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Designing a combined casting mold for manufacture of a gasoline centrifugal pump body using CAD/CAM-systems

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Abstract. The present paper examines designing of a combined casting mold for manufacture of a gasoline centrifugal pump body. The paper offers technological solutions for obtaining high quality castings at the testing stage of the finished mold. The paper is intended for practical use and prepared by order of JSC ‘Tomsk Electrical Engineering Plant’ using software and equipment of the department ‘Technologies of Computer-Aided Machinery Manufacturing’ of the Tomsk Polytechnic University (TPU) under the economic contract within state import substitution program. In preparing the paper, CAD/CAM-systems KOMPAS-3D and PowerMILL were used. In 2015, the designed casting mold was introduced into the production process at JSC ‘Tomsk Electrical Engineering Plant’.

1. Introduction

Method of casting into long-life metallic forms (chill molds) is applied for producing more than one third of the total amount of products from nonferrous metals and alloys that become essential components for machinery industry [1]. The variant of chill casting ensures higher density and better mechanical properties of metal, higher accuracy and quality of a cast surface, and higher operating rate as compared to sand casting [2].

This method is used in series and large-scale manufacturing [3] and involves designing of a casting mold for product manufacturing. At present, high manufacturability and competitive ability of this production method are provided due to using of CAD/CAM-systems and NC machine tools especially if we talk about designing products of a complicated form.

According to the technical task of JSC ‘Tomsk Electrical Engineering Plant’, it was required to design a long-life metallic casting mold for manufacturing a body of a gasoline centrifugal pump (GCP) from aluminum grade Al-6%Si-0.2%Mg [4] meeting all the constructive and process requirements. This type pump is used in a fuel system of military machinery and is intended for providing light fuel (gasoline) operation of a multifuel diesel engine. It should be noted that previously these products have been manufactured only by sand casting.

2. Task setting

A 3D-model of a gasoline centrifugal pump body (Figure 1 a) was designed using CAD-system KOMPAS-3D based on the drawing submitted by the customer.

After analysis of the body design that showed that the product has a complicated form requiring nonstandard solutions, the following tasks were formulated:

1. Providing a mold design with the least number of jointing planes.
2. Providing mold filling when producing thin-wall castings with many undercuts.
3. Creating favorable conditions for air venting from casting volume.
4. Reducing labour intensity of mold assembly/disassembly.
5. Reducing costs for manufacture of a chill mold.
6. Minimizing rejection of castings.

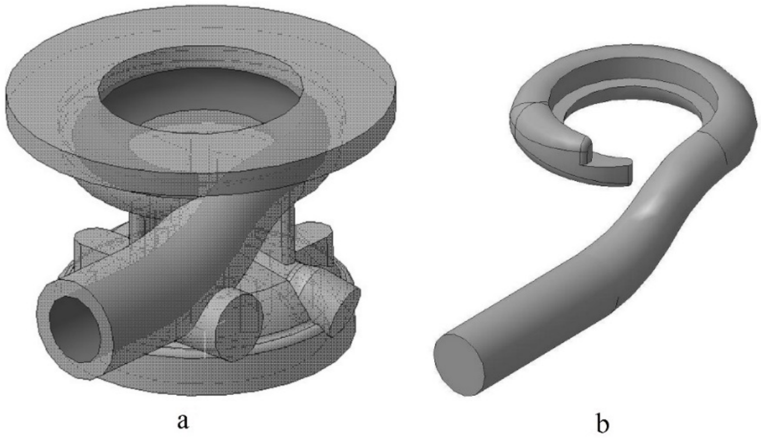

Figure 1. a – 3D-model of a gasoline centrifugal pump body, b – sand core.

3. Designing a combined casting mold

In most cases, a chill mold has 1-2 jointing planes [5]. Due to complexity of the casting configuration, the casting mold designed shall have a combined (curved) jointing plane, and shall consist of four main elements (Figure 2 a). Arrows on the figure indicate parting directions.

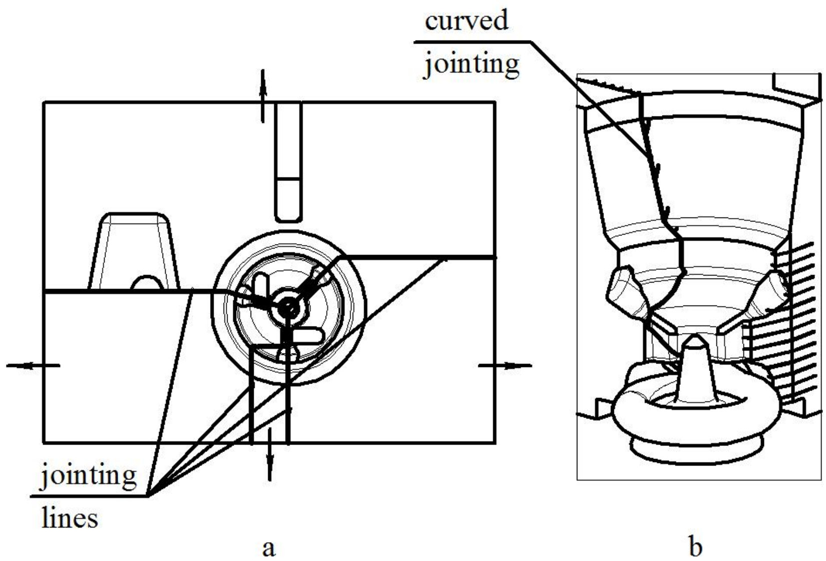

Figure 2. a – Scheme of location of jointing lines and parting directions, b – curved jointing.

A problem of formation of a complex nozzle channel was solved by using a sand core [6] – ‘volute’ (Figure 1 b), for which purpose a sand box was manufactured.

A curved jointing (Figure 2 b) that allowed maintaining the body original form as full as possible, was made between nozzle-forming parts. The body inner cavity and lug (ridge) were formed by a core rod installed on the lid. Metal was fed from the bottom, and a dashpot was made in the lower plate. Air was vented through the lid. The designed casting mold is shown on Figure 3.

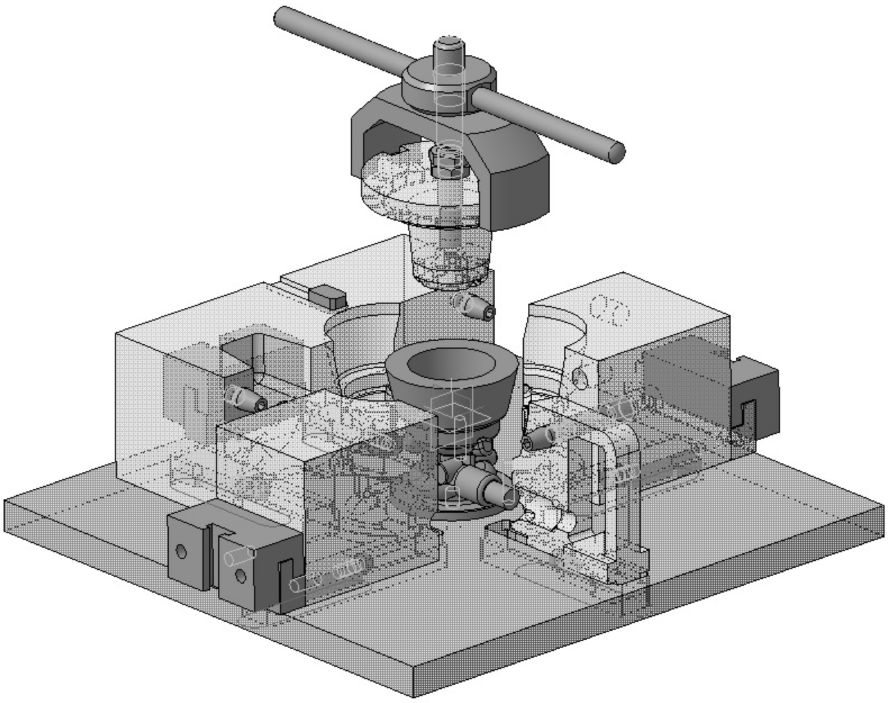

Figure 3. Combined casting mold.

For reducing manufacturing costs and time of the project implementation, it was decided to manufacture the mold from aluminum grade Al-0.5%Si-1.5%Mg [7] with coating of the working surfaces with refractory ceramic. Technique of applying refractory coatings is widely used in product manufacturing by casting method [8, 9]. In our case, it allowed preventing adhesive bonding of the casting and the mold.

Shape-generating components of the casting mold are products of a complicated form that is why it is practically impossible to manufacture them without Numerical Control (NC) tools. For preparation of a control program for a NC machine tool, CAM-system PowerMILL was applied. For manufacture of the components, the machine tool DMU 50 was used.

4. Testing the mold

After the first tests, rejection amounted to 45%. In addition to a severe shrinkage defect 1 in the casting central part, places of ‘misruns’ 2 in the pump lower part and on lug bosses 3, and pores 4 on the nozzle were detected on some specimens (Figure 4).

Despite the fact that rejection 45% for chill casting can be considered acceptable, we were not satisfied with this result. For preventing shrinkage in the area 1, it was decided to install an additional central metallic core.

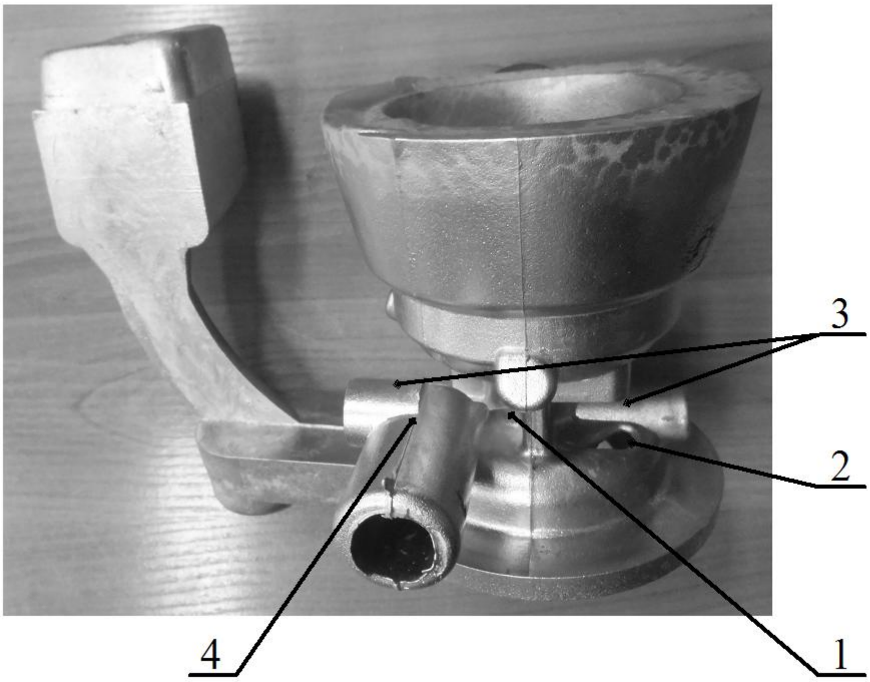

Figure 4. Casting defects: 1 – defect shrinkage, 2 and 3 – places of ‘misruns’, 4 – pores.

For preventing shrinkage [10] on lug bosses, copper coolers with a snakelike slot (Figure 5 a) contributing to both air cooling and venting, were built into the casting mold parts. The problem of pore formation was solved by making additional air venting channels (figure 5 b) on all the mold joint surfaces. During further testing, the mold initial temperature [11, 12] was increased from 300 ^{o}C to 400 ^{o}C, and casting time was reduced from 20 sec to 10 sec.

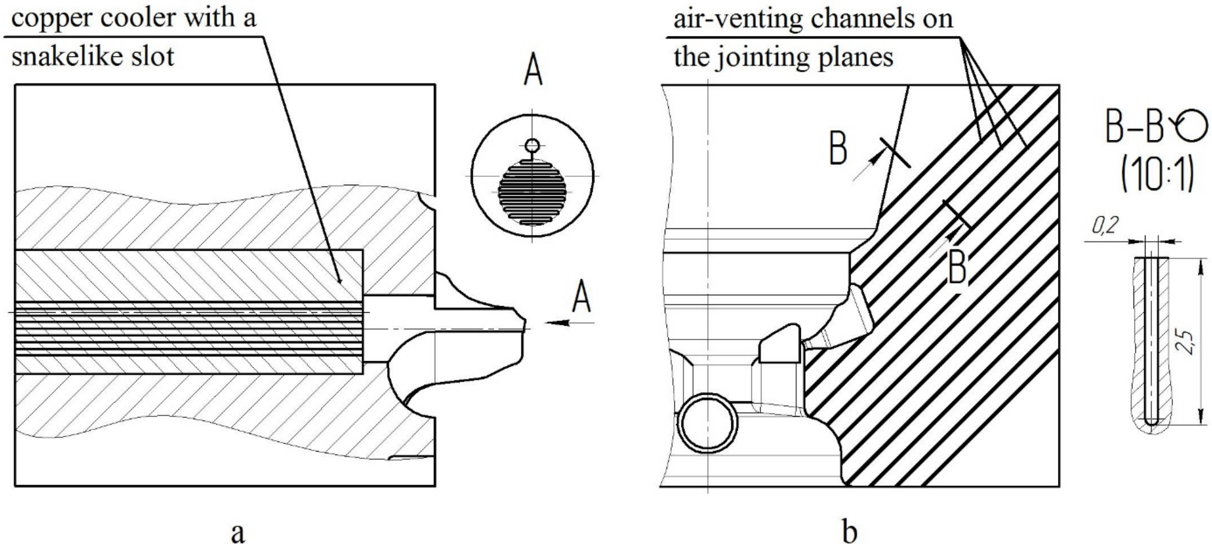

Figure 5. Methods of defect prevention.

5. Conclusion

The solutions implemented increased the amount of acceptable castings to 80%. At present, practical work on selecting casting modes is being conducted for further rejection reduction. Theoretical work on calculating temperature patterns, solution phase field, and velocity and pressure fields, on calculating segregation (chemical inhomogeneity) and defects, and on calculating stresses and deformations, is also being planned.

Within the project implementation, a computer-aided installation for casting a gasoline centrifugal pump body was constructed and introduced into production at JSC 'Tomsk Electrical Engineering Plant'.

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