PHYSICOCHEMICAL INTERACTION OF THE MATERIAL OF CASTINGS WITH THE METAL OF THE INSERT OF MOLDS FOR INJECTION MOLDING OF NON-FERROUS METALS AND THEIR ALLOYS

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Abstract: *In the article the process of destruction of the tooling for injection molding of non-ferrous metals from the point of view of the interaction of the material of the mold and the casting melt is considered. The main reasons are the failure of molds. A method for increasing the operational resistance of molds for injection molding.*

Keywords: injection molding, mold, non-ferrous metals, forming surface, coating.

During the entire period of operation of the mold for injection molding, processes occur leading to failure of the forming inserts. Therefore, the study of these processes is necessary to improve the performance of the injection molding tool. All the processes passing through the working cavity of the mold can be divided into two components: the chemical and physical interaction of the cast metal with the mold material for injection molding.

As a result of the chemical interaction of the metal of the castings and the mold, various chemical reactions occur, resulting in the formation of hydrides, nitrides and various oxides. These compounds change the composition of the surface layer of the inserts, which leads to an increase in brittleness, as well as to a decrease in ductility and, as a consequence, a decrease in the resistance index of the mold as a whole. The decrease in durability is due to the fact that under the action of a jet of molten metal, the fragile compounds formed from the surface of the inserts are discolored. Another important point is that the rate of chemical reactions increases with increasing melting temperature of the alloys. This can explain the low resistance of molds for die-casting alloys with a high melting point. Nevertheless, nitrogen saturation of the surface layer of rods and liners can slow down the rate of chemical reactions in the working cavity of the mold, which is confirmed by experimental data [1].

In addition to the chemical action from the molten metal, the mold for injection molding undergoes unfavorable physical effects, manifested as diffusion, erosion, cavitation, phase transformations, adsorption-surface effects, hydrodynamic entrainment, corrosion cracking, and corrosion fatigue.

Diffusion in molds for injection molding, manifests itself in the form of sticking and welding of molten metal to the working surfaces of rods and liners. This effect is most pronounced in the casting of aluminum alloys, according to [1], aluminum can diffuse to a depth of up to 7 mm in the body of the forming parts.

The main measures to reduce diffusion are coatings (chromium plating, phosphating, oxidation), as well as chemical-thermal treatment of the surface layer (nitriding, sulfidation, sulfonation). However, these measures can lead to a decrease in the heat resistance of molds.

When choosing metals for liners, one should pay attention to the fact that allotropic and phase transformations can increase the time and residual temperature stresses.

The disruption of the continuity of the flow of the molten flowing fluid manifests itself in the form of bubbles, voids and cavities is described by the concept of cavitation. It occurs when the hydraulic and hydrodynamic pressures exceed certain critical values and lead to a violation of the integrity of the flow. These voids are filled with gases or steam dissolved in the liquid and form cavitation cavities. Moving in a stream of molten metal, cavitational voids and bubbles fall into areas with a pressure exceeding critical values, where they contract and disappear. The reduction of the cavitation cavities proceeds at a high rate and is accompanied by a hydrodynamic impact on the working surface. A lot of such hydrodynamic impacts lead to the destruction of the working layer of the mold. The phenomenon of cavitation is most pronounced when using high inlet and flow velocities of a metal with large specific pressures in areas blocking the flow of molten metal (wall, rod). In most cases, the fracture of the mold occurs in local areas. The most effective way to combat cavitation is to use low inlet velocities and small specific pressures of the flow of molten metal.

By the type of destruction of the surface layer similar to cavitation is the process of metal erosion. However, there are several opinions about the appearance of this effect. Some believe that as a result of friction of abrasive particles, surface chipping occurs, which is called mechanical erosion. Another view is that erosion occurs under the action of cavitation and is called pseudocavitation. Another explanation of the erosion is the result of the friction of the liquid metal on the working surfaces of the molds. However, the destruction from cavitation and erosion is of a local nature and it is extremely difficult to distinguish between them. Nevertheless, with detailed consideration, it is possible to distinguish between the erosion of the metal of the molds and the mesh of the swing.

Possible disruption of the surface layer at the points of impact of the liquid jet against the walls of the mold are the abrasions. This defect is explained by hydrodynamic entrainment or plastic deformation. The difference between these phenomena is that in the hydrodynamic impact, the metal of the forming parts is removed together with the jet, and during plastic deformation near the hollow a certain elevation is formed, that is, the metal moves for some small distance.

Stresses and temperature effects can lead to kaogulation of individual phases, which leads to a change in the mechanical properties of the surface layer. During coagulation, the microstructure of the surface layer is disturbed, layers with different degrees of spheroidization are formed. These layers have a higher hardness, but also an increased index of brittleness, which reduces the life of the mold.

Due to the high-temperature impact on the mold parts, the material of the molds hardens and softens, as well as the processes of recrystallization, recovery, dispersion hardening and aging. All these processes lead to a change in the hardness index of the surface layer of the forming parts, but the hardness value must be strictly in the range 43 ... 48 HRCe. The process of hardening and softening is very difficult and depends on the specific conditions, but in general, when the values of 43 ... 48 HRCe are exceeded, the softening occurs, and vice versa, at low hardness values hardening occurs. The important point is that, the higher the temperature of the working alloy, the more intensively the process of hardening or softening occurs.

At the first pressing, it is possible that cracks appear on the working surfaces of the mold due to adsorption-surface effects (the Rehbinder effect) arising from the interaction of the liquid metal with the solid mold material. If the unfavorable conditions coincide, due to the Rebinder effect, the mold can be destroyed within minutes. Therefore, when the mold is put into operation, it is necessary to monitor the performance indicators for at least a hundred pressings.

Under the influence of corrosive media such as: water, air, gas, steam, cracking can occur due to corrosion cracking. Also, the mold material itself has a corrosive fatigue. Reduction of the effect of this effect is possible due to the application of surface treatment of the working cavity of the mold.

Thus, the destruction of molds is due to the following processes: wear, deformation and thermal fatigue. Reduction of negative impacts from these effects is possible in various ways, the main ones are: application of various coatings, chemical-thermal treatment of the surface layer of the forming parts, selection of the optimal composition of the mold material, and modification of the design and technological parameters of the injection molding process [2]. However, in the general case, it is impossible to determine the most effective method for increasing the resistance index of a mold, but when it is chosen one of the most important conditions is the determination of the physico-chemical effects on the mold material from the molten metal side of the casting.

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