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GATING OPTIMIZATION AND CASTING SIMULATION FOR MW4 HUB ANTI BUILD-UP INVENTOR

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ABSTRACT

Design of gating system in sand casting takes enormous attempt to obtain optimum design. It is costlier and time consuming. Proper gating system gives sound casting and also helps to provide heat in casting till it solidifies. Optimized gating system design give prevention towards the liquid to liquid shrinkage and liquid to solid shrinkage and it improve yield with optimum resources and man power. When new product comes in a foundry, it should carry out experiments to achieve sound casting design and implementation for maximum yield need attention. In this project it is proposed to develop MW4 HUB ANTI BUILD UP INVENTOR through optimized gating system. To reduce trial attempts for optimum gating system of a given product thermal simulation through E-Foundry is targeted. With the help of thermal simulation, scientific methodology and mathematical formula, design of component can be done which increase yield of casting. It gives assured design parameters which leads to directional solidification. In this project it is planned to design optimum gating system to obtain sound casting by thermal simulation of product with gating system.

Keywords: *Optimized gating system, Sound casting, Improve yield, Thermal simulation*

1. Introduction

Casting process takes enormous trial to obtain sound casting. In casting mainly three types of shrinkage occur, such as liquid to liquid shrinkage, liquid to solid shrinkage and solid to solid shrinkage. To compensate liquid to liquid shrinkage, runner is used and for compensation towards solid to solid shrinkage, allowance in pattern is given. Same way riser give prevention towards the liquid to solid shrinkage. To obtain this design of riser such that it should prevents towards liquid to solid shrinkage. Design of riser also give better preference as per casting soundness and economically. Compensation of shrinkage give sound casting. To making casting as economically good, yield of casting should be high as possible. In this paper 11 different riser design is carried out and through compare as per casting soundness and economically, conclusion is developed. Simulation of different designs is performed in E-foundry platform. CAD model in solid

modeling software with casting allowances are prepared and converted to STL format. In E- Foundry STL file can be uploaded with mesh size, mould type and material to be cast can be selected for simulation.

Design of gating system involves use of verified scientific background to obtain parameters for which the casting obtained will be defect free. Thermal simulation can be used to detect locations of hot spots and modifying the gating system accordingly.

2. Part Modelling

3D drawing of MW4 hub anti build-up inventor is created in Fusion-360 solid modeling software. In this design various allowance is added such as, Shrinkage allowance is 2.5%. Draft allowance is 1.5 degree. Machining allowance is 2.5mm on surface and 5mm in hole.

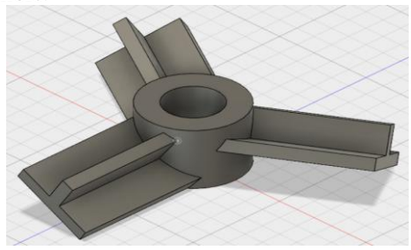

Fig. 1 Solid model of part

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3. Product Description

Product Name	MW4 anti build-up inventor
Material	SS 304L
Gating	Top Gating
Gating Ratio	2:2:1
Pouring Temperature	1600 °C
Pattern use	Single piece pattern
Pattern material	Wood
Riser	Single top riser
Shrinkage allowance	2.5 %
Machining allowance	2 mm
Draft allowance	1 degree

4. Part Modeling With Gating System

Use of formulas into set of data sheet reduces cumbersome process of repetitive design calculation to be carried out even for a small change in casting parameter. Gating system Methodizing involves orientation of the part and selection of type of gating system required for minimizing complexity of parting line. Gating system CAD model is created in Autodesk Fusion-360 with casting part. Gating ratio is selected as 2:2:1 to make medium pressurized gating system. This gating ratio gives prevention towards entering slag into mould cavity.

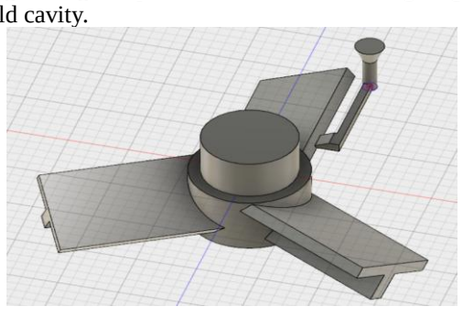

Fig. 2 Solid model of part with gating system

5. Design And Analysis Of Gating System

For riser design, Naval Research Laboratory method is used in which the shape factor is calculated to find out volume ratio. The ratio of volume of riser to volume of casting (Vr/Vc) is obtained. Afterwards from the ratio, volume of riser is obtained using volume of casting. In this research an attempt is made to develop optimum gating system and riser design. For which different 11 riser designs is carried out and through comparison casting soundness and economically, conclusion is developed.

Table 1. Gating system design data

Design No	Casting Yield (%)	Riser Dia. (mm)	Riser Length (mm)	Riser Volume (mm^3)	Gating system Volume (mm^3)
1	68.17	200	200	6283185	274000
2	73.8	200	150	4712388	274000
3	80.41	200	100	3141592	274000
4	78.67	150	200	3534291	274000
5	83.76	150	150	2650718	274000
6	87.31	150	100	1767145	274000
7	74.48	170	200	4539601	274000
8	73.24	170	150	3404701	274000
9	84.66	170	100	2269800	274000
10	88.38	50	200	1570796	274000
11	86.26	50	200	1963495	274000

As show in table, different dimensions are taken to vary riser's volume. Riser dimension is important as it play vital role to maximize yield of casting. Different designs results into optimum riser design through which casting yield can be improved. Thermal simulation of 11 different riser designs is carried out in E-foundry platform. Riser design of above product is simulated in E- foundry platform. Interpretation of simulated result can be interpreted and compared with hotspot using with temperature scale as shown below.

Ambient 

1493 °c

In design – 10 and 11 there is 4 and 5 riser respectively of that dimension but as shown in result there is not good effect of that riser.

5.1 Design – 1

Riser Dimension – 200 D x 200 L, Riser Volume – 6283185.30 mm^3, Gating Volume – 2.74 x 10^5 mm^3, Casting Volume – 1.4 x 10^7 mm^3, Yield – 68.17 % . Riser design gives sound casting but economically it is not preferred as it is having high riser volume and lower casting yield.

This casting simulation is very sound as there is no hotspot in casting. It gives sound casting but not preferable due to lower casting yield. If such casting is produced in mass quantity so there is high cost to industry.

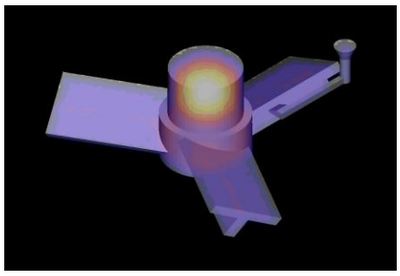

Fig. 3 Thermal Simulation Result of design-1

5.2 Design – 2

Riser Dimension – 200 D x 150 L, Riser Volume – 4712388.98 mm^3, Gating Volume – 2.74 x 10^5 mm^3, Casting Volume – 1.4 x 10^7 mm^3, Yield – 73.80 %. Riser design gives sound casting and economically preferred because it is having high riser volume and lower casting yield. But it's more economically than Design – 1.

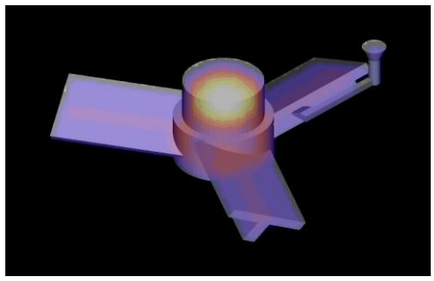

Fig. 4 Thermal Simulation Result of design-2

5.3 Design – 3

Riser Dimension – 200 D x 100 L. Riser Volume – 3141592.98 mm^3, Gating Volume – 2.74 x 10^5 mm^3, Casting Volume – 1.4 x 10^7 mm^3, Yield – 80.41 %. Riser design does not provide sound casting but it is economically preferred because low riser volume and high casting yield. It's more economically than design 1 and 2.

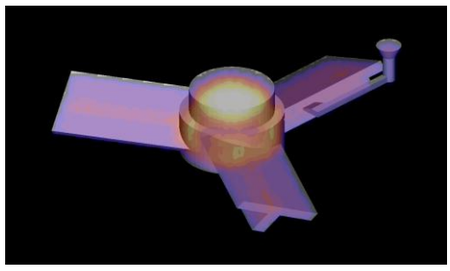

Fig. 5 Thermal Simulation Result of design-3

5.4 Design – 4

Riser Dimension –150 D x 200 L**,** Riser Volume – 3534291.73 mm^3**,** Gating Volume – 2.74 x 10^5 mm^3**,** Casting Volume – 1.4 x 10^7 mm^3**,** Yield – 78.67 %. Riser design gives sound casting and economic design because of low riser volume and high casting yield. This design gives medium sound casting as there is less hotspot in casting. It gives medium optimal sound casting but it is not preferable due to medium casting yield. In such design modification is needed to increase casting yield. Through chilling plate heat caring capacity of riser can be increased but initial cost of this solution is high compare to modification of riser design.

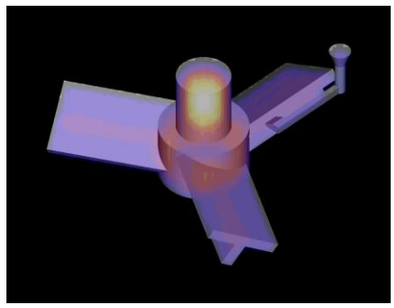

Fig.6 Thermal Simulation Result of design-4

5.5 Design – 5

Riser Dimension – 150 D x 150, Riser Volume – 2650718.80 mm^3, Gating Volume – 2.74 x 10^5 mm^3, Casting Volume – 1.4 x 10^7 mm^3, Yield – 83.76 %. Riser design gives sound casting and it is also economically preferred due to low riser volume and high casting yield**.** This design is best among the all design as there is good sound casting with high casting yield. Diameter of riser if reduce from 150 mm diameter, there is chance of crack at section where sudden cross sectional is change.

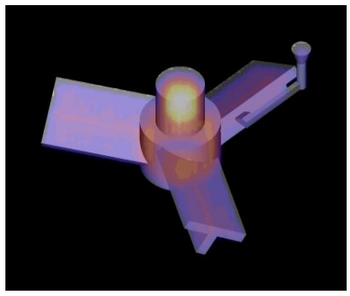

Fig.7 Thermal Simulation Result of design-5

5.6 Design – 6

Riser Dimension – 150 D x 100 L, Riser Volume – 1767145.86 mm^3, Gating Volume – 2.74 x 10^5 mm^3, Casting Volume – 1.4 x 10^7 mm^3, Yield – 87.31 %. Riser design does not gives sound casting. It is economically preferred because it has high casting yield among the all design but it cannot accepted due to less soundness in casting

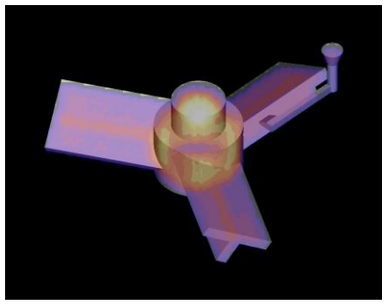

Fig. 8 Thermal Simulation Result of design-6

5.7 Design – 7

Riser Dimension – 170 D x 200 L, Riser Volume – 4539601.384 mm^3, Gating Volume – 2.74 x 10^5 mm^3, Casting Volume – 1.4 x 10^7 mm3, Yield – 74.48 % . Riser design does not give optimum soundness in casting. It is economically preferred occasionally because it has medium casting yield. It can be used only when some critical section is available in casting.

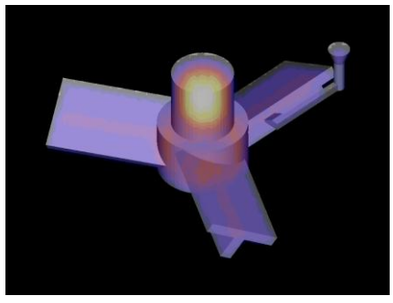

Fig.9 Thermal Simulation Result of design-7

After designing six casting real time casting is performed with 170 mm diameter to find out impact of diameter variation on casting soundness. Hence medium diameter between 150 mm and 200 mm is selected. With the help of this variation diameter and height, it easy to identify variation of casting soundness In this design it is clearly visualized effect of riser height.

5.8 Design – 8

Riser Dimension – 170 D x 150 L, Riser Volume – 3404701.038 mm^3, Gating Volume – 2.74 x 10^5 mm^3, Casting Volume – 1.4 x 10^7 mm^3, Yield – 73.24 %. This design gives moderate sound casting. It is occasionally preferred because it is having medium riser volume and medium casting yield.

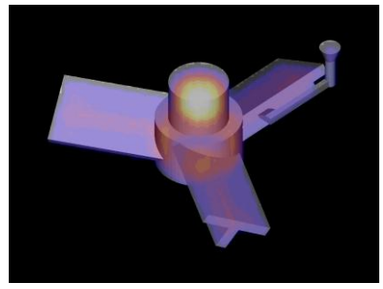

Fig.10 Thermal Simulation Result of design-8

5.9 Design – 9

Riser Dimension – 170 D x 100 L, Riser Volume – 2269800.69 mm^3, Gating Volume – 2.74 x 10^5 mm3, Casting Volume – 1.4 x 10^7 mm3, Yield – 84.66 %. This riser design gives very less sound casting. It is preferred economically because low riser volume and high casting yield. But due to less in soundness it is not accepted.

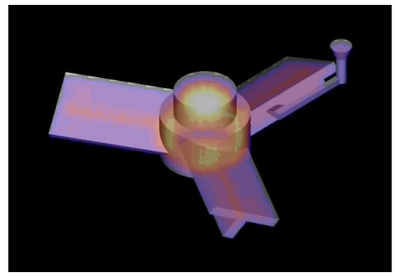

Fig.11 Thermal Simulation Result of design-9

5.10 Design – 10

Riser Dimension – 50 D x 200 L (4 Nos.), Riser Volume – 1570796.32 mm^3, Gating Volume – 2.74 x 10^5 mm^3, Casting Volume – 1.4 x 10^7 mm3, Yield – 88.38 %. This riser design gives very less sound casting. It is preferred economically because of low riser volume and high casting yield. But due to less in soundness it is not accepted. It is also noted that multiple intermediate riser cannot give sound casting due to less surface area.

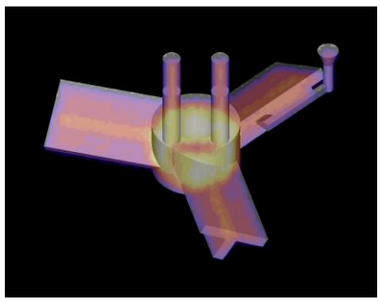

Fig.12 Thermal Simulation Result of design-10

5.11 Design – 11

Riser Dimension – 50 D x 200 L (5 Nos.), Riser Volume – 1963495.40 mm^3, Gating Volume – 2.74 x 10^5 mm^3, Casting Volume – 1.4 x 10^7 mm3, Yield – 86.26 %. In this Riser design 5 intermittent risers are used but it gives very less sound casting. It is preferred economically because of low riser volume and high casting yield but not economical. It is also noted that multiple intermediate riser cannot give sound casting due to less surface area. After design – 10 and design 11 it is clearly shows that effect of intermittent riser is not capable to give good casting because casting modulus is high of centrally hub.

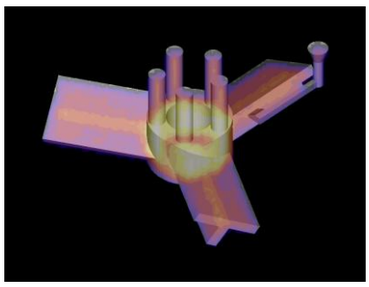

Fig. 13 Thermal Simulation Result of design-11

6. Analysis of Thermal Simualtion

Based on casting soundness and economical interpretation, rating is given in a scale of 1 to 10 as very bad to excellent respectively. As per combined rating 3 designs can be consider best out of 11 as per casting soundness and economical interpretation both. This whole exercise is illustrated in table and Design 2, 4 and 5 is best design.

It is privilege that design selection of riser should be such that it gives heat to the casting till it is solidify last. This function of riser gives prevention towards the liquid to solid shrinkage.

So it is required to make effective result by rating of design 11. Through this rating procedure best design can be found out in terms of casting soundness and economical preference. So this rating procedure of this 11 design has been illustrated in table.

Table 2. Casting Economics and Soundness comparison

Design No	Yield	Sound Casting 1- 10 Scale	Economic relation 1 -10 scale	Rating in terms Of accept In 1-10 scale
1	68.17	10	5	7.5
2	73.80	9	7	8
3	80.41	5	8	6.5
4	78.67	9	7	8
5	83.76	8	8	8
6	87.31	4	9	6.5
7	74.48	9	6	7.5
8	73.24	7	6	6.5
9	84.66	5	9	7.5
10	88.38	2	10	6
11	86.26	2	9	5.5

To find optimum gating system which fills mold cavity with less time, turbulence free flow and sound casting various design are practiced. Riser which provides economic and sound casting are show in table 2 using the weights,

6. Comparision of Gating Design

Comparison is made between company design (Yield – 83.33) and improved design. (Yield – 83.76). In both case riser volume is same but with reducing diameter and increasing height casting soundness is achieved.

7.1 Industry Design

Riser Dimension – 170 D x 100 L, Riser Volume – 2269800.69 mm^3, Gating Volume – 2.74 x 10^5 mm3, Casting Volume – 1.4 x 10^7 mm3, Yield – 84.66 %.

Riser design gives very less sound casting. Its prefer economically because low riser volume and high casting yield. But due to less in soundness it's not accepted. Through this exercise it can be noted that if we reduce height so hot spot fall under casting instead of riser. Design number 2,4 and 5 were implemented by the industry to study soundness economic issues.

Hence location of hotspot depends on the riser height rather than diameter. directly reduces the overall cost of designing gating system can be reduced for new casting by minimizing the time, resource as well as man-power involved in it. If there is large number of trials to be performed, quick thermal simulation on software package and optimum result can be obtained which leads to increase in the profit margin of any foundry industry.

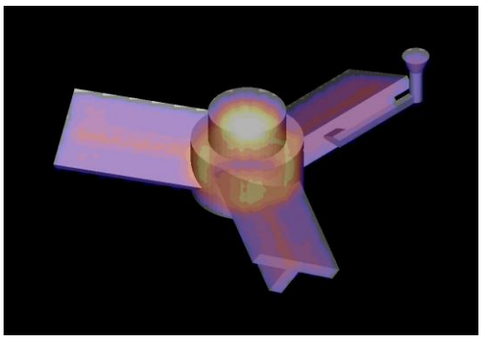

Fig. 14 Industry Design

7.2 Improved gating design

Riser Dimension – 150 D x 150, Riser Volume – 2650718.80 mm^3, Gating Volume – 2.74 x 10^5 mm^3, Casting Volume – 1.4 x 10^7 mm^3, Yield – 83.76 %. Riser design gives sound casting and it's also economically preferred because low riser volume and high casting yield**.** This design best among the all design as there is good sound casting as well as good economically preferable due to high casting yield. In this design diameter is reduced and height of riser is increased to achieve same riser volume. After modification of riser dimension there is reduction of hotspot in casting and it is transfer into riser.

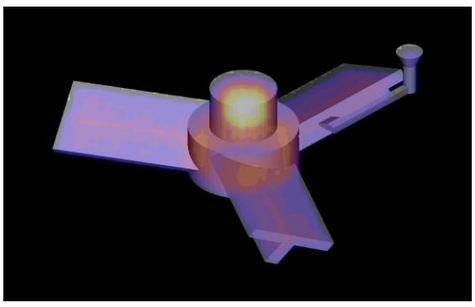

Fig. 15 Company Design

7. Conclusion

There is no effect of intermittent riser of design 8 and 9 as it is having low surface area. Centrally located riser with high surface area as design number 2, 4 and 5 is preferred which gives optimum design in terms of casting soundness and economically both. The same is validated through simulation and implementation at industry casting resulting into more than 70% yield. Rated weight of design 2,4 and 5 is also highest as compared to other designs, which helps to select optimum gating system and riser design before performing real casting exercise. Attempt is made to achieve optimum gating system design, volume of riser is made same and by varying length and reducing diameter. Gating system Simulated result helps and indicates that height of riser should be increased rather than diameter to obtain sound casting.

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