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Optimization Of Runner And Riser Locations To Reduce Blow Hole Defect In The Casting

Mahesh Kori[1], Veeresh Gurav[2], Veeranna[3]
[1]Assistant Professor, Department of Mechanical Engineering., Karnataka, (State), INDIA
(Corresponding author: Veeresh Gurav
(Corresponding author: Veeranna

ABSTRACT
For any metallic components casting is a primary manufacturing process. And this casting is a combination of various processes that include sand molding, sand core making, assembly of mold and core, melting the raw materials in the furnace pouring the molten metal in the patterns, shake out, inspection and final dispatch. Sometimes the casting process is also difficult to define because even in the proper calculated and controlled casting process the defects are going to appear which is very difficult to obtain sound casting. This study is aimed to solve the blow hole defect which occurs in the casting, and to reduce rejection rates. Blowhole is nothing but the smooth walled cavities of various dimensions created by gas and not allowed to escape out during casting process.
Keywords – Casting, molding, Manufacturing.

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I. INTRODUCTION

Manufacturing complex shaped components is a difficult task, here casting process made easy to solve this complexity. The casting may have one or more defects and these defected parts lead to casting rejections because the stress concentration occurs in the defected area while using the component in respective applications. It is possible to produce hundred percent good defect free casting there will be more time and money could be saved. By taking the precautionary measures in the casting process we can minimize the casting defects. Modern foundries have advanced inspection equipment's which they can easily identify the defects on the outer surface as well as the defects which are located internally located. In metal casting production the defects are caused by the several factors rather than single one.

During metal casting process various unwanted internal defects occurs including blow holes fractures, inclusions, slag formations and many more. While using the internally defected components looks ok in the beginning of the use but later it will become serious threat to the application and these problems resulting in weakness of the component, so before actual use of the product it is necessary to ensure that the product is free from defects that will be safe.

As compared to other defects blow holes are appearing the different way, the size of the blow holes can vary from microscopic to macroscopic. Here macroscopic blowholes can easily appear to naked eyes while the microscopic blowholes are difficult to locate, so the present technology has a difficulty in dealing with such cases. And it requires more investment for equipment's which are used to detect defects in the castings. Sand casting method is the most accurate and efficient method which is used in modern foundries. Here also there are some defects which will occur in castings. In this study we mainly concentrated to solve blow hole defect in an industry. Here we concentrated on a specific part of casting to reduce blowhole defect by making some changes in molten metal pouring direction. The casting productivity is increased to another 50% compared to earlier rejection rate incorporating the change in the design and location of riser.

II. LITRRATURE REVIEW

In the year of 2011, *Dr. SB Raju, Dr. RN Baxi* said there are more benefits and better tools that improve the quality of casting components using modernized methods using modern simulation performed by various software. This will reduce casting waste, which helps improve productivity. This study is aimed at minimizing cast rejection by considering cast defects.

In the year 2015 *Divyesh Sathwara, Kushal Shah, Rushik Trivedi, Hardik Seth* seeded in the industry, the main flaws are discovered through the approaches that are systematically executed and applied to discover the causes of those main flaws. Here they discovered the origin of the defects by applying some approaches such as simulation analysis and control tools which are statistically achieved. And also applying approaches like lean manufacturing and six sigma in industries involves training employees in a better way at the grassroots levels, which makes employees better at their jobs and this will lead to cultural changes in the organization.

Praevadee Kaewkongkha, Somkiat Tangjitcharoen (2015) in their research study showed aluminum alloys used in blown compressors in automotive parts, they studied the factors that cause blowouts. Here they investigated some factors that affect defects, such as vacuum pressure, flow rate, and casting pressure. At first, they used a low casting speed to fill the mold cavity with molten metal, this resulted in producing more blow holes, then they increased the casting speed and thus the blow hole defect was reduced.

Pradeep kumar Ganguly and Rajesh Rana (2018) these two people have studied the defects found in the industry that occur during the component casting process and these people have shown how these defects really look and for this defect what kind of precautions should be taken to avoid these defects. They concluded that by using six sigma there will be an improvement in the casting methodology and therefore the quality of the product will be improved by 50%. And they have shown that by using the DCMAIC approach in small-scale industry, their performance will improve and customers will be satisfied with their products and there will also be a financial advantage for the industry in the foundry market.

Xinyue Zhao, Jingjing Liang, Zaixing He, and Shuyou Zhang (2019) these people showed some methods used to detect small holes that are difficult to see with the naked eye by X-ray inspection in omnidirectional enhancement and bidirectional enhancement. They are non-destructive procedures that do not damage the components. In the bidirectional enhancement method, defects are detected by highlighting defects that are blurred in appearance. They also used the proposed method to detect fusion defects and ultimately concluded that the proposed method offers the best performance in detecting spiracles.

Ahmed Fattah, Aude Cailluada, Zehra Jalouli, Amine Ammar (2020) These people have done a numerical frame work in which they have developed their work on the formation of the shrinkage defect in the solidification phase under some cooling modifications and this method is used to separate the liquid. molten metal and gases produced during melting and casting. They concluded that the mobility is created between the two molten metals separated from each other and that the mobility depends on the temperature.

2.1 Blow Holes:

Blow holes are considered to be the voids found in solidified metal that are formed due to trapped gas and this trapped gas is the main cause of the blow holes. They are not the same size, they can vary greatly in size.

FACTORS AFFECT THE BLOW HOLES: -

1. Presence of foreign particles in the molten metal and particles that are present on the surface of the mold just before the casting of the molten metal.
2. Improper model design.
3. Appearance of the entrained slag that is present in the casting vessel of the molten metal.
4. Slow cooling of the molten metal in the mold lining.
5. Blow the holes formed using wet molds.
6. Gas entrapment in the mold.

III. CASE STUDY: -

In this paper by considering blowhole defect we concentrated on a product called 4BM25 and 4BM26 which is used in hydraulic pedal.

Fig 1: - actual view of 4BM25 and 4BM26

The above-mentioned product was facing a lot of blow hole defect during casting because of this the rejection rate of this product was 50% to 60%.

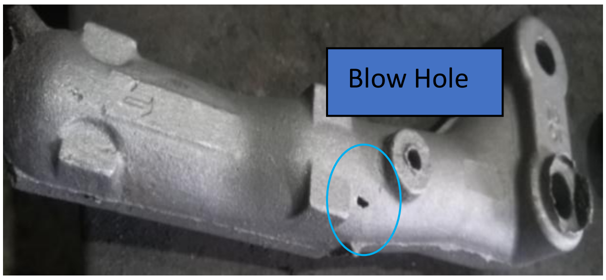

Fig 2: -view of blowhole on the casting surface

To solve this, we did some changes in gating systems and we tried different pouring angles to reduce the turbulence during molten metal pouring.
First we tried different pouring positions as shown below.
This is the best result from the any other result.

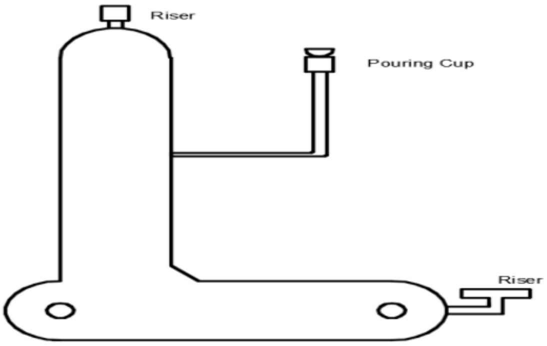

Fig3.a: -Middle-side Runner & top-bottom Riser Pouring

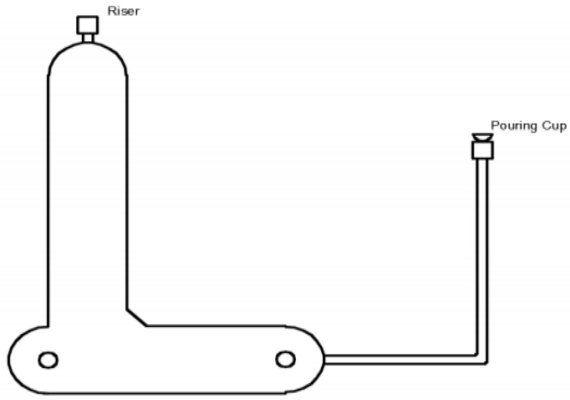

Fig3.b: -Bottom-side Runner & top Riser pouring

As we showed above, we tried different runner and riser positions to avoid defect but this try was not up to the mark. Here the rejection rate is reduced only 5% to 6% as compared to earlier so then we decided to change the pouring angels.
After changing the different pouring positions then we tried different pouring angles as shown below.

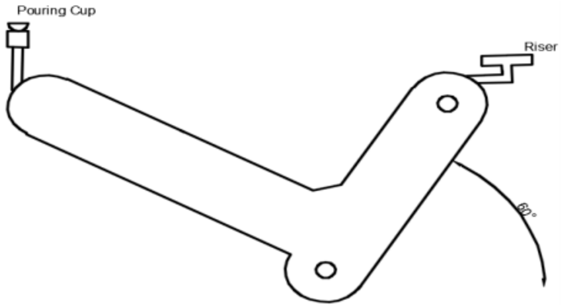

Fig 4.a: -Top Runner & Bottom Riser Pouring with inclined 60°

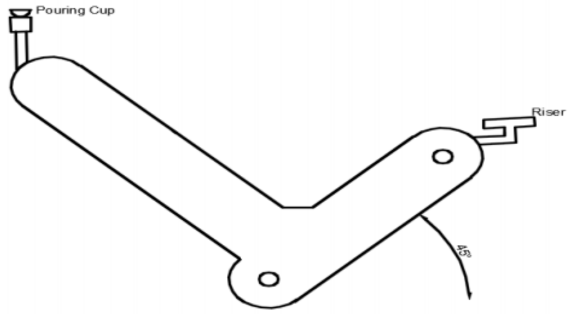

Fig 4.b: -Top Runner & Bottom Riser pouring with inclined 45°

As we showed above, we tried only two possible inclined pouring angles to reduce the turbulence. But here including as a result we got slag inclusion with blowhole and it became a serious threat to the casting product and rejection rate of the product is as same as before.

Fig 5: -View of slag inclusion on the product

After completing all these trials then we provided ventilation to remove the gases which are entrapped in the casting product when the molten metal starts solidifying and in the same time, we tried different position of runner and riser as shown below.

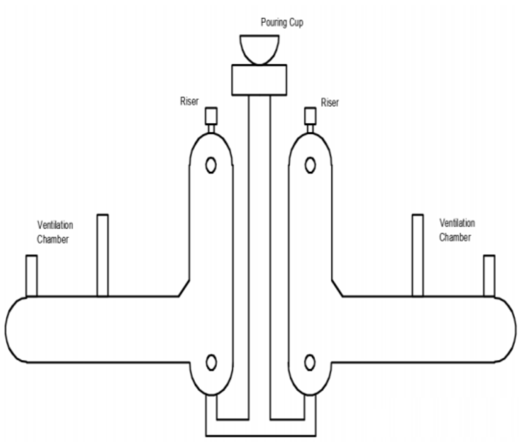

Fig 6: -Casting with multiple gating system with ventilation channels

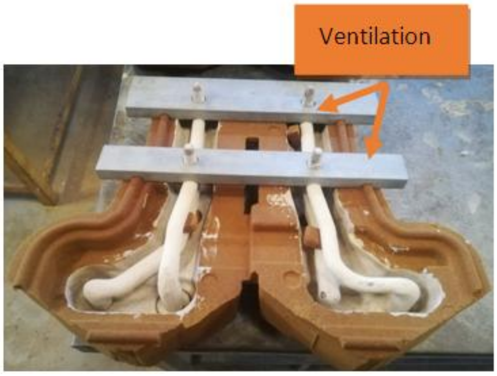

Fig 7: - Sand mould with ventilations

In sand moulds ventilation is provided along with the cores during the assembly of mold and core. The ventilations provided with the same material of the casting. The main aim of the ventilation is to remove the entrapped gases from the

Then finally we find out the best way to reduce the blowhole defect by providing ventilations to the sand molds. This helps to remove the gases produced during molten metal pouring in the molds. From this method we got extremely low rejection rate which is around only 5% of the total production.

After solidification of the product some of the tests on the specimen are done.

The chemical composition of the product is as shown below.

Table: CHEMICAL COMPOSITION

S.RNO	CHARACTRERSTICS	SPECIFICATION
1	CE-CARBON EQUIVALENT	-
2	TC-TUNGSTEN CARBIDE	3.00 – 3.40 MAX
3	Si -SILICON	1.80 – 2.30 MAX
4	Mn - MAGANESE	0.5 – 0.8 MAX
5	P - PHOSPORUS	0.1 MAX
6	S - SULPHUR	0.07 – 0.15 MAX
7	Cu - COPPER	0.8 – 1.0 MAX
8	Cr - CHROMIUM	0.3 – 0.4 MAX

molten metal after pouring and during solidification. The metal provided with the ventilation melts when the hot molten metal poured in the mold.

This method gives the perfect solution to avoid the blowhole defect in the castings. This design reduces rejection rate and produces the sound casting. From this method the rejection rate is decreased to only 5% and production rate also increased. This is the best result from the any other result.

IV. RESULTS AND DISCUSSION

In foundry the casting defects are mostly depends on the process parameters. Here in this paper, we try to avoid the defects by changing the process parameters only. So as we mentioned above in the case study tried 2 different molten pouring positions and two different angle of pouring into the sand mold. But the results are not satisfied by these 2 methods, from first trial the rejection rate was 50% and from the second trial the rejection rate increased to 55%.

The tensile strength test details for final product are as follows

Specimen shape :- Solid round
Specimen type :- Cast iron
Specimen diameter :- 20 mm
Initial elongation :- 80 mm
Preload reading :- 0 KN
Load at peak :- 94.648 KN
Maximum load :- 410 KN
Maximum elongation :- 202 mm
Specimen cross section area :- 314.159 mm2
Elongation at peak :- 11.940 mm
Tensile strength :- 301.274 N/mm2

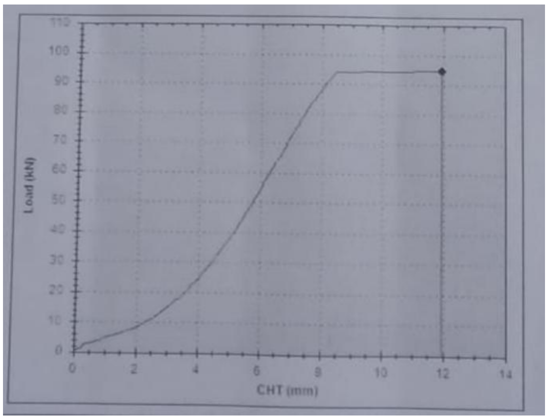

Fig 9: - Load VS cross head diagram of specimen which is done on universal testing machine

LOAD RATE (KN/Sec)	TARGET LOAD (KN)	HOLD TIME (Sec)
1.00	400.00	1

The above figure represents the load vs cross head diagram carried during tensile strength test on the product. The table represent the load rate given at the time of tensile strength test.

REMEDIES: -

- Providing ventilation channels so that entrapped gas from molten metal.
- Apply external heat to core paintings so that painting can deposit on the core properly.
- Reduce the amount of binder used in melting so that reduce amount of gas production.
- Use completely dried molds and cores.
- Remove inert dust particles which are present in the sand.
- By using coarser sand for mold preparation. Reduce bentonite and carbon carrier content.
- Use proper gating system, properly designed runners and risers.

V. CONCLUSION

There are lot of variable defects that arises in the castings and defect on which we have concentrated is Blowholes. We had looked for the root causes of it and the remedies that we can take. We found that it mainly depends on many factors but the main factor is entrapped gases during molten metal pouring and solidification. There are many variables to obtain the defect free castings and lot of parameters are to be taken case. in our case particularly we focused on blowholes occurring during solidification process which were resulting in rejections of casting is around 50%, due to major factor gas entrapment by poor gating design and riser design.

we suggested and tried with various changes in the gating system. Then we came up with some solutions where we tried some changes in the runner and riser positions but here, we did not reach the expectations and here the reduction in the defects was not up to the mark. Then tried to pour molten metal at some possible angles by tilting the sand mould at certain degrees, but this method also did not give proper result instead slag inclusion defect was found here. Because of this the rejection rate is increased. Finally, at last ventilations to the casting sand molds came in work, this has done to remove entrapped gases from the molten metal during solidification. This method gives least rejection rate compared to other trials and also increased 50% in the production rate.

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