MAIN ASPECTS INFLUENCING THE TECHNOLOGY OF PRECISION CERAMIC MOULDS

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Introduction

The Shaw method is one of less familiar methods of precision casting in ceramic moulds with using of permanent pattern. The method uses special ceramic mixes with increased heat resistance, strength at higher temperatures, low heat expansion and chemical resistance against molten metal [1]. These enable to achieve the prescribed properties as strength, heat expansion, dimension stability, surface quality and resistance to heat changes during casting. Therefore the precision castings produced by this method have high dimensional and shape precision, surface and casted material quality (from metallurgical point of view), without stresses and majority of foundry flaws. [2, 3, 4]. Thus produced precision castings are characterized with majority of their function surface created during casting and solidification in ceramic moulds, because of the ceramic moulds dimension stability and excellent reproduction of precision permanent pattern's details. These pattern must fulfil some specific aspect from the technological, material and application points of view [4, 5]. The produced castings have such surface roughness, size and shape accuracy that the subsequent machining is almost not necessary [3, 6, 7].

The described technology have to fulfil some critical aspects which distincts it from other commonly used technologies of precision ceramic moulds production. The technology is based on production of snap cantilever ceramic mould by using of oversized precision permanent pattern. Its carrier part consists from refractory skeleton and the precision ceramic mould is produced by pouring of ceramic mixture in the space between pattern and the space created by oversized precision pattern in chamotte. The slurry ceramic moulding mixture is poured through the moulding holes in chamotte skeleton. It consists from chamotte ceramic components, liquid binder – ethylsilicate NT – 40 and addition of gelling catalyst, which causes the solidification of ceramic mixture during preset time. This depends on the amount of catalyst and temperature of suspension. The mould is ignited after the removal of precision pattern. Burned out and annealed mould is prepared for casting. This technology is unique between other methods of precision casting, because of specific structure of precision ceramic mould. It depends on gelling process caused by addition of catalyst in ceramic mixture so as on creation of fine microfissures, which resemble on thick spatial net. They are created in the whole volume of precision ceramic mould after its ignition by burning out of alcohol, which is released by hydrolysis of ethylsilicate. The created microfissure net increases the permeability of mould, prevents internal stresses on the walls of mould and simultaneously eliminates the creation of macroscopic cracks and flaws. Thus the mould shrinkage and deformation do not take place, which influences especially the dimensional precision of castings [7, 9]. This method enables economical small-lot production of precision castings (up to 700 kg each [4, 6]) with complex shape, high utilization of casted metals (especially high alloyed steels, special casted high speed steels and tool steels) and low costs on secondary machining [8, 10].

This method is recently not used in Slovak foundries so the aim of this paper is to contribute basic information about technology.

Technology of precision ceramic moulds production

The Shaw method of ceramic mould production is complicated, because of necessity to prepare and process several kind of components and also for some partial techology processes never used in classic foundry technology. The main stages of technology are following:

- technology of carrier chamotte skeleton
- technology of production
- removal of precision patterns from mould
- burning out of precision ceramic mould
- annealing – firing of precision ceramic mould.

The technology of ceramic moulds production is showed on Fig. 1. The chamotte skeleton is produced by mixing of chamotte with particle size 0 – 2 mm (1/3) and 2 – 6 mm (2/3) with water glass (module M = 3,3) with ratio 10 : 1 in vertical rib mixer MJP 50 P during 10 minutes. Thus prepared chamotte mixture is filled in space between mould board, frame in sections and perforated oversized pattern with three gate pins. The mixture is rammed by rammer and the excess is removed by steel bar. After partial releasing of the gate pins and connecting of CO_2 inlet from the bottom of mould board the hardening of chamotte CT mixture begins. The oversized pattern and gate pins removal is followed by chamotte skeleton releasing from frame in sections.

The precision permanent pattern with separator layer (dental wax Ceralent dissolved in trichlorethylene) is placed on mould board by two drived in pins of different diameters. The chamotte skeleton is placed manually or by electric tackle with microlifting on mould board over precision pattern by using its outer contour lined by colour paint on mould board. To keep the uniform gap between precision pattern and chamotte skeleton at assembly, the use of gates created by gate pins is also necessary. At assembly great care is necessary not to crumble the chamotte. The ceramic mould mixture is poured from heigth cca 150 – 200 mm into thus created cavity through gates. The mixture is mixed from ceramic components Fine Face and Standard with ratio 1 : 1 and liquid binder – hydrolyzed ethylsilicate NT 40 with addition of gellatio catalyst (dilute ammoniaacetate) during mixing in such amount taht the mixture gellates during 2 – 2,5 minutes. This time was experimentally established as optimal, however the end of gellation can be established manually in gates. After the gellation the chamotte skeleton with ceramic mould and mould board is turned around and the mould board is removed by tapping. Afterwards the plane of division is levelled.

On thus prepared bottom part of chamotte skeleton the special lifting device of precision patterns is placed and centered. It is designedso that the deformation and jamming of the pattern is avoided. The lifting device have to secure precise guiding. The lifting of its working board have to be uniform on each guide post. The uniform lifting is secured by precise trapezoidal threads. When the precision pattern is lifted by lifting device from ceramic mould to such heigth that damage of mould cavity shape is not possible, the lifting device with pattern can be taken away from chamotte skeleton to working stool. The top part of precision ceramic mould is made by similar process, only instead of oversized and precision pattern the oversized and precision pattern of feeding gates are used. Through those the assembled moulds are filled. The ceramic mould is ignited by flame torch after the removal of precision model to secure the fastest possible burn out of alcohol in ceramic mould. Belated ignition can cause the creation of macroscopic cracks which decrease the strength of the mould. The ignition must begin in the bottom of the mould, so that the burning flame gradually ignites the whole area of mould and thus creates the microfissure net in the whole volume of the ceramic mould. When the all free alcohol is burned out, which is displayed by selfextinction of the flame, the mould is placed into annealing chamber furnace (900 – 950 °C during 4 hours). There the last remains of alcohol and possible humidity are evaporated. The top part of mould is similarly thermally treated (ignited and annealed). At last both parts of mould are assembled, loaded and casting can take place (either in cold mould or preheated on 450 – 500 °C).

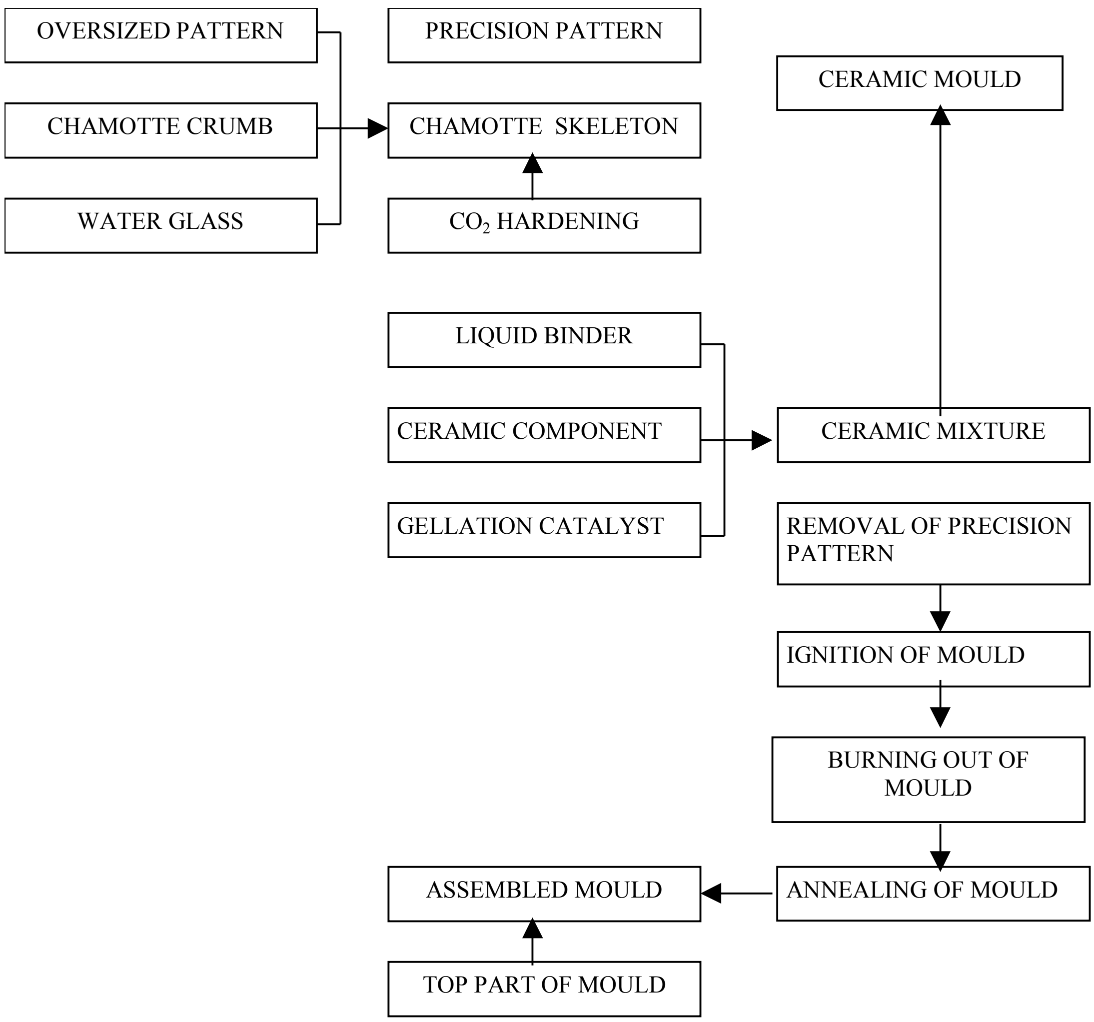

Fig. 1 *The technology of ceramic moulds production*

Conclusion

The experiments proved that keeping the crucial aspects of production technology enables the production of ceramic moulds of required quality, precision of dimensions and cavity shapes. In recent time with increased requirements on material, energy savings and technology steps reduction this technology can be used in every foundry if producent knows what can be produced cost effectively and what not. He must also have the required equipment, devices, high-quality materials and qualified personnel. The more complex the shape of precision casting is the savings on secondary machining and material costs are higher.

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