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Modeling techniques for enhancing barrel-type part casting processes

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Abstract. This article discusses the principles of modeling the casting process for casting parts - "Barrel". A detailed overview of the casting drawing is provided, as well as the designed 3D model according to this drawing. The values of allowances for the machining of the part are analyzed. The characteristic of the obtained alloy is presented, on the basis of which the calculation of the technological yield of the suitable one is made. At the end of the article, the result of the output of a suitable casting is given.

1 Introduction

A technological process is understood as an ordered sequence of interrelated actions that are performed from the moment the initial data appears until the desired result is obtained. The casting process can also be attributed to such a process [1-6]. The technological process of casting production consists of the following operations: manufacture of models and rod boxes; manufacture of molds according to models; manufacture of rods; metal melting and casting of molds with liquid metal; extraction of castings from molds; stumping and cleaning of castings; heat treatment (if it is necessary according to technical conditions) [7-9].
Modeling should be understood as the construction (or selection from existing ones) of a model, its study and use in order to obtain new knowledge about the object under study [10]. Casting process modeling systems allow analyzing the technological process of casting production at the stage of its development, selecting the necessary gate-feeding system and determining the optimal technological parameters of the casting process [11, 12]. The use of such calculations in the "end-to-end design" allows you to save on possible refinement of foundry equipment and reduce the time for testing foundry technology [13].
The purpose of this article is to obtain a 3d model of the developed casting with a gating system - "Barrel", as well as the calculation of the technological yield of a suitable one [14].

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2 Result and discussions

A. Development of the casting drawing

A barrel is a housing part designed to hold grease or working fluid/gas in it. In the first case, it is a barrel of bearings, in the second - a barrel of the nozzle, for example. Gear shaft bearings are usually placed in the cups, the typical representative of which is in the drawing [15-19].
Figure 1 shows a drawing of a barrel part. The part is made of gray cast iron SCH 18. The total mass of the part = 11.11 kg, the calculation of the mass of the part was made by building a 3D model in Compass-3D.
When designing the part, simple geometric shapes were used, allowing the use of high-performance processing methods [20]. Convenient and reliable technological bases are provided. Sufficient rigidity of the part is provided.

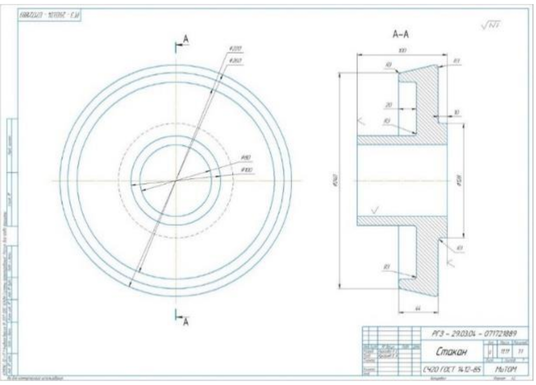

Fig. 1. Drawing of the "Barrel" part.

Figure 2 shows a 3D model of the part from different angles.

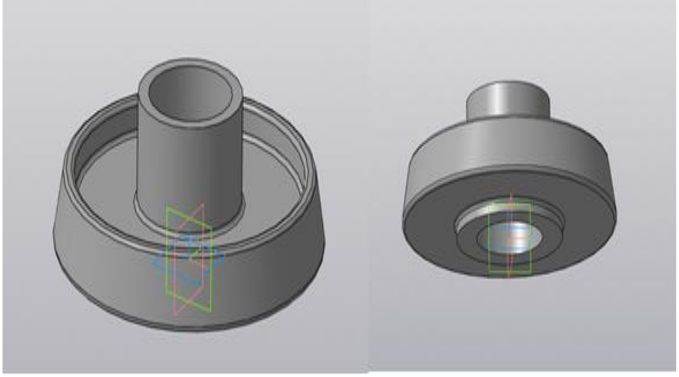

Fig. 2. 3D model of a part from different angles.

Next, we determine the position of the casting in the mold and the plane of the model connector.

The connector line is selected based on the following positions:

1. If possible, place the casting in one half-mold, and the most relevant surfaces of the part with the least roughness are lower or lateral [21, 22].

2. Place the massive and thick parts of the casting at the top, the thinner ones at the bottom.

3. Apply the principle of the minimum number of rods forming the internal cavities of the casting. If possible, use "dummies" instead of rods - the protruding parts of the actual mold [23].

4. Casting models performed at the selected connector plane must ensure formability, i.e. they can be easily removed from the compacted molding mixture without destroying the configuration of the model imprint [24].

5. In the simplest version, the connector plane is assigned according to the symmetry plane of the part, if any. The plane of the shape connector as a rule coincides with the plane of the model connector [25].

After assigning the connector plane, it is necessary to assign allowances for machining. The values of allowances are assigned according to Table 1. The data given in Table 1 are calculated for the case of manufacturing castings in sand molds with an accuracy of 8-0-0-8 GOST 26645-85 [26]. The table takes into account the size of the part in the drawing, as well as the surface when filling and the material. The surface when filling is determined according to the connector line.

TABLE 1. Values of allowances for machining

The size of the part in the drawing, mm	Surface when pouring	Part Material	
		Cast iron	Steel
Up to 50	Upper Lower, side	3.5 2.5	4.0 3.5
Over 50 to 120	Upper Lower, side	4.0 3.0	5,0 4,0
Over 120 to 260	Upper Lower, side	5.0 4.0	6,0 4,0
Over 260 to 500	Upper Lower, side	6.5 5.0	7,0 6,0

For linear dimensions, we assign allowance values equal to half of the specified value in one direction, and half of the value in the other direction. For diametrical dimensions, the values of allowances are assigned according to Table 1 in both directions an integer value [27].

According to the size values of the drawing shown in Figure 1, we assign allowances for machining:

80 mm in the drawing. This is an internal diametrical size, so we assign an allowance for this size according to the table of 3 mm in both directions, the size of the part is from 50 to 120 mm, the material is cast iron [28, 29].

100 mm in the drawing. This is a linear size, we assign an allowance of 4 mm, since the size of the part in the drawing is from 50 to 120 mm and this is the upper surface of the part, the material is cast iron.

100 mm in the drawing. This is a linear size, we assign an allowance of 3 mm, since the size of the part in the drawing is from 50 to 120 mm and this is the lower surface, the material is cast iron [30, 31].

Further, it is necessary to assign the values of molding slopes when using sand-clay mixtures, they are assigned according to Table 2. Molding slopes are set in order to make the extraction of the casting as easy as possible.

TABLE 2. Values of the molding slopes of the model

Height of the forming surface, mm	Parameters of molding corners models	
	corner	mm
Up to 10	2○55’	0.50
Over 10 to 16	1○55’	0.55
Over 16 to 25	1○30’	0.65
Over 25 to 40	1○05’	0.75

Over 40 to 63	45’	0.85
Over 63 to 100	35’	1.00
Over 100 to 160	25’	1.20
Over 160 to 250	25’	1.85
Over 250 to 400	20’	2.30

Since the height of the forming surface is 20 mm (from 16 to 25 mm), we assign a slope of 1 to 30’. We assign a slope of 2 ° 55’, to a height of 10 mm (up to 10 mm). And a slope of 35’, to a height of 100 mm (over 63 to 100).

In the places of the interfaces of surfaces (corners), we assign casting radii. For this casting, we assign 2 symmetrical linear radii, H = 10 mm, hence R = 3mm. The drawing of the casting, taking into account the values of the slopes, is shown in Figure 3.

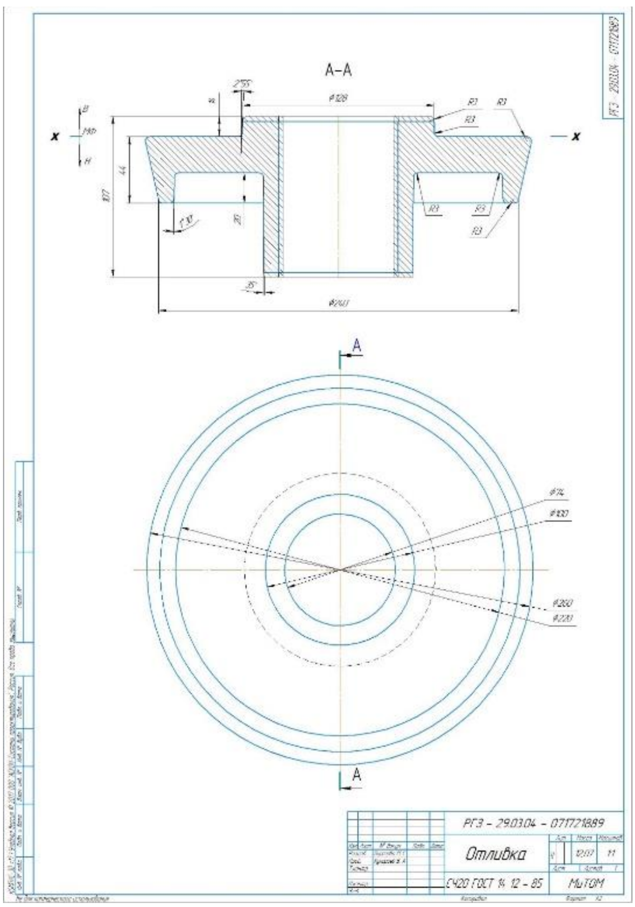

Fig. 3. Drawing of the casting taking into account the values of the slopes.

B. Characteristics of the alloy

Brand: SCH 20. Classification: grey cast iron for the manufacture of castings. The chemical composition according to GOST 1412 - 85 is given in Table 3.

Table 3. Chemical composition of cast IRON SCH-20

Chemical element	%
C	3.3 – 3.5
Si	1.4 – 2.4
Mn	0.7 – 1.0
P	To 0.20
S	To 0.15

C. Calculation of the gate system

Filled gate systems are used for castings made of gray cast iron. First, the total cross - sectional area of the narrowest element of the gate system calculated by formula 1 is determined (1):

$$F_e = \frac{G}{\gamma \cdot \tau \cdot \kappa \cdot \sqrt{2q \cdot H_p}} \quad (1)$$

where: $\sum F_e$ - total cross–section of feeders, cm^2; γ - density of liquid cast iron grade SCH20, equal to 7.1 g/cm^3; τ - duration of filling, s; κ - coefficient of resistance; G - mass of castings, g; q - acceleration of gravity, cm/s^2; H_p - calculated static pressure, see.

In order to calculate the pressure when pouring, it is necessary to calculate the dimensions of the flasks, first the height of the flasks, then the length and width. To do this, it is necessary to take into account the distances between the casting and the individual elements of the mold according to Figure 4.

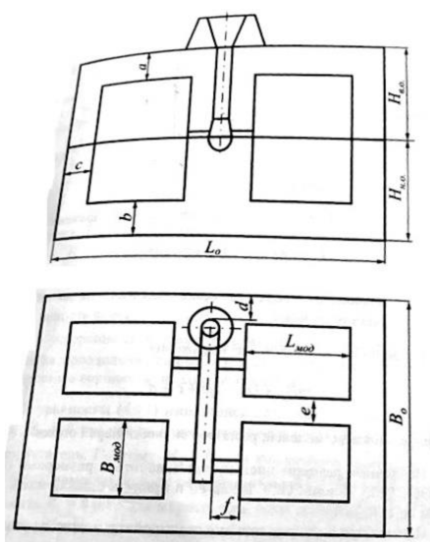

Fig. 4. Scheme for determining the distance between the casting and individual elements: a, b, c, d, e, f – the distance between the models and the elements of the mold, Lo – the length of the flask, Vo – the width of the flask, Lmod – the length of the model, Vmod – the width of the model.

Figure 5 shows the location of the casting, side view.

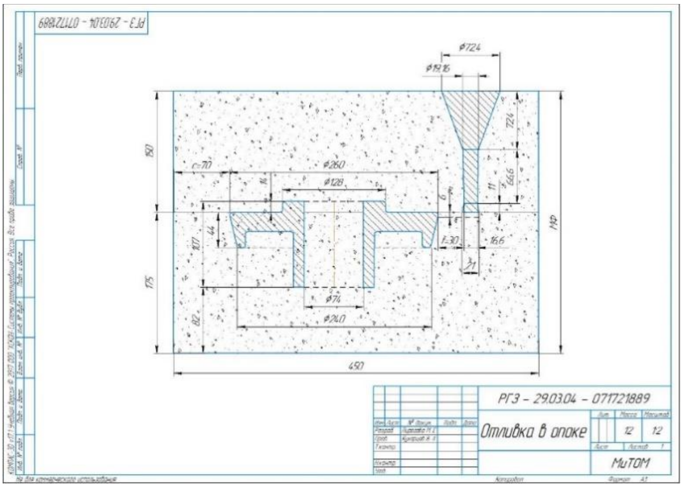

Fig. 5. Casting location in the flask (side view).

Next, we find the height of the upper and lower flanks, respectively. The height of the upper flask, according to calculations, can be 74 mm, because the part of the model, equal to 14 mm, is located in the upper half-form, and the minimum tabular distance between the top of the model and the top of the form is 60 mm. But the height of the upper flask must be taken more, since in this part there will be a riser and a funnel, and this height will not be enough. Let's take the height of the upper flask equal to 150 mm.

Using formula (3), we calculate the height of the lower flask. Here it is necessary to lay down such values as the casting height located in the lower half-mold and the minimum allowable distance between the bottom of the model and the bottom of the flask [32].

According to the constructed drawing (Figure 5), we will find the size of the flasks in length and width. This formula uses the values of the feeder length and the width of the slag collector. These values are taken from further calculations of the actual dimensions of the gate system and placed here. Preliminary calculations of the approximate dimensions of the flasks are made. The estimated length is 401 mm.

Next, it is necessary to calculate the technological yield of the product using formula 2:

$$\eta = \frac{G_0}{G} \cdot 100\% \quad (2)$$

where G0 is the mass of two castings in the flask, and G is the mass of two castings with a gating system.

In order to calculate it, it is necessary to build a gating system together with castings. The 3-D gate system with castings is shown in Figure 6.

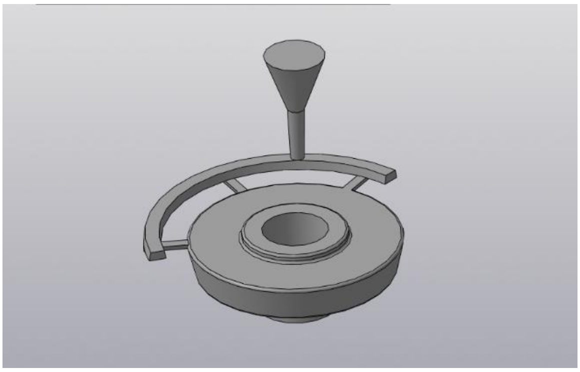

Fig. 6. Construction of casting and gating system in Compass 3D.

Substituting in the MCC model, the density of gray cast iron, in Compass-3D, we calculate the mass of the gate system with castings and get equal to 12.96 kg.
The yield of suitable casting can be assumed to be 80% for cast iron castings and 70% for steel blanks. It can be concluded that the yield of a suitable casting corresponds to one.

3 Conclusion

The following drawings were presented in this article:
The drawing of the part is a barrel. This part is made of cast iron grade SCH 20. The weight of the part is 11.11 kg.
Casting drawing. The weight of the casting is 12 kg.
Drawing of the mold assembly. Side view. The mass of the casting with a gating system is 12.96 kg.
Drawing of the mold assembly. View from above.
This paper also provides a complete calculation of the gating system, calculated the parameters of the elements of the gating system, as well as the constructed 3d models in the program COMPASS-3D v.17 elements of the gating system, castings, as well as the general constructed type of assembly.
In addition, this work is completed by calculating the technological yield of a suitable one, which is equal to 92%.

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