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Effect of Squeeze Cast Process Parameters on Fluidity of Aluminium LM6 Alloy

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Abstract

In squeeze casting process, the liquid molten metal charge is compressed under a pressure inside the mould cavity. The applied squeeze pressure should be optimum because the cooling rate of molten metal increases with the increase in applied pressure there by fluidity property decreases. In the present work investigation about the effect of Squeeze pressure on the Aluminium LM6 fluidity property.

Fluidity refers to the property of a metal; the most prevalent fluidity tests is the spiral-shaped mould test, Aluminium LM6 alloy in the molten state is applied into the spiral die cavity by the squeeze pressure. The distance covered by molten metal in spiral channel after the application of pressure is the measure for fluidity. The fluidity keeps increasing up to a particular pressure and drops suddenly. At a pouring temperature of 750°C the maximum fluidity of LM6 alloy during squeeze casting was obtained under the applied pressure of 30 MPa and the fluidity of LM6 alloy during squeeze casting increases with increase in pouring molten metal temperature.

Keywords: Fluidity; Squeeze casting; Squeeze pressure

Introduction

The group technology centre at USA introduced the Squeeze casting process in 1967. First they produced prototype car wheels and then extended for engine piston manufacturing. There are also some investigations carried out at Russia, Germany and Japan.

In recent years, Squeeze casting has found production applications for Aluminium alloys and metal-matrix composites. In 1983, Toyota used Squeeze cast fiber reinforced aluminium pistons for high speed diesel engines and car wheels. The Squeeze casting technique is still in the experimental stage in India. With rapid expansion of automotive and aerospace sectors, the demand for superior engineering components is expected to increase in course of time and Squeeze casting technology has the potential and it will play an important role to improve the quality of engineering products. The materials like steel, cast iron are replaced by the cost efficient aluminium, particularly in the field of automotive components such as brake discs, pistons, aircraft parts, engine cylinder blocks and in structural components.

Squeeze casting, sometimes known as liquid forging process, is hybrid in nature and enjoys the advantages of both forging and casting in a single step by which near net shaped components can be casted .Squeeze casting is one of the most popularly improved casting techniques used for the manufacturing of engineering components mostly in non-ferrous metals by the application of squeeze pressure on the cast metal to eliminate the gas porosity and shrinkage cavity defects. In squeeze casting, a weighted amount of molten metal is poured into the die cavity and the pressure is applied on the molten metal during solidification. The solidification under applied load eliminates shrinkages and gas porosity which increase the isotropic properties, leads to that minimization of component machining.

Fluidity is used to indicate that how far distance a molten metal can flow before it solidifies. Fluidity refers to the important property for casting alloys and it determines the ability of the liquid metal to fill the mould cavity, it is measured in length (meters or millimetres). In fluidity measurement, molten metal is allowed it to flow in a standard fluidity test channel. This channel in the form of spiral or it may be in straight in which the cross-section may be circular, half circle, trapezoidal or rectangular. The first fluidity test in 1902, many equipment are developed and modified for fluidity testing. Currently, the most prevalent fluidity tests are the vacuum fluidity test and the spiral-shaped mould test. In the first method when metal is sucked from a crucible by using a vacuum pump how far length the metal flows inside a narrow channel. In the second method measures the length of the metal flows inside a spiral-shaped mould. Traditionally, the spiral test method has been most prevalently used because it is compact, portable and can be used easily in the foundry.

Objective of the Project

The main objective of the project work is as follows.

Determination of suitable parameters

Analyzing the best parameters for Squeeze casting

1. Pouring temperature of molten metal
2. Optimum squeeze pressure

Experimental

The fluidity of Aluminium LM6 alloy was evaluated by using a squeeze casting machine of 30 ton capacity, as shown in Figure 1. Pressure up to 150 MPa can be applied with a plunger. The diameter of the plunger is 50 mm. The die is made of mild steel. The die for testing fluidity consists of male and female die. Melt was poured through the plunging cylinder attached at the center of the top of the male die. The dies are designed based on the ASTM standards spiral pattern for fluidity analysis, as shown in Figure 2. The temperature of the die and plunger was controlled within the range of ±3°C, by the controller. A total weight 300g of the charge materials was charged into the crucible. This was then put into the furnace, in which the temperature was maintained at the required superheat temperature for 1 hour. The molten Aluminium has to be poured at superheat temperature. Narrow freezing range alloys tend to form solid layers immediately upon making contact with the die wall, and therefore a higher superheat temperature 750°C is used which is 125°C higher the liquids one of 625°C. The die temperature has to be monitored within close limits. Too low a die temperature may result in premature solidification, and cold laps in the castings. Too high a die temperature can cause surface defects and welding of the casting to the die. Temperatures above 300°C are generally not recommended for Aluminium alloys [1]. The correct operating temperature has to be determined for each alloy and product design. The die is heated by a circular coil type heater and the temperatures are monitored by means of a thermocouple attached to the die. The die preheats temperatures selected for the process is 180°C. When the desired superheat temperature reached, the melt was poured into the die and the pressure was applied by operating the squeeze casting machine. The time interval between pouring and pressure application and plunger velocity were 10 s and 60 mm/s, respectively. The fluidity test specimen was removed with ejector pins after holding for 50 s under the applied pressure. An average of 4 results of fluidity spiral lengths was obtained for each condition.

Aluminium LM6 alloy was used to investigate the effect of applied squeeze pressure on the fluidity during squeeze casting. The melt of this alloy was poured at 750°C; the applied squeeze pressure was varied from 0 to 90 MPa at intervals of 30 MPa. The applied pressure of 30 MPa was chosen, because the experimental result had shown that the fluidity was the best at this value.

Aluminium LM6 alloy was also used to investigate the effect of pouring temperature on the fluidity during squeeze casting [2,3]. At squeeze pressure of 30 MPa was chosen the pouring temperature was varied in the range between 750 to 850°C at intervals of 50°C.

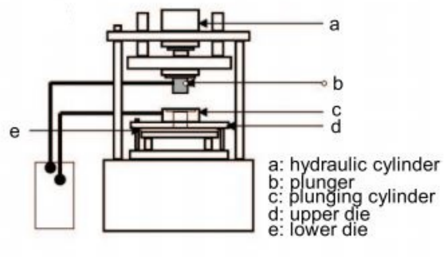

Figure 1: Squeeze casting machine.

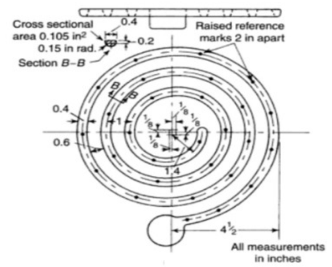

Figure 2: ASTM standard lower die with fluidity spiral channel.

Applied pressure (MPa)	Fluidity spiral length (mm)
0	307
30	415
60	359
90	316

Table 1: Variation of fluidity of squeeze casted Aluminium LM6 alloy with various squeeze pressure at a pouring temperature of 750°C.

Pouring Temperature °C	Fluidity spiral length (mm)
750	415
800	688
850	746

Table 2: Variation of fluidity of squeeze casted Aluminium LM6 alloy with the pouring temperature at a optimum pressure of 30 MPa.

Results and Discussion

Effect of squeeze pressure

The fluidity got increased while applying pressure from 0 to 30 MPa. When the applied pressure was higher than 30 MPa, the fluidity began decreasing. The maximum fluidity was obtained at 30 MPa. When the applied pressure was 30 MPa, the effect it had forcing liquid into the fluidity spiral channel was more pronounced than others [4-6]. Incidentally, on increasing applied pressure further above 30 MPa, the molten metal moves very quickly into the spiral channel which results in increasing the cooling rate thereby decreasing its fluidity as shown in Figure 3.

Effect of pouring temperature

The fluidity of Aluminium LM6 alloy during Squeeze casting is increased with increase in pouring temperature as shown in Figure 4. The temperature at the tip of the molten liquid flows through the spiral channel would be at the lowest temperature (Figures 5-8). Aluminium LM6 alloy contains 10-15% Si, at the tip due to the lowest temperature, silicon particles would be nucleated immediately thereby increase in viscosity of the melts [7]. At higher temperatures this nucleation would

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be retarded more and the fluidity increases with increase in pouring temperature.

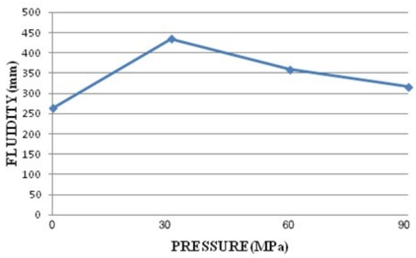

Figure 3: Variation of fluidity of squeeze casted Aluminium LM6 alloy with various squeeze pressure at pouring temperature of 750°C.

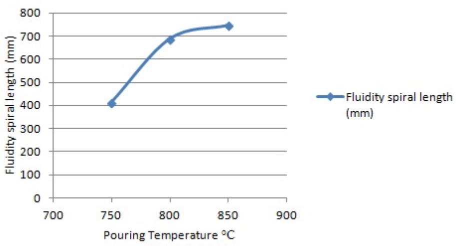

Figure 4: Variation of fluidity of squeeze casted Aluminium LM6 alloy with the pouring temperature at a squeeze pressure of 30 MPa.

Figure 5: Fluidity spiral length 307mm at a pressure of 0 MPa.

Figure 6: Fluidity spiral length 415 mm at a pressure of 30 MPa.

Figure 7: Fluidity spiral length 359 mm at a pressure of 60 MPa.

Figure 8: Fluidity spiral length 316 mm at a pressure of 90 MPa.

Conclusion

1. The maximum fluidity of Aluminium LM6 alloy during squeeze casting was obtained under the applied pressure of 30 MPa at a pouring temperature of 750°C.
2. The Fluidity of Aluminium LM6 alloy during squeeze casting increased with increase in molten metal pouring temperature [8].

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