A Research Paper on Squeeze Casting

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Abstract: ***The most cost-effective way of transferring raw materials into ready-to-use parts is casting. Moreover, the development of defects such as porosity is one of the major drawbacks for traditional or even more modern casting techniques, e.g. high pressure die-casting. Additionally, during as-cast component service process, segregation deficiencies of hot tears, A and V segregates and banding may be potential crack initiators. Therefore, to compensate for these shortcomings, new casting techniques were developed. Of the many other casting techniques available, squeeze casting has a greater capacity to produce fewer defective cast components.*** ***Squeeze casting is a generic term for a manufacturing technique that facilitates solidification in a reusable die under high pressure.*** ***This paper reviews squeeze casting in all its aspects: its origins and developments, the various processes and equipment involved, including the main parameters, metallurgical characteristics including porosity, recrystallization as well as grain refinement, the mechanical properties of that same products, the mechanics of the various processes involved and the advantage and disadvantages of the squeeze casting.***

Keywords: Squeeze casting, pressure die casting, melting temperature, material property, Manufacturing.

INTRODUCTION

The most cost-effective way to transfer raw materials into products that can be readily used is casting. In addition, one of the major disadvantages of conventional or even more modern casting methods, such as high pressure die-casting, is the creation of defects such as porosity. Additionally, during as-cast component service process, segregation deficiencies of hot tears, A and V segregates and banding may be potential crack initiators. Therefore, to compensate for these shortcomings, new casting techniques were developed. Squeeze casting can produce less faulty casting components from the many such casting techniques available [1].

Squeeze casting (SC) is a common term for a technique of production that encourages solidification under high pressure in a reusable die. It is a method of metal-forming that combines permanent mould casting with die forging into a single procedure in which molten metal is solidified by hydrostatic pressure. While squeeze casting is now the agreed term for this forming method, it has been referred to in various ways as ‘extrusion casting’, 'liquid pressing’, pressure crystallization " and " squeeze formation." It has been suggested that steam pressure should be applied to molten metal when being solidified. However, following its century-old innovation, squeeze casting marketing has only recently been achieved and is focused primarily in Europe and Japan. It is primarily used to produce parts with or without reinforcement of high integrity engineering [2].

A technique to pressurize Al alloy solidification in reusable dies produced by GKN Technology has been released. A die set is placed on a hydraulic press and preheated in this process, and the exact amount of molten alloy is poured into the lower half of the open die set, the press is closed so that the cavity can be filled and the pressure maintained until complete solidification takes place. External undercut shapes can be created and through-holes can be built using retractable side cores [3].

METHODOLOGY

Process outline:

The method of squeeze casting involves the following steps:
1. A pre-specified quantity of molten metal is squeezed into a preheated die cavity on a hydraulic press bed.
2. The press is activated to close off the die cavity and to pressurize the liquid metal. This is carried out very quickly, rendering solidification of the molten metal under pressure [4].

3. The pressure is maintained on the metal until it is fully solidified. This not only increases the heat flow rate, but can also eliminate the porosity of macro / micro shrinkage most importantly. Furthermore, since the nucleation of gas porosity depends on pressure, the formation of porosity is restricted due to the dissolution of gases in the molten metal.
4. Finally the punch is withdrawn and the component is ejected [5].

Mechanics of squeeze casting:

- *The Die*

The die itself and, most significantly, the die design, including the selection of an acceptable die material, the production process, the correct heat treatment and maintenance procedure, are the most important aspect of permanent mould casts such as die-casting or squeeze casting. A die's design and features are greatly affected by the unique alloy to be cast. H13 tool steel is currently a commonly used building material, but die steels should usually have strong hot hardness, high temperature tolerance, sufficient strength and a high level of cleanliness and uniform microstructure [6].

- *The casting process: key features*

Depending on whether the pressure is applied directly to the solidifying cast product via an upper or male di e (punch) or the applied pressure is exerted through an intermediate feeding system as shown in Figure 1, tw o basic forms of the process can be distinguished as:

(i) The direct squeeze casting mode, and (ii) the indirect squeeze casting mode.

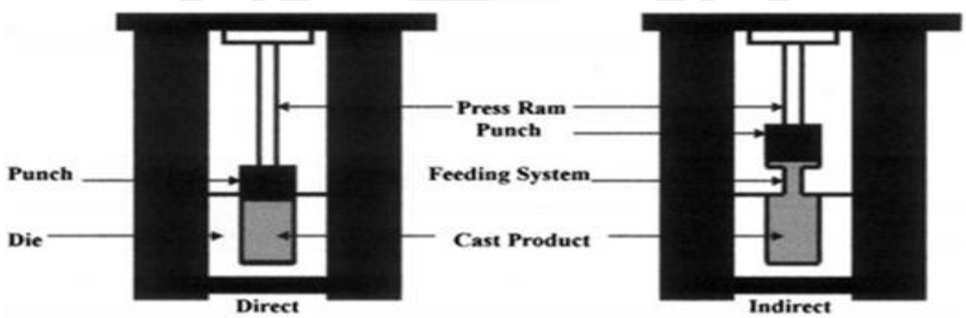

Fig. 1 Schematic Diagram for Direct and Indirect Modes of the Squeeze Casting Process

Now, based on the liquid metal displacement initiated by the punch movement, direct mode is divided into two types: first is without metal movement, this is better suited for the ingot type of part that can be cast within the die without the metal travel and second is with metal movement, this is also known as the backward method and this is also more flexible than the first one.

- *Equipment :*

A variety of squeeze casting systems are in use in various parts of the world. These are either designed by the researchers themselves, the so-called home-made ones, or produced by companies using machine tools on a mass production basis. Direct SC-machines are simple and simple, but indirect ones typically fall into the following categories: I vertical die closing and injection, (ii) horizontal die closing and injection, (iii) horizontal die closing and vertical injection, and (iv) vertical die closing and horizontal injection.

Parameter:

The most important process parameter is the alloy itself. Due to its direct influence on the life of the die, the composition and physical characteristics of the alloy are of primary importance. Both involve the melting temperature and thermal conductivity of the alloy, along with the combined effect on the die content of the coefficient of heat transfer and soldering. The choice of casting parameters such as die temperature, which has a direct effect on die life, is actually determined by the alloy. Squeeze casting is also commonly used for low melting temperature alloys of aluminum and magnesium [1][7].

In addition to the composition of a casting alloy that determines its freezing range and affects the consistency of the finished parts, the casting parameters should also be closely monitored in order to achieve a sound casting. Although the pressure level applied is also important, die temperature and pouring temperature, and superheat, are the most dominant process parameters. When the metal is cast under strain, there is little or no question about the inherent casting ability of the alloy [8]. The cleanliness of the metal in relation to the presence of inclusions, the movement of the metal within the die that can cause friction, the surface of the die and the time interval over which the pressure is applied, that is, the so-called dead time, are some important parameters. The die temperature for aluminum and magnesium alloys is usually held between 200^0C and 300^0C, whereas the applied pressure ranges between 50 and 150 MPa. The medium of lubrication, i.e. the die cover, is usually based on graphite. Casting metal being pressed against the die surface due to this heat transfer coefficients are extremely high [9].

Microstructure and properties of the squeeze cast alloy:

Squeeze cast products have superior mechanical properties to their conventionally cast counterparts due to higher density, finer grain size and more homogenous microstructure. Furthermore, thermal diet limitations restrict squeeze casting to aluminium and magnesium alloys, although there are allegations that copper alloys, cast iron and steels were also squeeze cast, mainly light and low melting point alloys.
Squeeze casting process provides new opportunities for the manufacture of advanced materials, particularly in the composites field. There are a large number of publications dedicated to MMCs manufactured by squeeze casting. Squeeze casting can also be used to manufacture bi-metals, where cast iron inserts can be incorporated to increase wear resistance in alloy components, for example. For example applications were plates, pistons and brake disks [10].

CONCLUSION

A large number of publications on the squeeze casting process indicate that it is still being successfully developed. The majority of publications are aluminum-and magnesium-based alloys and, in particular, their matrix-based composites. Therefore it may be true to say that the key trends in the development of the process of squeeze casting, equipment and alloys are linked to the manufacture of advanced materials, particularly in the field of alloys and composites based on alloys. Some progress is being made with regard to high temperature alloys such as cast-iron, but the main focus is on Al and Mg light alloys. Comparing squeeze casting with other casting methods may be helpful in illustrating the benefits of squeeze casting. The overall advantages are as follows: superior mechanical properties, fine structure, minimal porosity heat-treatable, weld able, good surface finish, high productivity, and composite fabric applications.

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