Elephant Caput Mould Reliable Sampling for Quality Control

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Abstract: Defect free casting begins with starting melt cleanliness, casting speed and well-designed sprue and runner systems. Failure of one of these three main components has a significant negative impact on the quality of the final product. ASTM B108/B 108M Tensile Test Specimen Casting mold (ASTM mold), which produces only 2 tensile test specimens in a single casting, is widely used to determine mechanical properties in aluminum alloys. The idea of statistical work is fundamental to science. Therefore, the more test samples are produced and analyzed, the higher the reliability of the results are. A new tensile test mold was needed to be designed instead of ASTM mold due to its negative aspects such as turbulence in filling the mold, taking only two samples in one casting, increase operator effect, time loss and excessive metal loss in feeder and runners. In our previous study, different mold designs and different casting (gravity and tilt casting) methods were examined to produce 10 samples in a single casting without turbulence in sand mold. The statistically enough samples were produced in a single casting to give a reliable mechanical property result, eliminating the extrinsic effects. It is also critical to observe the microstructural changes with regard to cooling rate. Therefore, a step mould was also incorporated into the new design together with cylindrical tensile bars.

Keywords: Gravity Casting; Quality Control; ASTM B108/B 108M; Permanent Mold

1 Introduction

In order to obtain reliable results from experiments, a minimum of 3 experiment results are typically required. ASTM B108/B 108M Tensile Test Specimen Casting mold is widely used to determine mechanical values in aluminum alloys as it is determined by ASTM standards. ASTM B108/B 108M Tensile Test Specimen Casting mold produced only 2 tensile test specimens in a single casting. In order to provide sufficient data, it is necessary to make more than one casting. Turbulent filling of the mould is one of the ways to introduce extrinsic defects that could deteriorate the mechanical properties of any casting [1]. In this work, the different pouring basin, sprue, and runner systems were designed to optimize a mould in an aim to achieve defect free castings. The filling and solidification behavior were analyzed with simulation software. The inclined sprue has been designed to prevent turbulent flow resulting from free fall in the sprue with proper pouring basin. The location and thickness of the 5 bars and step mold were optimized.

2 Experimental procedure

The experimental study consists of two stages. The first stage is the simulation for optimized mould design, and the other is the comparison of these analyzes with the actual casting results.

Table 1. Composition of Aluminium alloys

	Si	Fe	Cu	Mn	Mg	Ti	Al
CP	0.18	0.21	0.05	0.02	0.08	0.01	Bal
A360	9.86	0.45	0.05	0.01	0.09	0.1	Bal

Different mold designs were drawn in 3D (Figure 1) in SolidWorks software and were subjected to filing and solidification analysis in Anycast software. A360 alloy was selected and simulated in permanent mold with a casting temperature of 750ºC and mold was preheated at 250°C for all different designs. Tensile test sample was machined according to the ASTM E8.

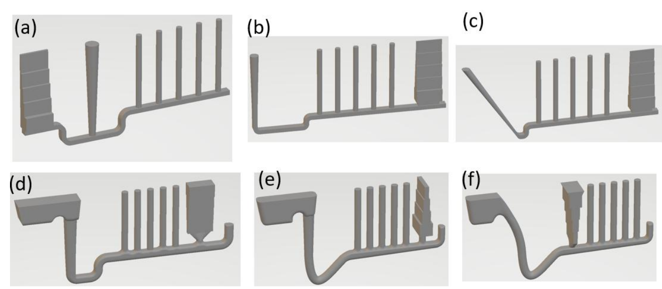

Figure 1. Different mould designs.

3 Result and discussion

Due to the taper sprue design, the liquid metal does not have enough space to provide turbulence. Provides a 50% reduction in its speed for each turn in the runner. When the turn does not have radius, flow is unstable and provides turbulence. There are two turns with 90-degree angle that decreases the velocity without providing turbulence. There are so many turbulences as the velocity of the liquid increases. The main reason for the speed increase is due to the metallostatic pressure caused by the mold height. The turns have not enough radius to decrease the velocity of the molted metal. Even though pouring basin and stopper was used, the turbulence at the entrance of the liquid metal to the bars is reduced, however it was not completely prevented [2].

Although different designs were tried, the most stable runner design and smooth filling were achieved with the taper runer and trapper in Figure 3 (d). Despite the pouring basin, narrowing runner and 3 ninety-degree turns, the liquid metal velocity, turbulence and uncontrol movement caused by free fall could not be controlled. These issues were eliminated by the slope of the runner that guides the molten metal movement, smoother turns rather than ninety-degree turns and the pouring basin design.

The new mould design was named as “Elephant Caput” mould which could produces 5 cylindrical bars and a step mould with thickness ranging from 5 to 30 mm (Figure 2).

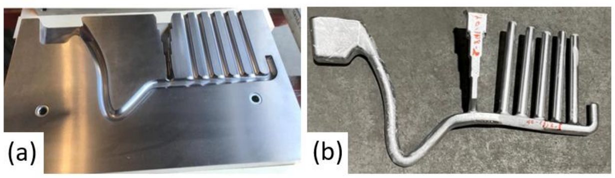

Figure 2. New design (a) permanent mold and (b) casting part.

The tensile test conducted with CP and A360 alloys. The average Yield Stress (YS), Ultimate Tensile Stress (UTS) and Elongation at fracture results were given at Figure 3.

YS was 90 MPa, UTS was 142 MPa and 2.1 elongation% with A360 alloy. YS was 53 MPa, UTS was 96 MPa and 22.1 elongation% with CP alloy. In the tensile test results showed that the standard deviation was ±10 MPa, whereas it was 0.8% for elongation.

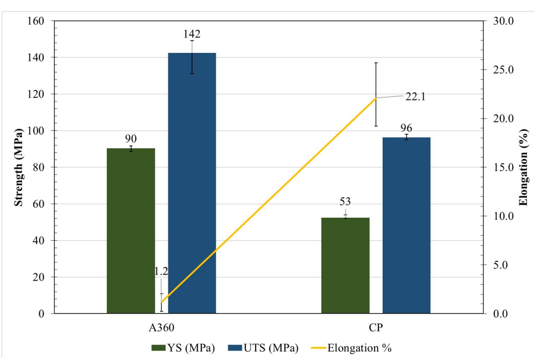

Figure 3. Elephant Caput mould tensile test result with A360 and CP alloys.

4 Conclusion

In this work, the different pouring basin, sprue, and runner systems were designed to optimize a mould in an aim to achieve defect free castings. The filling and solidification behavior were analyzed with simulation software. The inclined sprue has been designed to prevent turbulent flow resulting from free fall in the sprue with proper pouring basin. The location and thickness of the 5 bars and step mold were optimized. A series of tests were conducted with different alloys. Statistical analysis had shown that for UTS, the standard deviation was ±10 MPa, whereas it was 0.8% for elongation.

The new mould design was named as elephant caput mould which could produces 5 cylindrical bars and a step mould with thickness ranging from 5 to 30 mm. The reproducibility of the test results was proven to be reliable with a very low scatter. This permanent mould was proposed as a simple quality control measure that can be used easily in foundry floor together with reduced pressure test.

References

[1] Campbell, J., 2004. Castings practice: the ten rules of castings. Elsevier.

[2] Birsan, G., Ashtari, P. and Shankar, S., 2011. Valid mould and process design to cast tensile and fatigue test bars in tilt pour casting process. International Journal of Cast Metals Research, 24(6):378-384.