IMPROVEMENT THE LIFE OF CORE PIN USED IN GRAVITY DIE CASTING

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Abstract - *Core pins are frequently used for Aluminum-bronze alloy die casting to produce net shape parts in casting section. As molten metal temperature of Aluminum-bronze alloy is very high about 1150°C -1170°C there must be thermal stress generated. Due to this stress generation & sudden quenching into water to cool die leads to bending of core pin and this leads to improper production of through holes. Thus the material used for core pin should generate low thermal stress. The purpose of this study is to investigate the cause of bending of core pin & to suggest the best material to used for production of through holes at high temperature. In this paper by taking trials on different materials we concluded the best material for core pin to be used for production of through holes. And also how the addition of heat treatment process improves the life of core pin is described in this paper.*

Key Words: **Gravity die casting, core pin, aluminium-bronze alloy, bending, heat treatment**.

1. INTRODUCTION

Die casting is metal casting process where high temperature molten metal is poured into die cavity and allow to solidify for few seconds. According to application we use different types of casting processes such as gravity die casting (GDC), high pressure die casting (HPDC), sand casting. Gravity die casting is permanent mould casting process, where molten metal is poured from vessel or ladle into mould. The mould cavity fills with no force other than gravity, filling can be controlled by tilting the die. Although in casting process through holes are produced by use of core pins. This core pins are fitted to fixed half or moving half of die according to the shape to be cast. On each shot of core pin two castings are formed. Temperature of molten metal is ranges between 1150-1170°C. This molten metal surrounds the core pin and thus through holes are produced in castings. By continuous use of core at high temperature and quenching of die along with core pin for cooling purpose generates more thermal stresses in core pin and pin bends from its end portion. By continuing the production with bend in core pin number of defective casting produces and rejection continuous till the replacement of pin.

Austenite is normal phase of steel at high temperature. As the die quenched suddenly austenite does not transform into martensite and causes of generation of retained austenite. This retained austenite occurs when steel is not quenched to the martensite finish temperature. Retained austenite transformed to martensite if the temperature drops significantly below the lowest temperature to which it was quenched. Mechanical properties are affected by high percentage of retained austenite. Amount of retained austenite is the function of the carbon content, alloy content (especially nickel & manganese), quenchent temperature, and subsequent thermal and mechanical properties.

By controlling the level of retained austenite, its beneficial effects can be realized without suffering from its negative influences. Such as excessive dimensional growth.

1.1 Literature Review

Suguru Takeda et. al.[1] study the stress analysis on the aluminium core pin. The heat is flow through the core pin. The optimum cooling channel diameter should be 70 percent of the outer diameter of the core pin. This thin wall core pin in combination with high pressure water cooling would eliminate soldering and would give a longer core pin life.

Q.Zhou et.al.[2] effect of heat treatment on mechanical properties of H13 alloy steel. To get different grain size & in austenite phase the grain size affects on the hardness and toughness of heat treated H13 alloy steel, while the largest grain size gives highest hardness and lowest toughness.

Yan Guanghua et. al.[3] The main aim is to explore the influence of heat treatment on the strength, hardness, and impact toughness of H13. It is found that H13 exhibits excellent mechanical properties after vacuum quenching at 1050°C and twice tempering at 600°C.

WILZER. J et. al.[4] study the effect of Heat Treatments on the Fatigue Strength of H13 Hot Work Tool Steel. Different preheating, quenching and tempering treatments were applied and get Highest fatigue strength obtained by applying a double tempering heat treatment (first tempering at 550 °C for two hours and second tempering at 610 °C for two hours) after initial preheating and quenching.

2. PROBLEM STATEMENT

In casting through holes are not formed after certain number of shots (castings) because of bending of core pin due to unsustainability of core pin material at 1150°C - 1170°C. As shown in figure below.

3. METHOD OF STUDY

For selection of better material we have taken trials on different material. Checked microstructure of each material and find out the retained austenite percentage in each material. Austenite that does not transform to martensite upon quenching is called retained austenite. In this casting process die along with the core pin is quenched into the graphite and water solution to cool the die. Graphite powder is added into water for easy removal of casting product from the cavity and it also not allow the molten metal to stick to the core pin and other parts of die cavity.

Proportion of graphite and water solution:

20% graphite of 800 litres of water.

Equipment

The following equipment were used

1. Digital vernier caliper (LC-0.02mm)
2. Temperature Gun (MT4) (Temperature Range -50˚C to 600˚C)
3. Rockwell hardness tester (load-150kg)
4. Optical metallurgical microscope (Magnification range-100X)

3.1 METHOD & MATERIAL

3.1.1 QRO 90

Table No.1

Chemical composition					
C	Cr	Mo	Si	V	Mn
0.38	2.6	2.25	0.30	0.9	0.75

❖ No. of shots obtained-354

Microstructure

Result: It shows fine tempered martensite structure less than 5% retained austenite.

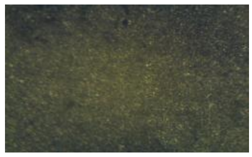


Fig.1 Microstructure of QRO 90

3.1.2 YXR

Table No. 2

Chemical composition					
C	Cr	Mo	W	V	Co
0.50	4.20	2.00	1.60	1.2	<1.0

❖ No. of shots obtained - 201

Microstructure

Result: It shows fine tempered martensite structure less than 5% retained austenite.

Fig.2 Microstructure of YXR

3.1.3 KIND RPU

Table No. 3

Chemical composition					
C	Cr	Mo	Si	V	Mn
0.38	5	3	0.40	0.60	0.40

❖ No. of shots obtained- 471(Heat

3.1.4 AISI H13

Table No. 3

Chemical composition							
C	Cr	Mo	Si	V	Mn	Ni	Cu
0.32-0.45	4.75-5.5	1.10-1.75	0.80-1.20	0.80-1.20	0.20-0.50	0.3	0.25

Pre-treatment

Microstructure

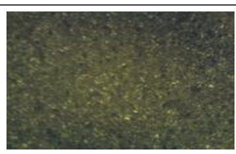
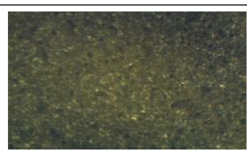
Result: It shows consist of the Spheroidal particles of carbide in a matrix of ferrite.

Fig.3 Microstructure of H13

❖ No. of Shots obtained- 450

Heat Treatment (HT)

Table No.4

Before use	After use
 Fig.4 Microstructure of H13	 Fig.5 Microstructure of H13

It shows carbide particles in a matrix of untempered martensite (dark areas) and retained austenite (light areas) While spots are grain boundary carbide, black spot are non-metallic inclusion.	It shows fine tempered martensite structure less than 5% retained austenite.

- No. of shots obtained- 850

4. RESULT&DISCUSSION

After analyzing the above result heat treatment process gives us the better results.

4.1 Heat treatment:

Heat treatment is the processes involving heating and cooling operation (in a specified sequence) as applied to a material so as to modify its internal microstructure. The extent of change required within the internal microstructure can be easily controlled through variation cycle time of heat treatment. The internal microstructure is influential in determining the physical, mechanical and chemical properties of material.
Vacuum heat treatment process as follows:

4.1.1 Hardening process

The purpose of hardening is to convert the phase of metal to hard phase; this cycle involves three phase:

- Heating to temperature called austenitizing temperature.
- Maintaining this temperature to dissolve the carbide and obtain a homogeneous solid solution austenite.
- Cooling by immersion in some medium which is oil sufficiently rapid to obtain the desired quenching components.

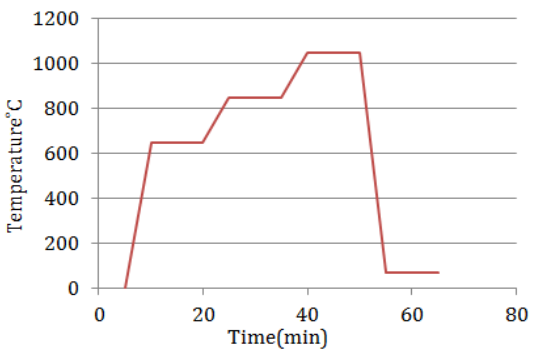


Chart – 1: Hardening Process

Chart 1 shows the hardening process of H13. In this H13 was hardened in different temperatures. The process is done firstly by rising the temperature to 650˚C and then holding at this temperature for 10 mins, then again it is heated to 850˚C and hold at this temperature for 10 mins and again it is heated to 1050˚C for 10 mins and finally it is quenched upto room temperature.

4.1.2 Tempering Process

Chart-2 shows the tempering process of H13. In this process the quenched metal is too fragile to be actually used therefore quenching is followed by tempering. The main purpose of this process to remove internal stresses caused by the hardening process; it also provides a combination of a two contradictory requirements hardness and toughness.

Unlike hardening the tempering process is done under the eutectoid transformation degree where no phase change occur and the cooling process is done on air so that the grains set in their position therefore no internal stresses are found and the toughness will increase. The H13 steel specimens were entered to the furnace under 550 °C with one and half hours holding time, then cooled up to room temperature. Again it is heated to 650˚C and hold it at this temperature for 40 mins and cooled up to room temperature and lastly it is heated to 650˚C and hold it at this temperature for 40mins and cooled to room temperature.

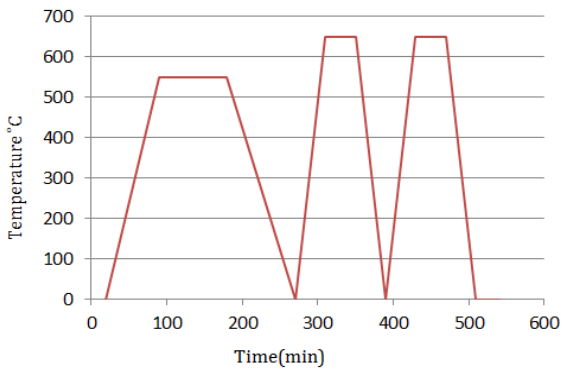


Chart-2: Tempering process

4.2 Effects of heat treatment:

- Figure 4.shows the microstructure of H13 in which retained austenite i.e., light area has more intensity that means the amount of RA is in higher content.
- Figure 5. shows the microstructure of H13 after heat treatment in which the amount of retained austenite is reduced upto desirable range
(i.e. < 5%).

- Due to this sustainability of H13 material is increased and it gives us better results.

AISI H13 material gave the best result than other materials.

Table No.4

Sr. No.	Material	Shots obtained	Number of Casting (2*No. Of shots)
1	QRO 90	354 HT	352
2	YXR	201	402
3	KIND RPU	471 HT	942
4	AISI H13	450	900
		850 HT	**1700**

- HT-Heat Treatment

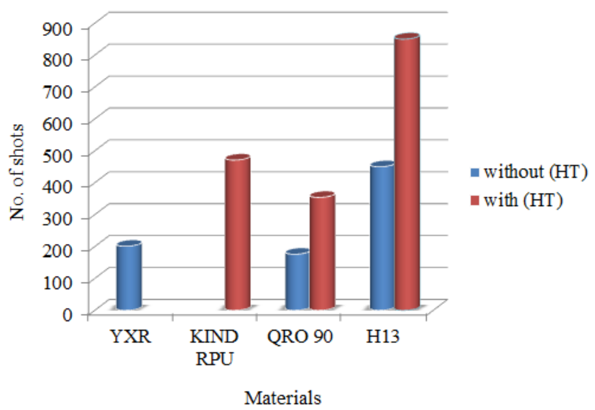


Fig.6 Control chart

5. CONCLUSIONS

- After taking number of trials on different materials such as KIND RPU, QRO 90, YXR and H13. Among which H13 gives us the best result upto 450 no of shots.
- Considering this H13 and doing heat treatment process and controlling the process it gives us the increased results upto 850 no. of shots.

6. REFERENCE

[1]Suguru Takeda et. al. DEC 5 2016 “Stress Analysis of Thin Wall Core Pin in Aluminum Alloy High Pressure Die Casting” Japan Foundry Engineering Society.

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[4]Q. Zhou et. al. (2017), “Effect of Heat Treatment on the Mechanical Properties, Microhardness, and Impact Energy of H13 Alloy Steel” International Journal of Scientific & Engineering Research.

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