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AN INVESTIGATION OF SHRINKAGE DEFECT IN INVESTMENT CASTING OF SS304 BALL VALVE: A REVIEW

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Abstract
In the manufacturing of ball valve, which requires corrosion resistance and long service life enabling the production with high efficiency, there has been some studies to achieve its forming method for high durability and designated smooth surface. The process of investment casting is also known as "lost wax casting", is one of casting methods to fabricate metal part with a complex shape. Flow behavior of stainless steel grade 304 at the temperature higher than 1550°C is a critical factor in casting mold design of the lost wax process. Non-desired heat transfer phenomena and using of the unsuitable mold design normally lead to defects in casting such as misrun, cold shut, shrinkage, pin hole and porosity. Parameters in casting such as pouring temperature, preheating temperature, pouring time, pouring rate and cooling rate were given by the current production condition. This paper deals with defect free investment casting of SS304 ball valve.

Keywords: *Investment Casting, Shrinkage defects, Ball valve*

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1. INTRODUCTION

Production of castings involves a large number of steps including casting design, pattern making, molding, melting, pouring, shake out, fettling, inspection and finishing. It is not uncommon for one or more of these steps to be performed unsatisfactorily due to use of defective material or equipment, carelessness of the operator or lack of skill. Such unsatisfactory operations result in a defective casting which may be rejected at the final stage. It is therefore necessary to understand the various defects that occur in castings and the main factors that are responsible for their occurrence.

Nearly 200 alloys are available with investment casting. These metals range from ferrous stainless steel, tool steel, carbon steel and ductile iron to non-ferrous aluminum, copper and brass. When cast in vacuum, super alloys are also available. The only process that matches this breadth of materials is machining, but it cannot produce the complex geometries that investment casting can deliver. Since investment casting uses expendable patterns and ceramic shells, it is excellent for complex and detailed part designs. The process manufactures intricate parts that are difficult, if not impossible, to machine, forge or cast. Examples include internal passages and ports in a valve body, curved vanes of an impeller and internal cooling channels in a turbine blade **[1]**.

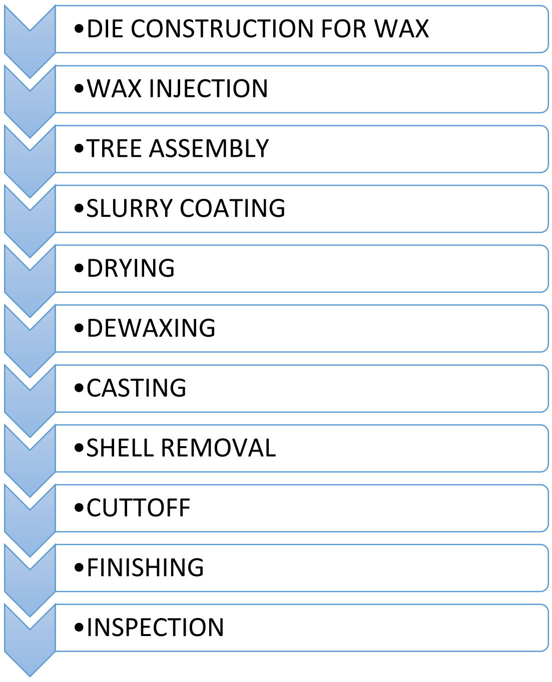

Fig. 1: Investment Casting Process Flowchart

1.2 CASTING DEFECTS

Probable Causes and suggested remedies for the general casting defects are as follows **[2]**:

Table 1: Causes and Remedies for Casting Defects

Sr no	Name of casting defect	Probable causes	Suggested remedies
1	Blow holes	1. Rust and moisture on chills 2. Cores not sufficiently baked. 3. Excessive use of organic binders. 4. Moulds not adequately vented.	1. Control of moisture content. 2. Use of rust free chills, chaplet and clean inserts. 3. Bake cores properly. 4. Ram the mould less hard. 5. Provide adequate venting in mould and cores.
2	Shrinkage	1. Faulty gating and risering system. 2. Improper chilling.	Ensure proper directional solidification by modifying gating, risering and chilling.

3	Misruns	1. Lack of fluidity ill molten metal. 2. Faulty design. 3. Faulty gating	1. Adjust proper pouring temperature. 2. Modify design. 3. Modify gating system
4	Hot Tears	1. Lack of collapsibility of core. 2. Lack of collapsibility of mould. 3. Faulty design. 4. Hard ramming of mould	1. Improves collapsibility of core and mould. 2. Modify casting design
5	Cold shuts	1. Lack of fluidity in molten metal. 2. Faulty design. 3. Faulty gating.	1. Adjust proper pouring metal. 2. Modify design. 3. Modify gating system.

1.3 SHRINKAGE DEFECT

1.3.1 TYPES OF SHRINKAGE DEFECT

Shrinkage defect occur when feed metal is not available to compensate for shrinkage as the metal solidifies. Shrinkage is reducing the volume of the casting material when metal is cooling and solidifying. So produce the Line, holes in the casting it is called the shrinkage defect. Shrinkage is a volumetric differences between solid and liquid phase during solidification in casting.

1.3.1.1 Porosity

This is porosity caused by gases absorbed by the molten metal. Practically all metals absorb oxygen, hydrogen and nitrogen. Oxygen and nitrogen form oxides and nitrides respectively. Hydrogen is responsible for causing pin-hole porosity. Molten metal picks up hydrogen from fuel, moisture in air and molds. As the metal solidifies solubility of hydrogen decreases considerably. The hydrogen thus comes out forming a number of small holes distributed throughout the metal Pin-hole porosity is quite common in aluminum alloys. Pin-hole porosity can be minimized by using improved melting and pouring methods are by prompting a rapid rate of solidification **[2]**.

Fig. 2: Gas Porosity

1.3.1.2 Micro shrinkage

Micro shrinkage is a form of filamentary shrinkage in which the cavities are very small, but large in number and can be distributed over a significant area of the casting. Some of the criteria functions used to predict casting soundness. If the size of defect is less than or equal to 5mm than it comes under micro shrinkage.

Fig. 3: Micro Shrinkage

1.3.1.3 Macro shrinkage

Macro shrinkage is a form of filamentary shrinkage in which the cavities are larger, but small in number and can be distributed over a significant area of the casting. If the size of defect is more than 5mm than it comes under macro shrinkage.

Fig. 4: Macro Shrinkage

1.3.1.4 Outer sunk

This defect is seen on the outside surface of the casting, also seen on thick section of casting part. There is some depression on surfaces. It's also called the "pull down" shrinkage defect **[3]**.

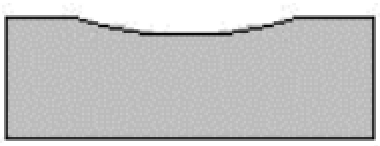

Fig. 5: Outer Sunk

2.2.2 SUGGESTIONS TO REDUCE SHRINKAGE DEFECTS:

1) Maximize the graphite precipitation expansion effect without nodule flotation.
2) Time the carbon precipitation expansion effect correctly.
3) Keep base sulphur content consistent.
4) Avoid long hold periods.
5) Use special nodulizers to avoid shrinkage.
6) Increase freezing rate rather than risering.
7) Produce uniformly strong, rigid moulds.

2 LITERATURE REVIEW:

Jack G. Zhou U and Zongyan, due to special manufacturing techniques and smaller temperature change, the shrinkage during the fabrication process of the master pattern can be neglected. Experiments show that the green strength of the green compacts mainly depends on the binder's type and green density, while the green density has a non-linear positive relationship with the compacting pressure. After the type and the amount of the binder are determined the major factor affecting the shrinkage during the hardening process of green compact is also the compacting pressure. Based on the needed hardness of the products, the program of the sintering and infiltration temperature can be designed following certain steps **[4]**.

Mohsin Raza and Mark Irwin, It has been observed in this paper that the thickness of the ceramic shell strongly influences shrinkage. The heat absorbing capacity of ceramic is determined by shell thickness, which is critical for casting of thin, complex shapes. In thinner sections and at sharp junctions, the heat absorbing capacity is important due to its effect on the heat transfer coefficient and the thermal gradient in the metal adjacent to the mould wall. Increasing the heat absorbing capacity of ceramic shell helps to maintain a high thermal gradient between melt and mould for a longer time interval. The width of mushy zone decreases with increasing thermal gradient making possible feed of metal to shrinkage pores. Adding insulation at thinner sections also slows the cooling rate which consequently minimizes the dendrite length resulting in a more planar solidification front **[5]**.

Xue-Guan SONG et al. In this paper by performing the optimization using orthogonal array, response surface method and trade-off method, the mass of ball valve is reduced from 2.34 to 1.95 kg (16.67% from the initial design), while the maximum stress and pressure loss coefficient are still kept in the available range **[6]**.

S. M. Bechara et al, In this paper, it was observe that simulation software is powerful tool to predict the shrinkage defect ins ide the casting parts. It helps to predict the shrinkage porosity defect inside the casting parts without shop floor trial. Casting yield improve up to some percentage, which indicates the new method design weight is less as compared to initial method and also shrinkage defect is also reduce to a minimum level. Proper design of feeding system helps to reduce the casting defect and give the sound casting. So from the whole study, simulation software helps to eliminate the shop floor trial, gives the accurate result related to shrinkage defect and assists to improve the casting yield **[7]**.

3 CONCLUSION:

(1) Wax pattern is selected for further processing, as it has minimum amount of shrinkage, this shrinkage allowance is mainly depends on geometry and pouring temperature of component. More the geometry more shrinkage allowance, especially in machine wax. Also from the shrinkage study that, high pouring temperature gives more shrinkage.

(2) In the casting design process, mostly shrinkage defect occur in most of part. In practice, these defects are eliminated by iteratively designing casting filling (gating) system through experience and experiments, but it requires large number of shop floor trials; taking huge amount of resources (cost) and time. So use of simulation software gives batter than trial and error method.

4 REFERENCES:

[1] Fortus systems, materials and applications by Ro Winker, Stratasys, www.fortus.com

[2]From the website: http://www.globalcastingmagazine.com/index.php/2013/10/25/7-ways-to-avoid -shrinkage-defects/

[3] Vipul vasava et al. International Journal of engineering trends and Technology, Volume 4 Issue 6, June 2013, page no. 2361-2365.

[4] Jack G. Zhou et al. Materials and Design, Issue 19, 1998, page no. 241-248.

[5] Mohsin Raza et al. Annual technical conference - investment casting institute - october 5 - 8, 2014.

[6] Xue-Guan Song et al. Trans. Nonferrous Met. Soc. China issue 19, 2009, page no. 258-261.

[7] S. M. Bechara et al. International Journal of Advance Engineering and Research Development, Volume 2, Issue 4, April – 2015, page no. 394-402.

4.1 BOOKS

[1] **B. Ravi,** Metal Casting _ Computer Aided Design and Analysis

[2] **John Campbell**, Complete Casting Handbook_Metal Casting Processes, Metallurgy, Techniques and Design

[3] **Rosenthal**, Principle of Metal Casting