

Critical analysis of the influence of the possibilities of establishing the moulding technology on obtaining the castings

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Abstract. The Romanian foundries give high priority to quality castings. Thus, the castings moulding technology decisively influences their quality. Therefore, it is necessary to study the possibilities of realization the moulds for castings. This paper presents a critical analysis of the influence of all factors of the moulding technology on the quality of steel castings. The purpose of the study is to analyze the way to establishing the separation plane, how to determine the processing allowances and technological allowances, the dimensioning of the riser, the choice of the optimal casting method of the liquid alloy. Establishing optimal moulding technology determines the optimal use of resources with direct implications for manufacturing costs.

1. Introduction

The principles of the construction of the steel castings are quite different from the known principles of the construction of cast iron castings [1]:

- First of all, the technological analysis of the steel casting construction must take into account the shrinkage factor. The large shrinkage of the cast steel during solidification and in a solid state requires measures to be taken to ensure that shrinking, tensions and cracks are produced in the casting.
- Secondly, in the case of steel castings the steps of obtaining the casting must be taken into account: moulding, cleaning, mechanical machining (which is necessary to be cheap and lead to material savings).

In this context, in the Romanian foundries it is necessary to provide technologies that will lead to a balance between all the factors of influence on the quality of the castings.

2. Critical analysis of the influence of the possibilities of establishing the moulding technology on the obtaining the castings

The castings of the *Toothed case*-type made of unalloyed cast steel, 340-550W steel grade, are very common in industrial practice of the foundries because they are used in various industries [2-4]. The chemical composition of the steel for the elaborated charges is in accordance with the standard SR ISO 3755-95 [5].

The special requirements for this type of castings imposed by beneficiaries led to the necessity of a critical analysis of the manufacturing technology for this type of casting.

With this end in view, the critical analysis of the foundry on this type of castings led to the conclusion that the percentage of the rejects is too high [6], with direct effects on the costs of foundry. Besides the registered defects due to the moulding mixtures used [6], the critical analysis has led to the



idea that the possibility of establishing the moulding technology has a particular influence on the quality castings (castings without defects).

Thus, several deficiencies have been identified in the moulding technology [7-9]:

1. Inappropriate positioning of the separation plane leads to the displacement of the moulds during casting of the liquid alloy and then to rejection of the castings
2. Inappropriate choosing of the processing and technological allowances leads to an excessive increase of the labor costs; this leads to an increase of the casting price.
3. Inappropriate dimensioning and positioning of the shrink head leads to the shrinking; this defects leads to the rejected of the casting

In this context, the design of moulding technology has a prime role.

The first step in obtaining the castings quality is to establish the position of the cast in the mould and the choice of the separation surface/plan so that the casting pattern and the entire set of pattern can then be made. The initial analysis of the drawing of finished piece definitely has this role so that the designer of the technology can perfectly imagine the spatial configuration of the casting.

For these purpose it is determined [10], [11]:

- a) The moulding and casting positions, respectively the separation surfaces,
- b) Shrinkage allowance and processing and technological allowances,
- c) The dimensions of the cores and the cores mark as well as their positioning.

All of these elements are featured on the technological drawing, in all views and sections with conventional colours and lines.

2.1. Establishing the position of the casting in the mould and chosing the separation surface

To make it possible to pattern drawing of the moulding mixture without damaging the mould it should be section with one or more separation surfaces. For each casting the possible solutions for sectioning of the pattern and mould are analyzed.

Of the possible solutions one must choose the one that ensures the following [12]:

- extracting the pattern (pattern drawing) from the moulding mixture;
- getting the mould with the fewest cores;
- easy and secure mounting of the cores in the mould;
- laying of the surfaces to be mechanically machined to the bottom or side;
- the number and dimensions of the burrs that can be formed must be minimal (the most undesirable ones are the inner ones and, therefore, the cores must not be made from two or more sealing parts except in special situations);
- the possibility of making the core correctly and easily as well as the correct and simple manufacture of the core box;
- the position of the casting in mould must be chosen so as to ensure a conduct solidification of the liquid alloy (from thin to thick parts) and to ensure minimal metal consumption and a lower cost price.

In particular, in the case of casting analysed, there are several theoretical solutions (Figure 1), which depend on the casting symmetry, the presence of the surfaces to be machined and the moulding and casting positions.

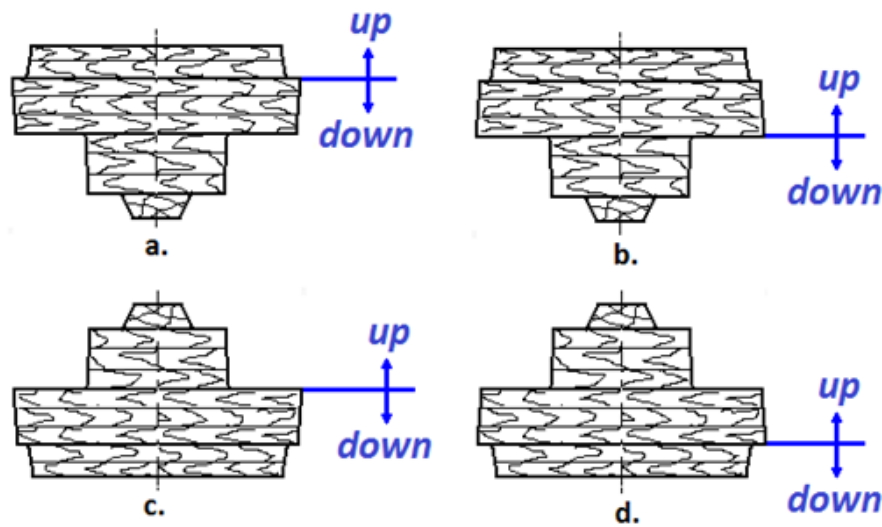


Figure 1. The possibilities of sectioning the pattern

In particular, in the case of casting analysed, there are several theoretical solutions (Figure 1), which depend on the casting symmetry, the presence of the surfaces to be machined and the moulding and casting positions.

Thus, the chosen solution must ensure the production of castings corresponding to the technical and economic requirements.

For this, it is necessary to perform the analysis of the possible solutions presented in Figure 1, with the presentation of their advantages and disadvantages:

- **case a** – has the disadvantage that the core covers the top of the casting so it is not possible to place the shrink head and it cannot be directed by the solidification process, resulting the internal shrinkages in the casting;
- **case b** – besides the disadvantage of the **case a** is added the possibility of displacement the mould parts and thus obtaining a decentralized casting;
- **case c** – present the disadvantage of the possibility of displacement in the separation plane and obtaining a decentralized casting (it is similar to **case b**);
- **case d** – is the most advantageous solution because it allows a correct positioning of the shrink head and thus directional solidification; the pouring of the liquid alloy in this case is of the cast uphill type, so pouring of liquid metal into the mould cavity is carried out without the risk of turbidity occurring (quiescent pouring).

Considering these recommendations, Figure 2 presented the mould separation plane; this surface is plane and the pouring position is horizontal.

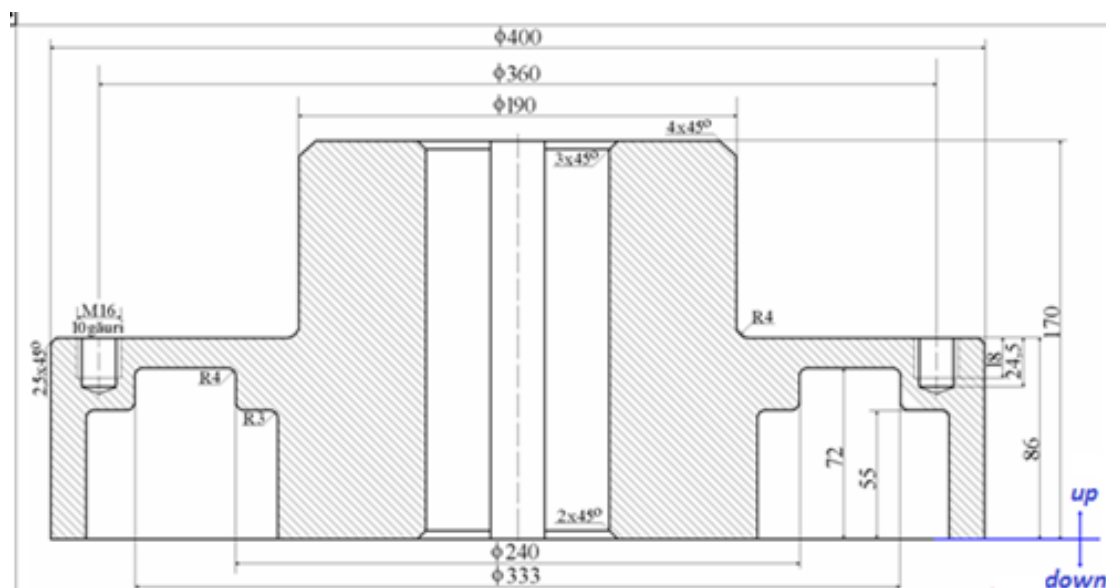


Figure 2. The separation plan of the casting studied

2.2. Establishing the processing and technological allowances

Processing allowances are additional allowances of material provided on the casting assembly surfaces. These surfaces require machining by cutting in order to obtain precise dimensions so that parts of the castings can be assembled [11], [12].

The size of processing allowances depends on several factors, namely [11], [12]:

- the type of cast alloy,
- the position of the processing surface during casting of the alloy,
- the dimensions of the casting and the surface to be processed,
- the method of moulding used etc.

Following the analysis of all these factors of influence and according to the specialty literature and industrial practice these allowances have been established for the analysed casting.

In industrial practice the processing allowances for steel castings are standardized and are determined according to the maximum dimensions of casting [mm] and nominal dimension [mm] [11], [12]. Thus, in Table 1 are presented, for casting studied, the values for processing allowances [10], [12].

Table 1. Processing allowances according to the dimensions of casting

Maximum dimension of casting, mm	Position in mould of the surface to be processed	Nominal dimension, mm
		301...400
301...500	Up	7,0 for H = 170 mm
		5,0 for h = 86 mm
	Down	5,0 for H = 170 mm
		6,0 for Φ 400 mm
	Side	5,0 for Φ 190 mm
		5,0 for Φ 80 mm

In Figure 3 there are presented the allowances applied to the casting as well as the final dimensions obtained on the technological drawing.

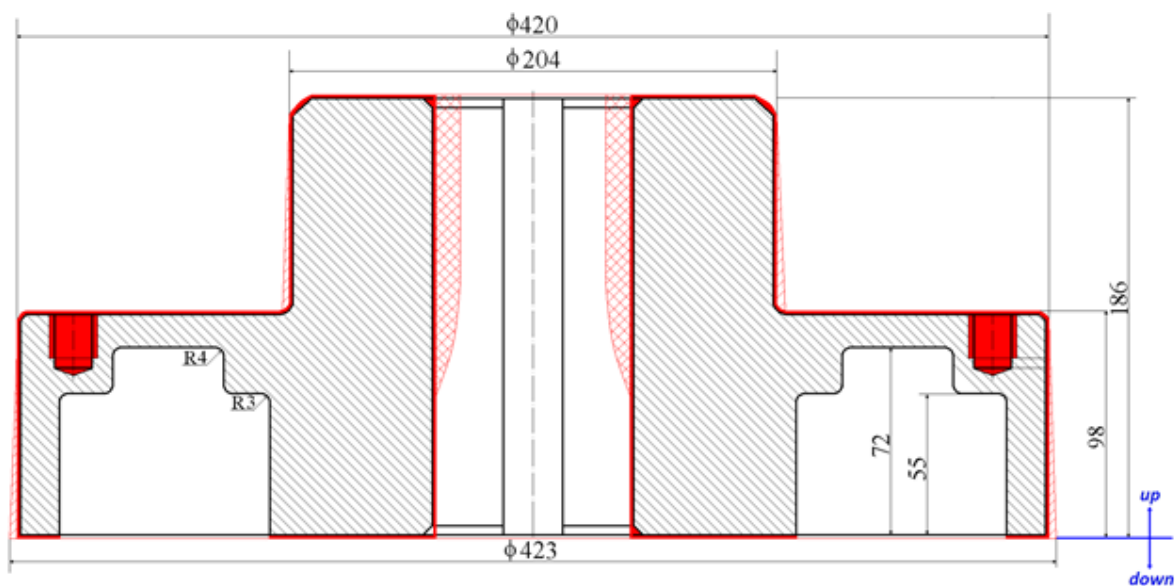


Figure 3. Presentation of the allowances for the studied casting

The elements of the pattern to be obtained are drawn on the technological drawing as far as possible according to the following rules:

- the separation surface (plane) – with a continuous blue line;
- the shrink heads – draw, color and quote in blue;
- the processing allowances and corresponding quotas – red; the graphic representation of the processing allowances, on the technological drawing, is done as follows:



- the technological allowances – for conduct solidification; the graphic representation on the technological drawing is done as follows:



- the constructive inclinations – has the rol of preventing excessive labor and steel losses as well as ensuring that castings with precise dimensions are obtained; the size of the constructive inclinations is regulated by the standard, depending on height H of the wall to be tilted; the inclination of the walls will be perpendicular to the separation surface. The graphic representation on the technological drawing is done as follows:



- the cores (internal or lateral cores)– with colors to show them (green e.g), on all the views and sections of the casing.

After establishing the size of shrinkage allowances, the constructive inclinations and the dimensions of the core marks, the configuration and the dimensions of the pattern can be determined.

For making the set of pattern account is taken of processing allowances, technological allowances, shrinkage allowance, respectively dimensioning the core marks [6]. It is specified that the set of pattern is made entirely of wood. Thus, Figure 4 presented the wooden pattern of the casting.

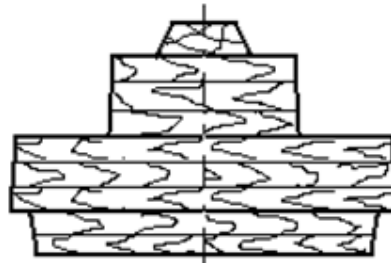


Figure 4. The wooden pattern of casting analyzed

Compared to other materials used in pattern shop, wood has the following advantages:

- it is cheap,
- it has a small specific weight,
- it is easy to process,
- it is easily glued by gluing and with some metallic elements.

2.3. Dimensioning the shrink head

To the solidification of some castings of alloys with a high volumetric shrinkage coefficient, at the top of the casting there is always a *concentrated shrinking*.

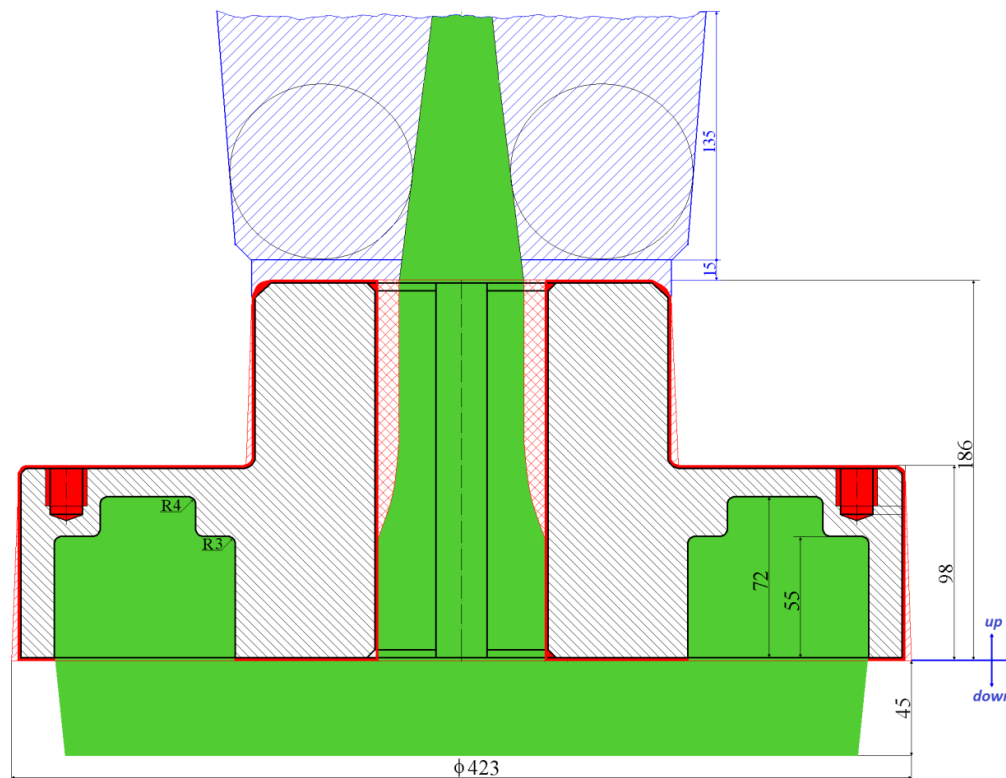


Figure 5. Technological drawing of casting analyzed

This occurs because during solidification, the already solidified parts decrease their volume, determining a lowering the level of liquid unsolidified [7-10].

In order to avoid the occurrence of concentrated shrinking from the top of the castings, a technological extension is made thicker than casting. In this extension will locate the shrinking so that the casting will have a compact height ("healthy") corresponding to the drawing of the finished piece. Thus, the shrinks head are "additional reservoirs" of the liquid alloy in the form of technological allowances. For calculating the dimensions the shrink head it is necessary to take into account the shrinkage coefficient β [1], [12]. This coefficient, for steel grade 340-550W ($C = 0,4...0,5\%$), has the value $\beta = 4,5...4,8\%$ [12], [13].

From practical experiments it has been found that for steel castings the dimensions of the casting being analysed it is best to use a circular shrink head to cover the top of the casting.

The dimensioning of the shrink head was performed using two method, respectively the graphical method of the spheres entered and expeditious dimensioning of the shrink head [10-12].

Following the correlation of the two dimensioning method of the shrink heads, the main dimensions of the shrink head are determined (Figure 5): $h = 15$ mm; $D_m = 108$ mm; $H_m = 135$ mm, which leads to significant material savings.

3. Conclusions

The rejected registered in the castings analyzed due to moulding technology, respectively due to positioning inadequate of the separation plane, the insufficient strength of the mould, the pouring method, represent 40% of the total rejects registered.

Thus, the position of the casting into the mould and the separation surfaces of the mould must ensure:

- required quality of the casting
- minimum consumption for mechanical machining
- minimum consumption of the metal.

The defects due to the inappropriate setting of the separation plan, depending on their severity, often lead to the increase of the cleaning work of the casting parts and even to their rejecting.

The processing and technological allowances are chosen so as to ensure the possibility of correct pattern-drawing and do not leads to an excessive increase of machining/trimming labor (this lead to an increase the price of casting).

For the studied technology, industrial practice indicates that it is best to use a circular shrink head to cover the top of the casting. Choosing this constructive option leads to a substantial material saving, compared to the current technology, which leads to a decrease in a manufacturing price of the casting.

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