Application of ZP131 powder for manufacture of casting molds using ZCast technology for Al-alloys castings

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Abstract

The paper presents the results of studies on the possibility of replacing the special powder used for the manufacture of molds using the ZCast - 3DP technology with the universal ZP131 powder. The ZCast technology allows the direct generation of the molds using the three-dimensional printing process. The type of powder used in the process is designated as ZCast501. That enables printing the molds which can resist the temperature of an alloy poured into as high as 1100 °C. Preparing the equipment to print molds with 3DP-ZCast technology requires removing formerly used powder, cleaning and refilling the apparatus with ZCast501 powder. In case, when the 3DP equipment is used as a universal Rapid Prototyping device for building all purpose models, frequent powder refilling is time-consuming and costly. For this reason, research was conducted on the possibility of application of universal ZP131 powder as an alternative material for ZCast technology. The objective of the study was to determine the thermal resistance of such molds for aluminum alloy casting. The results showed that there is a possibility of using ZP131 powder as a material for casting molds.

Keywords: Rapid prototyping, aluminum alloy, three-dimensional printing

1. Introduction

Rapid Prototyping methods used for direct generation of casting molds allow for significant acceleration of the production of prototype castings [1-9]. Three-dimensional printing 3DP - ZPrint is a universal system used both as a method of Rapid Prototyping and Rapid Tooling. For making prototypes in the process of Rapid Prototyping there is used a range of powders with different properties. ZP131 powder has found the broadest application. However, to make casting molds in the process of Rapid Tooling, ZCast501 powder with properties similar to sand molding compound is used. Versatility of 3DP method is, however, to some extent limited by the need for complete replacement of the powder in the transition process from Rapid Prototyping to Rapid Tooling and vice versa. For this reason, studies were performed on the practical application of ZP131 powder for the manufacture of casting molds. The very process of making the mold was not a technological problem. The aim of this study was to determine the thermal resistance of such mold for aluminum alloy casting.

2. TGA study of ZP131 powder

In order to determine the properties of ZP131 powder as a function of temperature, there has been performed thermogravimetric analysis (TGA) of samples - fragments of molds (Fig. 1). An analysis of the curve m’ = f(T) shows that the powder after infiltration is the multiphase
material. Thermal degradation of phases takes place in stages at temperatures of 165°C, 182°C, 307°C and 450°C.

Fig. 1. Thermogravimetric analysis (TGA) of the mold made of ZP131 powder

It was observed that after reaching by the tested material the temperature of 800°C, mass loss was recorded at a level not exceeding 19%. The structure of a mold made of powder is porous. The resin, in the process of infiltration, fills the pores of the material. It can therefore be concluded that the mass loss was mainly due to degradation of the infiltrating medium.

3. Manufacturing of casting molds

3.1. Preparation of 3D-CAD mold models

The object designated for making a prototype casting was a spur gear. The study was aimed to determine the suitability of ZP131 powder as a material for the molds of different shapes and with different casting into systems. For this reason, CAD model of the gear was prepared and on its basis various versions of a mold were designed (Fig. 2).

Each mold model consisted of two parts. The parting line was in a plane perpendicular to the axis of rotation of the gear. This type of division has been made in order to enable careful cleaning of the mold cavity of the excess powder in the 3DP process.

Fig. 2. 3D-CAD models of the molds: a) Option 1 with a gating system, b) Option 2 - poured directly

3.2. Mold manufacturing

Molds of research have been made on the three-dimensional printer Z510 Spectrum of ZP131 powder (Fig. 3 and 4). Then they have been hardened in the process of infiltration with resin Z-MAX™ Epoxy and hold at a temperature of 70°C in order to achieve proper mechanical properties of the material and evaporate water (Fig. 5).

Each mold was designed in such a way that the assembly of the two parts assured its stability. Persistent connection has been made using epoxy glue POXIPOL (Fig. 6).
Fig. 6. Molds after gluing

4. Casting

3.1. Pouring into molds

The molds were placed in a box filled with sand. Then there was prepared liquid aluminum alloy (AK7), and poured into molds (Fig. 7).

After the castings had been cooled down, the molds were broken (Fig. 8). The ready casting of the gear is presented in Fig. 9.

Fig. 7. Pouring the molds.

Fig. 8. Breakdown of the mold.

Fig. 9. Cast gear.

5. Conclusions

Study confirms the feasibility of ZP131 powder for the manufacture of molds. It was found that the molds show a thermal resistance which allows them casting in aluminum alloys.

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References


