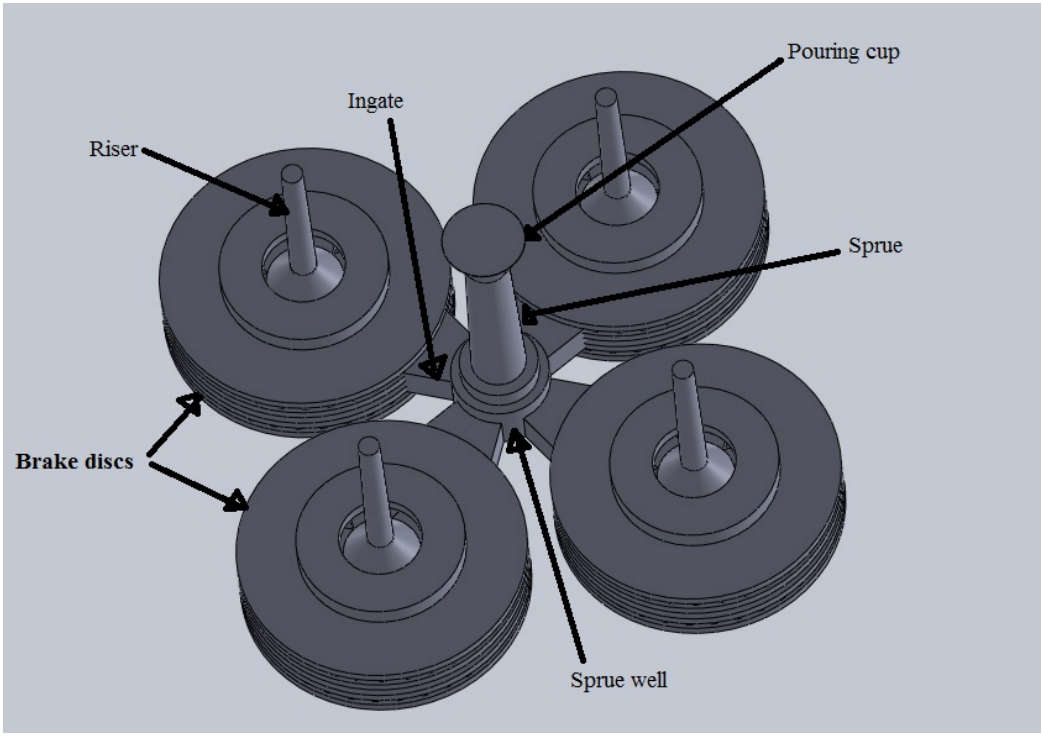

Fig. 1. The 3 D CAD model of casting with initial gating system.

2. 2 Analysis of the initial gating system:

From the dimension cross section area of each component is calculated and gating ratio of system is calculated given as: 1: 1. 5: 3. 28: 5. 1: 6. 4: 9. Also the theoretical choke area is calculated for initial gating system by design procedure, the value comes is 886 mm^2 but the actual value 1320 mm^2. It clearly indicates the system is overdesigned and hence results in lower casting yield.

3. Gating system design modification:

From using the gating design procedures, gating rules and with the base of theoretical knowledge we made various designs of gating system which are suitable to replace the current ones. From them most suitable designs are listed and compared for various characteristics to choose best one. The gating system are designed and represented in the tabular form as given below:

Table 1. Designs of the modified gating systems with the design parameters

Design	W	L_f	t_f	A_c	S_t	S_b	SW_d	SW_h	G_{in}	G_{out}
1	85	400	10. 50	857. 03	33	44	66	52. 5	1297. 54	1973. 47
2	80	400	10. 25	927. 85	35	46	69	51	1418. 24	2157. 57
3	75	400	9. 98	892. 95	34	45	68	51	1377. 44	2095. 86

W = Weight of casting in kilograms with the gating system, L_f = Fluidity length in mm. t_f = It is optimal mould filling time in seconds. A_c = It is choke area for the given system in mm^2, S_t and S_b are the diameters of the sprue top and base respectively. SW_d and SW_h are the diameter and height of sprue well respectively. G_{in} and G_{out} are cross section areas of entrance and exit respectively.

The comparison between the gating system is given below:

Table 2. Comparison between modified gating designs based on various parameters

Gating	Gating ratio	Flow rate [Kg / sec]	Proposed yield
Design 1	1: 1. 77: 3. 99: 6. 06: 9. 21	8. 09	76. 23 %
Design 2	1: 1. 79: 4. 04: 6. 14: 9. 34	7. 80	81 %
Design 3	1: 1. 78: 4. 06: 6. 07: 9. 25	7. 52	86. 23 %

The gating required is unpressurised, gating design 2 is having the maximum gating ratio yet the flow rate is optimum, also it is possible to obtain proposed yield with the same quality of casting.

4. Riser design modification:

For yield improvement purpose the risers are also modified based on the feeding rules, casting simulation, practical considerations etc, the table showing below the dimension of the initial and modified riser.

Table 3. Details of initial and modified risers

Riser	Top diameter	Bottom diameter	Height	Slant height
Initial	20	25	175	175.
Modified	26	30	50	50. 0076

Hence design 2 is finalized for further analysis using the autoCAST-X flow plus for the effectiveness of the gating system. The 3D CAD model of casting with modified gating and riser is made and given as input to simulation software for the further analysis.

The results are as follows:

The images showing the percentage mould cavity filling as given below:

Fig. 2 Mould filling at 5 %

Fig. 3 Mould filling at 25 %

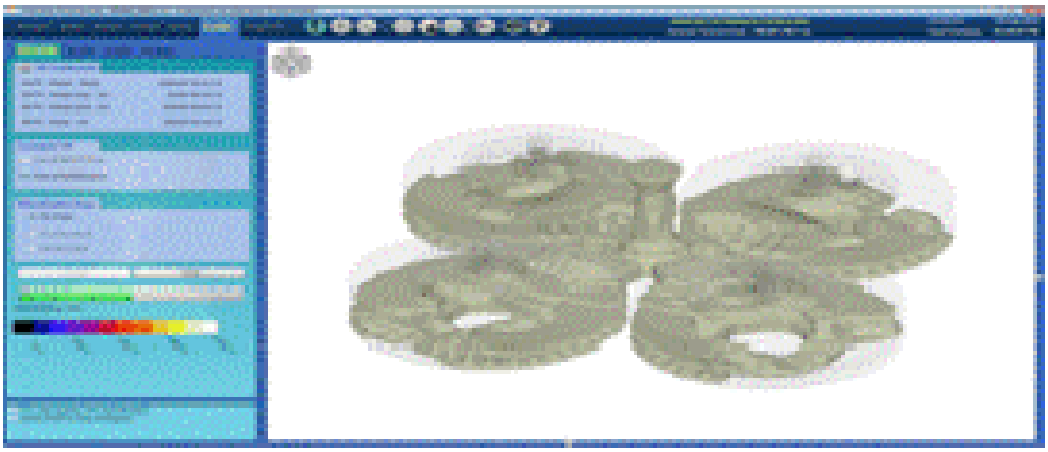

Fig. 4. Mould filling at 50 %

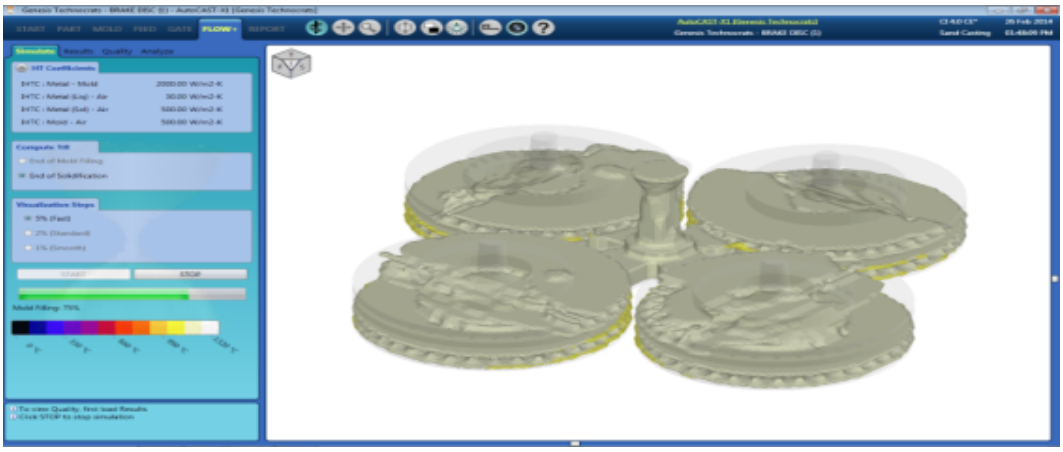

Fig. 5. Mould filling at 75 %

Fig. 6. Mould filling at 99 %

Fig. 7. Image showing result of simulation

5. Result of simulation:

The simulation results are showing no any defect is seen in the casting, micro-porosity can be occur at sprue top but is secondary component which is going for recycling and remelting again hence the casting obtained with the modified riser and gating system is sound casting with the higher yield.

5. 1Experimentation for calculating the improved yield:

For the achieving the goal of enhanced yield, the changes are done in the process, the risers and sprue at the top match plate (pattern plate) are replaced with the modified riser and sprue from gating system design 2.

Also the ingates at bottom match plate are replaced with modified ingates from gating design 2. And using this pattern plates mould cavity is formed and liquid metal is poured in a mould cavity to get a casting.

5. 2 Assessment of improved yield:

Initially liquid metal required is 90 kg but after gating modification metal required is 82 kg. Hence nearly 8 kg metal is reduced per mould box for the given casting.

Table. 4. Assessments of the weights of gating system and feeding system.

Gating system	Component	No of component	Component Weight [kg]	Total weight [kg]
Initial	Riser	4	0. 94	3. 76
Initial	Gating	1	10. 90	10. 90
Modified	Riser	4	0. 31	1. 24
Modified	Gating	1	5. 70	5. 70

Initial weight of the gating and feeding system = 3. 76 + 10. 90 = 14. 66 kg

Modified weight of gating and feeding system = 1. 24+ 5. 70 = 6. 94 kg

Total saving of the metal = 7. 72 kg

Piece weight= 8. 10 kg, No of casts= 8, good casting =64. 80 kg, liquid metal=82 kg.

Rejected scrap per mould box = 17. 20 kg.

Final Yield (%)= $\frac{64.80}{82}$×100 = 79 %

6. Conclusion:

After modification in the gating system and risers the yield improved is 7 % with the sound casting of brake disc. Per each mould box 8 kg raw material is reduced. Hence the productivity as well as profit increases due to properly designed gating system. Certain change has to made in current process to implement modified gating system.

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