

PAPER • OPEN ACCESS

Improving the quality of castings made of non-ferrous metal alloys when casting in metal molds

To cite this article: D L Pankratov and R V Gavariev 2019 *IOP Conf. Ser.: Mater. Sci. Eng.* **570** 012072

View the [article online](#) for updates and enhancements.

Improving the quality of castings made of non-ferrous metal alloys when casting in metal molds

D L Pankratov¹ and R V Gavariev²

¹Kazan Federal University, Naberezhnye Chelny Institute, 423812, Russia,
Naberezhnye Chelny, Prospekt Syuyumbike 10A,

²Kazan national research technical university named after A.N. Tupolev-KAI,

Gavariev@mail.ru

Abstract. The article deals with the quality of castings of zinc and aluminum alloys made by means of casting under pressure. The study identifies causes of defects in the outer surface and their influence on the roughness of the castings. The connection between the working surface of the mold and the roughness of the obtained castings is determined. The relationship between operation life of molds and the roughness of the castings is shown. The solution which increases the operational stability of molds as well as the quality of the surface of castings is proposed.

1. Introduction

Pressure casting is one of the most effective methods of obtaining blanks with the highest utilization rate of materials up to 95% [1]. Castings obtained by pressure casting often do not require subsequent machining. Therefore, the casting surface formed in the casting process must meet the requirements specified in the rough draft. The method of pressure casting allows to obtain castings with surfaces corresponding to the purity of not more than $Ra=1,6$ microns. However, with the wear of the casting equipment, the roughness of the castings increases [2], which will lead to the unfitness of the cast products. Therefore, in order to achieve these values of roughness as well as various other requirements for the surface it is necessary to obtain the desired results.

2. Results

Taking into account the relatively small range of values for regulating the technological parameters of the pressure casting process, due to the opposite of the requirements for obtaining a quality surface, on the one hand, and reducing the porosity inside the casting, on the other, one of the most important parameters is the operation life of the forming surface of the mold [3,4].

The operation life depends on many factors acting simultaneously in the process of obtaining the necessary casting. Therefore, to obtain the most effective technology for the production of high-quality castings by the method of pressure casting it is necessary to find a solution that will reduce the influence of negative factors on the forming surface. One of the possible solutions is coating the forming surface by cathodic-ion bombardment [5,6]. The most suitable option for pressure casting conditions is a coating TiCN-TiN-MoN [7].



To verify the effectiveness of the protective coating, we carried out a study of the roughness in terms of Ra at three different points on the outer flat surface of the castings of ZAMAK-5 (figure 1A) and aluminum alloy (figure 1B), obtained in the formative inserts of 4Cr5MoSiV material coated with TiCN – TiN – MoN in different periods of operation.



Figure 1. Determining roughness on the resulting casting and the casting of ZAMAK-5; b – casting aluminum alloy

For comparison we investigated similar performance in the casting obtained in the forming inserts of steel 4Cr5MoSiV with nitriding (table. 1).

Table 1. Values of roughness of zinc castings

Processing of molds	No. of the point	Roughness of casting surface Ra, mkm						
		Number of pressing-ins (number of cycles)						
		1	1000	10000	20000	80000	150000	200000
TiCN – TiN - MoN	1	0,547	1,140	1,999	2,109	2,270	3,468	5,867
	2	0,890	1,574	2,224	2,458	2,664	3,736	6,089
	3	0,457	1,325	1,879	1,889	2,005	3,404	5,796
Nitriding	1	1,049	1,726	2,778	3,503	4,798	6,368	-
	2	1,816	2,324	2,861	3,568	4,969	6,758	-
	3	1,593	2,193	2,708	3,373	4,566	6,397	-

According to the data obtained, it was found out that the points lying on the same plane for both aluminum and zinc alloys have different roughness indicators, which can be explained by two factors: the position related to the molding channel, as well as the position related to the structural elements of the forming surface (fillets, holes, low spots, collars and others) [8,9].

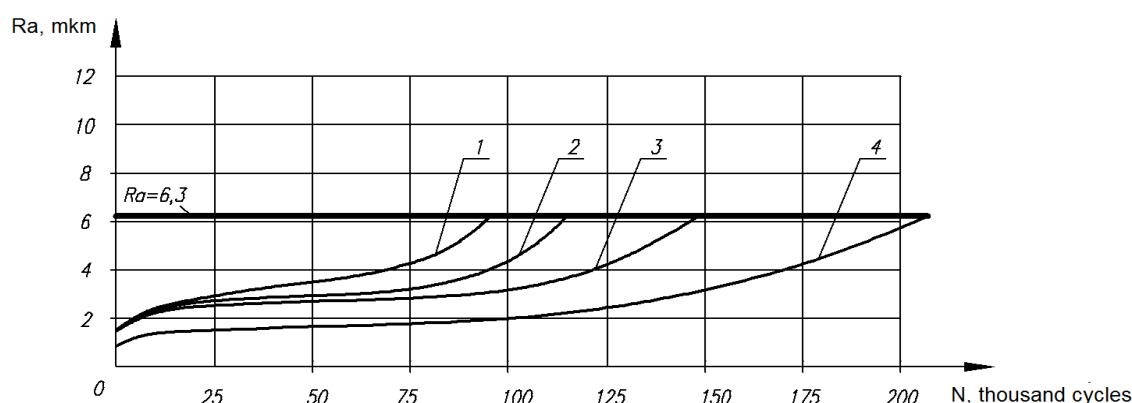


Figure 2. The graphs of surface roughness of castings from a period of operation of the forming panels of steel 4Cr5MoSiV: 1) during casting of the aluminum alloy with nitriding; 2) during casting of the aluminum alloy with coating TiCN-TiN-MoN; 3) in the casting of ZAMAK-5 with nitriding; 4) during casting of ZAMAK-5 with a coating TiCN-TiN-MoN

It is also revealed that the castings obtained from the forming inserts coated with TiCN-TiN-MoN have less roughness at the points under consideration than the castings from nitriding inserts (Fig. 2).

Figure 2 shows that in the initial period of operation (up to 5000 cycles) all curves have equivalent results, but then there is a sharp divergence [10-12]. The comparison of the castings obtained from forming of the surface coated with TiCN - TiN – MoN (curve No. 2 for the aluminum alloy, No. 4 for ZAMAK-5) and nitriding (curve No. 1 for the aluminum alloy , No. 3 for ZAMAK-5) showed that the change of roughness are similar in both cases. Thus, after 150,000 pressing cycles, zinc castings obtained from nitriding inserts have a roughness $R_a=6,3$ microns, and castings obtained from inserts coated with TiCN - TiN – MoN - $R_a=3,2$ microns.

3. Conclusions

Thus, the use of a complex coating TiCN-TiN-MoN, obtained by the cathodic-ion bombardment method, on molds for pressure casting of zinc and aluminum alloys can reduce the growth rate of roughness of end products. At the same time, there is an increase in the operation life of molds with applied wear-resistant coatings in comparison with the traditionally used method of nitriding of the forming surfaces of molds. It is shown that the complex wear-resistant coating TiCN-TiN-MoN, applied to the forming surfaces of molds for pressure casting of non-ferrous metals and alloys based on them can increase the operation life of molds with guaranteed compliance with the quality requirements of castings obtained by pressure casting which in turn reduces the cost of molding in production process.

References

- [1] Belopuhov AK 1985 *Tekhnologicheskie rezhimy lit'ya pod davleniem* [Technological modes of pressure casting] : Mechanical engineering 272 p
- [2] Goryanov II 1973 *Press-formy dlya lit'ya pod davleniem* [Press-molds for pressure casting]: Reference manual. - L.: Mechanical engineering 256 p
- [3] Gavarieva KN, Simonova LA, Pankratov DL and Gavariev RV 2017 Development of expert systems for modeling of technological process of pressure casting on the basis of artificial intelligence //IOP Conference Series Materials Science and Engineering, Institute of Physics Publishing DOI: 10.1088/1757-899x/240/1/012019
- [4] Gavariev RV, Savin IA and Leushin I O 2017 *Improvement of zinc castings surface quality by laminated protective coating* Tsvetnye Metally No 5 pp 84-88
- [5] Gavariev R V and Savin I A 2017 *Improvement of surface quality of casting produced by casting under pressure* Solid State Phenomena, pp 988-93
- [6] Gavariev RV and Savin IA 2018 *Research of the Mechanism of Destruction of Compression Molds for Casting under Pressure of Color Alloys*, Solid State Phenomena Vol 284 pp 326-31
- [7] Pankratov DL, Gavariev RV and Gavarieva KN 2016 *Influence of multilayer coatings on the operational stability of molds for injection molding* IOP Conference Series: Materials Science and Engineering Volume 134 Issue 1 **012031**
- [8] Gavariev RV, Savin IA and Leushin I O 2016 *Impact of the functional coating on service durability of injection molds for the zinc alloys pressure casting* TsvetnyeMetally No 1 pp 66-70
- [9] Deev V B, Prusov ES and Kutsenko AI 2018 *Theoretical and Experimental Evaluation of the Effectiveness of Aluminum Melt Treatment by Physical Methods* La MetallurgiaItaliana V 2 pp 16-24
- [10] Gavarieva KN, Simonova LA, Pankratov DL, Shibakov VG and Gavariev RV 2018 *Application of multi-agent system for control of parameters of precision stamping process of bevel gears* IOP Conference Series: Materials Science and Engineering, Volume 412 **012020**

- [11] Safronov NN, Mingaleeva L B and Savin I A 2018 *Optimization of charge material composition in shs process with ferrosilide fabrication from gaseous wastes of metallurgical production* Chernye Metally pp 53-59
- [12] Prusov E S, Panfilov AA and Kechin V A 2017 *Role of Powder Precursors in Production of Composite Alloys Using Liquid-Phase Methods* Russian Journal of Non-Ferrous Metals Vol 58 (3) pp 308-16