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PORE-FREE DIE CASTING

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This invention relates to die casting and more particularly to a new and improved method of pressure die casting.

The present invention is applicable to die casting machines in which relatively movable die members are closed to form a die cavity which is a negative impression of the article to be produced. The die cavity communicates with a reservoir of molten metal. In the operation of such die casting machines, the die members are brought together to form the die cavity and the molten metal is introduced. When the molten metal has solidified, the die cavity is opened and the article removed.

One of the major problems encountered in the field of die casting is caused by porosity in the cast object. As compared with products provided by other casting and fabrication techniques, die castings, due to the nature of the die casting process, are characterized by a relatively high degree of porosity. With proper die design and casting conditions, the degree and the location of porosity can be controlled. If, however, because of faulty or unsuitable die design or improper operating conditions, the level of porosity becomes exceedingly high of the pores extending to the surface of the metal, failure or deterioration of the casting when in service is likely to result.

Porosity in die castings is often caused by entrapment of air or other gases within the cast metal. Investigation has shown that the gases responsible for porosity in the die castings are principally hydrogen and nitrogen. The main source of hydrogen is generally considered to be organic die lubricants which decompose during the casting operation, and the principal source of nitrogen is the air originally in the cavity prior to injection of the molten metal. Although the use of thermo-stable lubricants, e.g., fluorocarbons, is an effective manner of reducing or eliminating the presence of hydrogen-induced porosity, nitrogen can be eliminated only by removal of the air from the die cavity, prior to injecting the molten metal. Removal of air from the die cavity is generally accomplished by means of a vacuum pump. Vacuum die casting is also beneficial since it reduces the turbulence caused by the mass flow retarding effect of a gas, e.g., air, which is compressed in the die cavity ahead of the advancing metal. Unfortunately, the employment of vacuum die casting techniques is not a simple solution for the problem of gas entrapment since the employment of vacuum techniques increases the complexity of the die casting operation and introduces an additional operating condition which requires precise control. It will be appreciated that the production of die castings of consistently good quality entails the control of a large number of interacting operational variables. Cavity evacuation, to provide a vacuum, adds a further variable which is both difficult to control and likely to diminish the degree of control which can be achieved over other variables. For example, if a die casting machine is equipped with a vacuum pump for cavity evacuation, the various phases of the operating cycle of the die casting machine must be modified and the operating values adjusted to give optimum results when, as in each cycle, the volume of air remaining in the cavity is reduced to some specific fraction of the total volume of the cavity. Should this fraction vary from cycle to cycle, all the

associated variables are affected in some degree. The difficulty of achieving, in practice, a constant level of cavity evacuation negates many of the advantages of vacuum die casting.

In the past, many attempts to apply vacuum techniques to existing die casting equipment have been made. However, such attempts have encountered numerous difficulties. For example, the equipment is complicated and involves substantial initial cost and relatively high maintenance expenses. Moreover, in the operation of such equipment the molten metal often freezes in the runners leading to the die cavity, and such premature freezing results in poor quality castings. The vacuum techniques hertofore known do not provide substantially complete removal of air or other gases from the die cavity, the metal chamber itself, and the runners connecting the metal chamber with the die cavity. Air and other gases which are entrapped in the metal chamber and associated runners are then entrained and trapped within the metal when the metal is introduced into the die cavity. Also, presently available vacuum techniques and apparatus are not readily adapted to existing die casting machines without extensive modification of the machine which involve substantial cost and reduces future flexibility of the equipment.

It is therefore an object of this invention to provide a method of die casting which overcomes the above-noted objections to prior vacuum die casting procedures while at the same time achieving the benefits generally attributed to vacuum die casting techniques.

It is another object of the invention to provide a die casting process which can be easily and conveniently adapted to available die casting equipment without substantial modification of the equipment itself.

Another object of the invention is to provide a die casting process which is capable of providing a consistent degree of removal of the air from the die cavity, the metal chamber, and the runners.

Still another object of the invention is to provide a die casting technique which achieves the effect of a vacuum casting process but does not depend on a vacuum pump or other conventional vacuum equipment.

It is still a further object of the invention to provide a die casting method by which entrapment of air and gases in the molten metal during the casting operation can be minimized or completely avoided.

It is another object of the invention to provide a die casting technique which will minimize surface porosity and thereby avoid the necessity of subsequent buffing and polishing of the cast object.

These and other related objects are achieved by employing a die casting method in which the die cavity and associated chambers and runners are flushed and substantially filled with a reactive gas prior to injection of the molten metal into the die cavity.

The term "reactive gas," as used herein, including the appended claims, is intended to refer to and include any gas which is soluble in both the molten and solidified metal or any gas which will react or combine with the molten metal during casting to form products which are soluble in both the molten and solidified metal or which can be randomly dispersed throughout the solidifying metal without adversely affecting the quality of the castings. It will be appreciated that the reaction or combination of the reactive gas with the molten metal within a sealed die cavity results in the disappearance of the gas contained within the cavity, thereby providing the benefits associated with vacuum die casting.

The particular reactive gas which is employed to combine with the molten metal will depend primarily upon the metal being cast. For zinc or zinc alloys suitable reactive gases include oxygen, chlorine, and bromine. Metal vapors, e.g., of zinc, aluminum, and magnesium, depending on the metal being cast, can also be employed as a reactive gas since such metal vapors would condense to the metallic state upon cooling, thus reducing the volume of gas within the die cavity. Oxygen is the preferred reactive gas for use in zinc, aluminum, and magnesium die casting, since these metals react with oxygen to form stable, non-corrosive reaction products which are compatible with the base metal.

For example, in the case of zinc die casting, the diecavity, vents, runners, and overflow wells can be flushed with oxygen at a pressure slightly above ambient pressure prior to the injection of the metal. After the cavity has been filled with oxygen, the gas inlet is sealed and casting commenced. During casting, the oxygen reacts with the molten zinc to form zinc oxide, thereby providing a gas-free cavity, i.e., the practical effect of a vacuum. The resulting finely divided zinc oxide is entrapped in and dispersed throughout the solidifying zinc, thus reducing or eliminating any porosity, other than shrinkage porosity, due to the presence of entrapped gas.

In order to minimize shrinkage porosity and attain the full advantage of reduced gas porosity, thermally insulated gates and runners can be used to prevent solidification of the molten metal at the gate and maintain molten metal pressure in the die.

The die cavity can be filled with a suitable reactive gas by making minor modifications on almost any existing type of die casting equipment. For example, a gas purging system operating at a pressure slightly above ambient pressure can be used to introduce the reactive gas into the cavity which is then sealed in order to prevent escape of the reactive gas into the atmosphere and leakage of air back into the die cavity. If the die cavity cannot be completely sealed, a positive pressure of the reactive gas can be employed to keep air from reentering the die cavity, thereby maintaining an atmosphere of reactive gas in the cavity during casting.

As an alternative to flushing the die cavity and its associated chambers with the reactive gas, the die itself may be operated within a sealed enclosure having an atmosphere of the selected reactive gas. Suitable seals for the die cavity and means for extracting the casting from within the enclosure can be easily adapted from existing hood-type vacuum die casting equipment.

The present invention provides a die casting process which is efficient and convenient. The process can be easily carried out in equipment which is simple in design and, therefore, economical in cost and maintenance. Changes and modifications which are necessary to adapt existing high-speed die casting equipment to die casting in accordance with the present invention are simple and relatively inexpensive. This invention can be employed in conjunction with both hot and cold chamber die casting techniques for die casting metals such as zinc, magnesium, aluminum, tin, brass, and the like, as well as alloys containing these metals.

We claim:

1. A die casting method comprises purging air from within the die cavity by flushing said cavity with a reactive gas, and subsequently injecting molten metal into the reactive gas-filled cavity, whereby the reactive gas combines with the molten metal, thereby reducing the tendency for voids to form in said casting.

2. A die casting process which involves feeding a molten metal into a die cavity positioned between movable die members, which process comprises closing the die members to form a die cavity, purging the die cavity with a reactive gas, and thereafter filling the die cavity with a charge of molten metal.

3. The process of claim **1** wherein the reactive gas is oxygen.

4. The process of claim **3** wherein the molten metal is selected from the group consisting of zinc, aluminum, magnesium, zinc alloys, aluminum alloys, and magnesium alloys.

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