Development of the foundry powder coatings for chill mold

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Abstract: The economic efficiency of producing castings in permanent metal molds (chill molds) is largely determined by their durability. Failure of the chill mold occurs due to the formation of cracks and gas corrosion on its internal surface which is in contacted with liquid alloy many times. During the pouring period of the chill mold by the alloy, its internal surface and nearby layers very quickly heat up to high temperatures, while other layers located further from the internal surface heat up more less. Compressive and tensile stresses may arise in the chill mold as a result. Various plastic deformations of the chill mold material can lead to the formation of small cracks or crack grid. As a result, quality of the casting surface is deteriorated and problems arise associated with removing the castings from the chill mold. Also, its contributes to further destruction of the chill mold from gas corrosion. In recent years there is various trend in foundry coating technology such as developing of anti-defect coating (for example anti-veining coating), developing of ecological friendly coating (water-based coating), developing of non-zircon coating and etc. In our opinion one of the potential and promising area of research in foundry coating development is powder coating technology.

Keywords: chill mold; powder foundry coating; refractory materials; casting quality; obtaining method.

1 Introduction

Various types of coatings have been very spread in different areas such as friction reduction, corrosion protection, wear resistance, self-cleaning, antifouling etc. Implementation Foundry is an industry which is widely implemented refractory coatings or foundry coatings and its allows a number of beneficial effects during casting.

The use of foundry coatings for molds and cores during casting is very necessary as a means of achieving high quality surface finish of castings more especially in complex internal channels created by use of cores [1]. Foundry coating eliminates the direct chemical interaction between casting alloy and material of the mold as well.

However, the main role of the foundry coating layer is the ability to create a certain, predetermined thermal resistance at the contact zone between casting and mold.

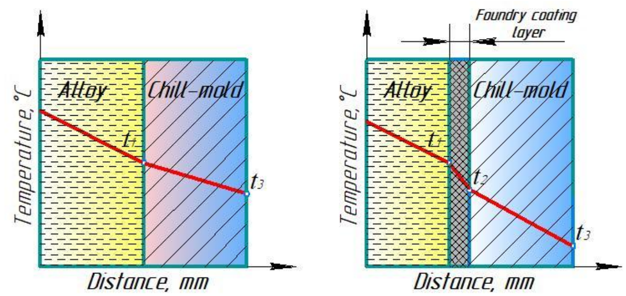

Fig. 1 Temperature distribution in the chill-mold with and without foundry coating

It's an excellent ability to regulate the amount of heat transferred from the casting to the mold (Fig. 1). The thermal resistance of the foundry coating affects to the skin casting formation and the mold as well. On the one hand, the presence of thermal resistance may lead to decrease of the cooling intensity and drop of temperature in the casting cross section. The presence of thermal resistance may lead to decrease of the cooling reduction of the physicochemical reaction at the metal-coating interface.

Research was carried out within the framework of this work and aimed to develop the technology of foundry powder coatings manufacturing, their application to the casting mold is carried out by electrostatic methods and the formation of strength (hardening) occurs due to polymerization when heating the thermosetting resins (binders) included in their composition.

2 Experimental procedure

The main stages of the research consisted of the investigation the coatings ability to form a protective layer of the required thickness on the surface of chill-mold, research and identification of strength models formation of the foundry powder coatings, investigation of the adhesive ability of foundry powder coatings and development of optimal modes and parameters of the application process (electrostatic coating) of chill molds.

The manufacturing of foundry powder coatings was carried due to laboratory extruder according to a pre-calculated recipe (Fig. 2).

Fig. 2 Laboratory extruder for foundry powder coatings manufacturing

Powdered highly refractory fillers such as kyanite-sillimanite and cryptocrystalline graphite were used for manufacturing of coatings. It's traditionally used in the manufacture of liquid refractory coatings, but at the same time its characterized by opposite physical-chemical and electrical properties. During the preparation process, simultaneously with mixing, the highly refractory filler and additives were clad with a thermosetting binder. At the next step, a homogeneous composition of highly refractory filler, additives and binder in the form of plates was ground and dispersed into fractions. The coarsely dispersed fraction (more than 70 µm) was returned to the attritor for repeated grinding. Next, foundry powder coatings were used for testing.

3 Result and discussion

Experiments results of the abrasion strength investigation have been established polyester resin optimal content which is necessary for creating required layer on the surface of chill-mold. It was established (due to mathematical processing of experimental data) that polyester resin content (C) influences on abrasion strength (σ) of foundry powder coatings as a one of the determining parameters according equations (1) and (2).

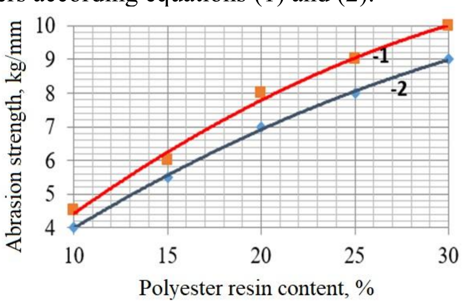

Fig. 3 Abrasion strength of kyanite-sillimanite (1) and cryptocrystalline graphite (2) foundry powder coatings

Polyester resin provides an inextricable connection between particles of highly refractory filler and affects other strength characteristics and when the percentage content of polyester resin increases from 10 to 30%, the abrasion strength increases proportionally from 4 kg/mm to 9 kg/mm for a coating based on kyanite-sillimanite and from 4.5 kg/mm to 10 kg/mm for cryptocrystalline graphite (Fig. 4).

$$\sigma_1 = 0{,}0057C^2 + 0{,}5086C - 0{,}1 \quad (1)$$

$$\sigma_2 = 0{,}0043C^2 + 0{,}4214C + 0{,}2 \quad (2)$$

It was also found that with an increase in layer thickness (δ) from 250 µm to 805 µm, the adhesive properties (A) deteriorate from 5 to 3 points for both types of coatings (Fig. 5).

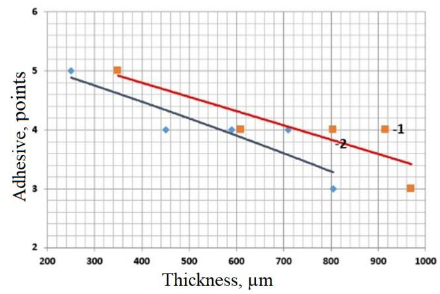

Fig. 4 Adhesive properties of kyanite-sillimanite (1) and cryptocrystalline graphite (2) foundry powder coatings

Mathematical processing of experimental data made it possible to obtain equations (3) and (4) as well.

$$A_1 = 07\,\delta^2 - 0{,}0025\,\delta + 5{,}5267 \quad (3)$$

$$A_2 = 08\,\delta^2 - 0{,}0024\,\delta + 5{,}7479 \quad (4)$$

Equations describe the changing of foundry powder coating adhesive properties based on kyanite-sillimanite and cryptocrystalline graphite fillers.

4 Conclusion

Powder coatings technology develops rapidly and has great potential for wide implementation in foundry industry. The foundry powder coatings can greatly reduce the packaging and transportation costs of the coatings because it does not contain solvent. The global safety regulations will be more strict, and the safety requirements for the production, transportation, and storage of flammable and explosive dangerous materials will be increasing, which will also greatly increase the transportation cost of alcohol-based foundry coatings and will greatly encourage the widespread application of foundry powder coatings. Also, it is very important for environmental friendly and safety trends in foundry industry because the foundry powder coatings is free of toxic chemicals and solvents, it's may deemed safe for future use and disposal.

References

[1] Nwaogu U.C., Tiedje N.S. Foundry Coating Technology: A Review. Materials Sciences and Application, 2011, 2(8): 1143-1160.