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GRANULARLY UNBIND MATERIALS FOR CASTING COMPOSITE MOULDS

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ABSTRACT

This paper present some partial result based on this idea (of pollution prevention) the domain of making composite-casting moulds (in time of casting, solidifying, and alloy cooling). Casting process impose temporary or permanent moulds in classical approach, capable to assure the liquid alloy flow and cooling. The moulds made by bound mixtures are considerer the most dangerous sources in foundries. Initially the mould is made only by gasified model and dry siliceous sand, the casting of the alloy concomitant with the thermo-destruction of the model and decomposing the products of thermo-destruction , filtering through the mould wall it makes possible realization the mould composite- siliceous- graphite, favorable the process of interface metal-mould. The elimination of the binder and of the separation plane, the raising of thermal conductivity of the mould and even the retention of thermo-destruction products in inter-granular spaces could be a solution to minimize the contamination in foundry

KEYWORDS: pollution prevention, composite, casting moulds

1. Structure of a composite mould at casting with gasified model

The principle of casting technologies that use gasifiable models is simple and consists in model obtaining from an expanded synthesis material, covered with a refractory material (in a container) and the refractory material consolidation (Figure 1).

There are peculiar problems at gasifiable model casting, comparing with casting in chills or classical one. In this case the gating has to assure two essential conditions:

- correct filling of the mould cavity with liquid alloy;
- optimum gasification of the model and quick evacuation of the gases resulted by thermal-destruction of the model.

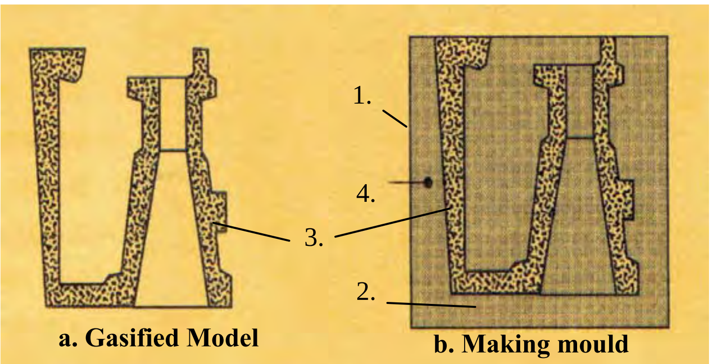


***Fig.1.** Making a full mould with gasified model. 1. Forming tank; 2. Sand bed; 3. Gasified model; 4. Consolidation sand.*

Thermo-destruction of casting mould lead to the appearance of the graphite flake with alongside with granularly unbind sand, making the composite of the casting mould.

2. Method theoretical fundamentation

Duration of the model thermal-destruction phenomenon is about few seconds, depending on melted alloy temperature, and size and model density. The importance of this phenomenon optimization is decisive with implication on quality part and specific fabrication. In figure 2 is presented the manner where the liquid alloy act over the gasified model in time of thermo-degradation and in figure 3 is sketch the filtering of the thermo-destruction products through form wall. Here is presented the variation mode of the main parameters, depending on the metal alloy flow velocity. Practically this principle stays at base “filling” of full mould, being the critical stage in obtaining of a quality piece.

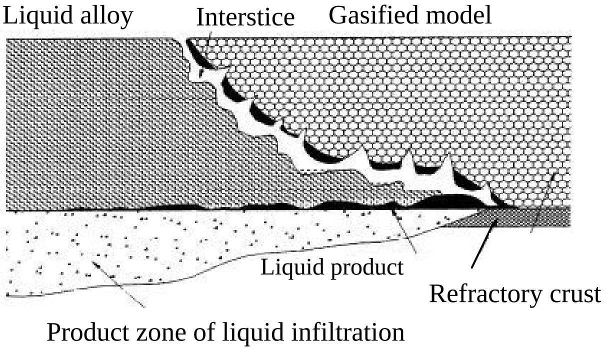


Fig. 2. *Thermo-destruction of model and filtering the gaseous product in mould*

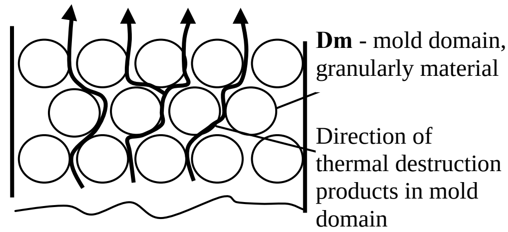


Fig. 3. *Flowing itinerary of thermal destruction products*

Determination of the volume of gases resulted by materials models thermal-destruction can be done with equation 1:

$$Q = a \cdot S \cdot t_{top}^{m} \tag{1}$$

where: **Q** is the volume of thermal-destruction gases; **a** is the coefficient of gasification process, proportional to the irradiation surface of model and the irradiation duration, in m3/m2×sm; it’s values are in the range (17.2…37.6)×10-2m3/m2×sm depending on the (calculated) velocity of cavity filling with alloy, in the range 4.00…17.30×102m/s; **m** is a coefficient that takes into account the gasifiable polystyrene characteristics; it is dimensionless and has values in the range 0.824…0.553.

It is necessary to know the permeability level of the granular material columns that form the mould with gasifiable model, because this must be correlated with the volume of the resulted gases from thermal-destruction.

Permeability determination can be done with classical apparatus (with few accessories) existing in usual laboratories for molding sand analyses.

The permeability value can be calculated with:

$$P = \frac{V \cdot h}{A_o \cdot p \cdot t} \tag{2}$$

where: **P** is the permeability value; **V** is the air volume that passed through sample, in cm^3 (usually 2000 cm^3), **h** is the sample height, in cm (usually 5 cm), $\mathbf{A_0}$ is the surface area of sand sample, in cm^2 (usually 19.66 cm^2), **p** is the pressure difference between the two plane surfaces after t time, in cm (water column height) – can be read from manometer, **t** is the necessary time for air volume crossing through sample, in minutes.

3. Interface process at casting with gasified models

Technological elements can be classified in some domains: the mould domain, D_m – sand, the gasifiable model domain, D_{gm} – cellular polystyrene, liquid alloy domain, D_a – aluminum alloy (see Figures 4, 5, 6). The model domain and the alloy domain modifies in time, from the moment of pouring to the moment of complete filling and solidifying of the part, the liquid alloy taking the place of the model that is gasified. The interfaces and the domains are variable in time.

The gasifying process duration is short and directly depending on the model size, density and thermo-physical properties.

The interstice may vary between 5-8 mm and consist in a mixture of polystyrene de-polymerization products.

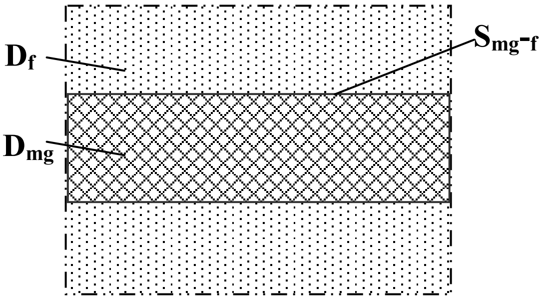


Fig. 4. *Technological element that participate, before pouring (in which S_{mg-f} is the surface or frontier among model and sand)*

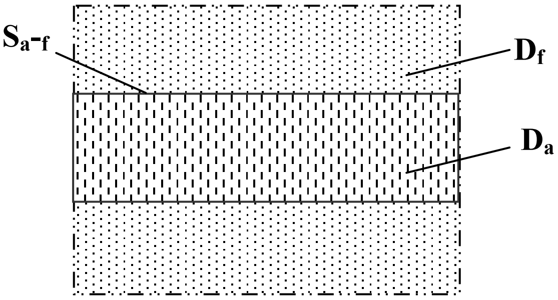


Fig. 5. *Technological element that participate, at complete filling of the form (in which S_{a-f} is surface or frontier among alloy and sand*

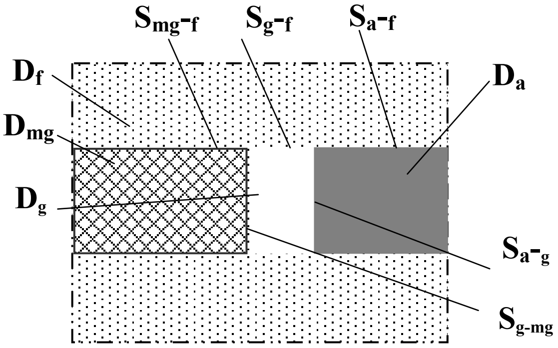


Figure 6. *The variation of technological elements that participate at the process of gasification models to the contact with liquid alloy*

Symbols:
S_{a-g} = liquid alloy – gas interface,
S_g = gas – gasifiable model interface;
S_{mg-f} = gasifiable model – mould interface;
S_{g-f} = gas – mould interface;
S_{a-f} = liquid alloy – mould interface;
D_g = interstice domain.

Their state of aggregation is different:
Solid – brown-russet pyrolysis carbon in flakes or ashes;
Liquid – brown-russet;
Gas – identified in the working environment.

Fig. 7. *Thermal-destruction products in sand around the cast part*

4. Experimental result

In order to reveal the pyrolysis graphite resulted from polystyrene thermal-destruction, we used an experimental installation (fig. 8). Pyrolysis graphite was collected on a metallic support (fig. 9). There was obtained a crust of from pyrolysis graphite on the metallic support. In the case of casting moulds, the resulted pyrolysis graphite by thermal-destruction of the model will depose on sand granules. Pyrolysis graphite retaining on sand granules (fig. 7), during casting process accordingly with the thermal destruction of gasifiable model determines the realization of a composite layer at the interface metal/mould, composed by sand granules sand and pyrolysis graphite flakes. This phenomenon favors a behavior specific to filled moulds made of granularly unbind material. So, during casting it is accomplished a reducing atmosphere in mould cavity and also changes mould behavior to thermal flux transfer.

Fig. 8. *Experimental installation for pyrolysis graphite revealing as a result of gasifiable model thermal destruction: a) equipment for process parameters control; b) detail of experimental installation.*

Figure 9. *Pyrolysis graphite layer resulted from thermal destruction of polystyrene: a) aspect of the pyrolysis graphite layer resulted from thermal destruction of polystyrene;b) aspect of the deposit of pyrolysis graphite on holde;1- holder for pyrolysis graphite collection; 2- aspect of the pyrolysis graphite deposit*

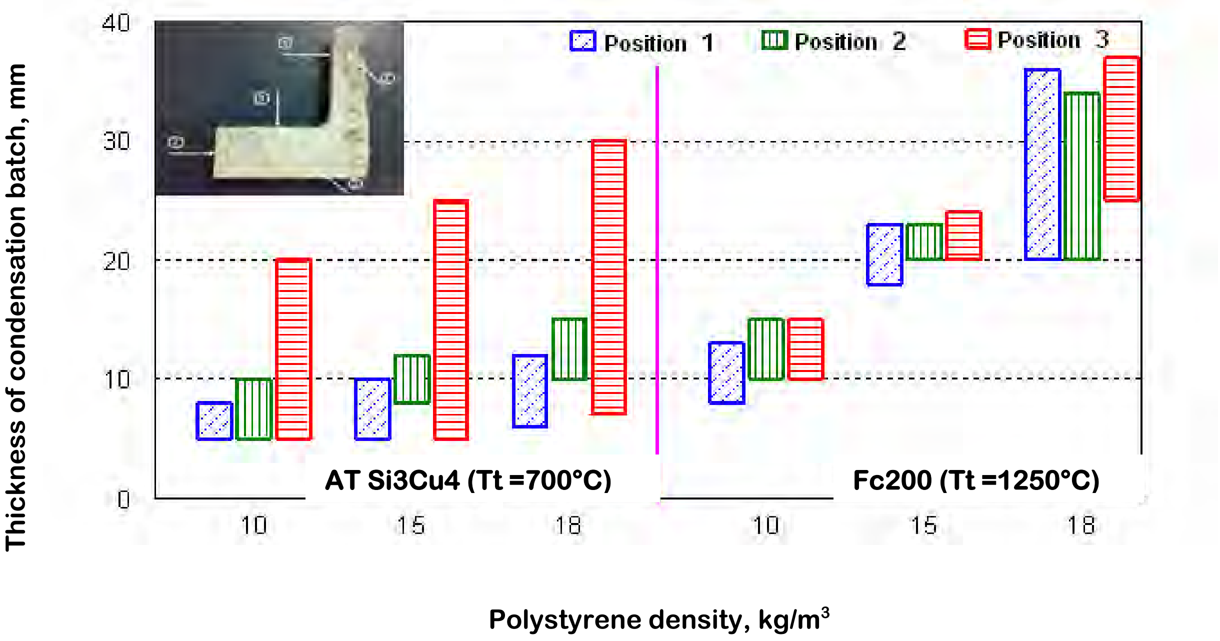


Fig. 10. *Casting temperature influence on polystyrene density.*

Laboratory experiments has followed the putting in evidence the composite thickness batch from full mould utilized at casting and the dependence of this by different agents, as casting temperature (nature of casted alloy), duration of mould cooling after casting, the position of the wall form regarding the front filtering gases. In figures 10, 11 are presented experimental laboratory result in this domain.

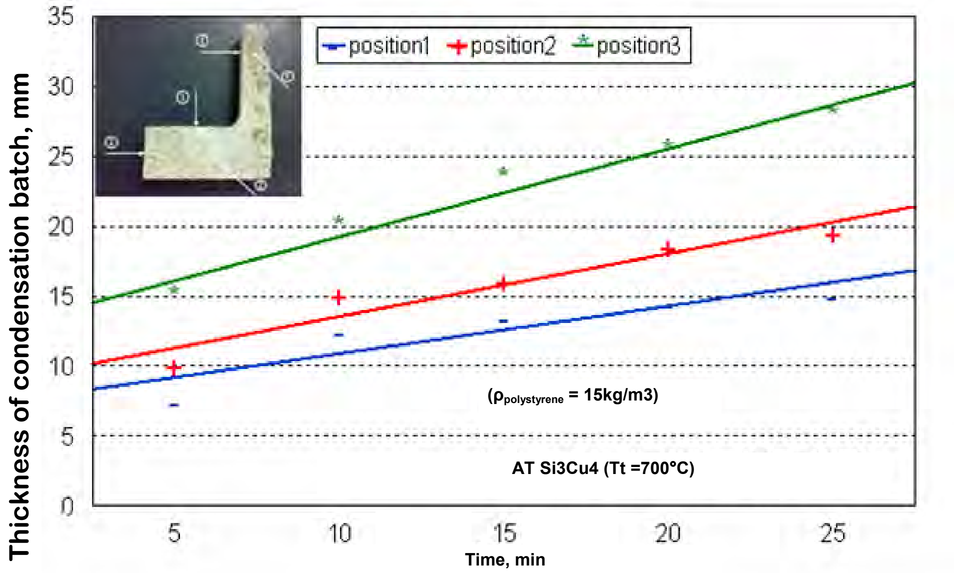


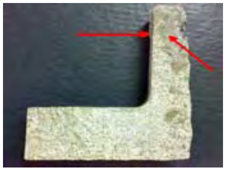
Fig. 11 *Influence of cast part cooling time on condensation batch thickness (different positions in mold: 1-beside the horn gate, 2-beside the part, 3-above the part).*

In table 1 and 2 are presented values of composite batch thickness in situation of changing polystyrene density and position in mould.

Table 1. *Values of composite batch thickness at casting aluminum (700^{o}C) and grey cast iron (1250^{o}C) for various density of model.*

						
Position	(position 1)	(position 2)	(position 3)	(position 1)	(position 2)	(position 3)
ρ, kg/m^3	Batch thickness, (aluminum), mm			Batch thickness, (*grey cast iron*), mm		
0	5-8 / 6.5	5-10 / 7.5	5-20 /12.5	8-13 / 10.5	10-15 /12.5	10-15 / 12.5
15	5-10 / 7.5	8-12 / 10	5-25 / 15	18-23 /20.5	20-23 /21.5	20-24 / 22
18	6-12 / 9	10-15/12.5	7-30 /18.5	20-26 /23	20-34 / 27	25-36 / 30.5
22	10-15 /12.5	10-18 /14	10-35 /22.5	-	-	-

Table 2. *Values of composite batch thickness at casting aluminum (700^{o}C) for various intervals of time for cooling the piece in mould.*

Position Time, min	 (position 1)	 (position 2)	 (position 3)
	Batch thickness, (aluminum), mm (ρ=15 Kg/m^3)		
5	5-10 / 7.5	8-12 / 10	5-25 / 15
10	10-15 / 12.5	10-20 / 15	10-30 / 20
15	10-17 / 13.5	10-22 / 16	15-32 / 23.5
20	10-19 / 14.5	12-25 / 18.5	17-34 / 25.5
25	10-20 / 15	12-27 / 19.5	20-36 / 28

5. Conclusion

Experimental observations revealed that the mould walls retain the condensed thermal-destruction products, resulting the composite mould.

The technological behavior of such mould at the alloy-mold interface and the reducing atmosphere that forms into the cavity of the mold confirm the composite mold status, with a reducing atmosphere during casting.

The experimental research revealed enough thickness for the impregnated layers with thermal destruction products, those layers thickness was about 5…30mm. Such a thick layer is capable to assure a behavior very similar to metallic molds (high cooling rates), an overpressure of the alloy during solidification, and a very good protection against oxidation,

The presence of pyro-graphite al interface metal-mould modified the humectation angle in way of diminution the capillary effect due to mould porosity.

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