

SOME ASPECTS OF HEAT TRANSFER FROM THE CAST TO THE MOULD

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Abstract: In the foundries is very important to understand and to control the transfer of the heat from the cast to the surface of the mould. This paper is an attempt to present some aspects concerning the transfer of the heat from the cast to the surface of the mould when appears a clearance or not.

Keywords: liquid alloy, sand mould, heat transfer, conduction, convection, clearance, time of formation of clearance.

1. INTRODUCTION

The thermodynamic system made from liquid alloy and the mould is changing the heat in accordance with the fundamental laws of the thermodynamics. The process is complex but it may be studied by separating in elementary heat transfer processes: conduction, convection and radiation.

In this paper it is trying to present some aspects concerning the mechanisms of the heat from the cast to the surface of the mould.

2. MECHANISM OF HEAT TRANSFER

The heat transfer in the wall of the cast is made by conduction, from one grain to another., following the Fourier law:

$$\frac{dQ}{dt} = -\lambda \cdot dS \cdot \left(\frac{\delta T}{\delta x} \right) \quad (1)$$

where: dQ/dt is the heat flux, in J/S=W;

λ – the coefficient of heat conduction, in W/m · K;

dS – the heat exchange surface, in m²;

$\delta T / \delta x$ – the temperature gradient, in K/m.

During the pouring of the liquid alloy takes place, also, the heat transfer by convection, from the jet of liquid alloy to the air, following the law:

$$dQ = \alpha_c \cdot (T_c - T_m) \cdot dS \quad (2)$$

ou:

$$Q = \alpha_c \cdot (T_c - T_m) \cdot S \quad (3)$$

where: Q is the heat quantity transfered by convection;

α_c – the coefficient of transfer by convection;

T_c, T_m – the temperature of cast, respectively, of the mould;

S – the surface of the heat exchange.

The transfer by radiation takes place during the filling of the mould cavity with liquid alloy (fig. 1). After the ending of the pouring and the appearing of the clearing, the transfer of the heat by radiation is made inside clearance. (fig. 2).

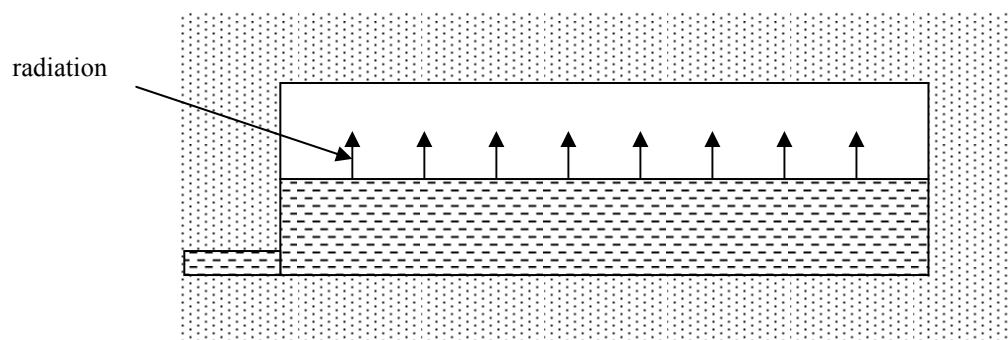


Fig. 1. The transfer by radiation during the filling of the mould cavity with liquid alloy

The heat quantity (Q) transfered by radiation is determined by the following relation:

$$Q = \varepsilon_{c-m} \cdot C \cdot \left[\left(\frac{T_c}{100} \right)^4 - \left(\frac{T_m}{100} \right)^4 \right] \quad (4)$$

where: ε_{c-m} is the emissivity coefficient between cast and mould;

C – the radiation constant of black objects;

T_c – the absolute temperature of the cast;

T_m – the absolute temperature of the mould.

In the case of when the upper surface of the mould cavity is horizontal, the emissivity coefficient is determined by the following relation:

$$\varepsilon_{cm} = \frac{1}{\frac{1}{\varepsilon_c} + \frac{1}{\varepsilon_m}} \quad (5)$$

The values of the emissivity coefficient for some melted metals and alloys are given in table 1.

The values of the emissivity coefficient for some melted metals and alloys. Table 1.

Metalic material	Emissivity coefficient
Melted aluminium	0,039...0,057
Melted copper	0,11...0,13
Melted lead	0,057...0,075
Melted steel	0,28
Melted pig iron	0,29...0,30

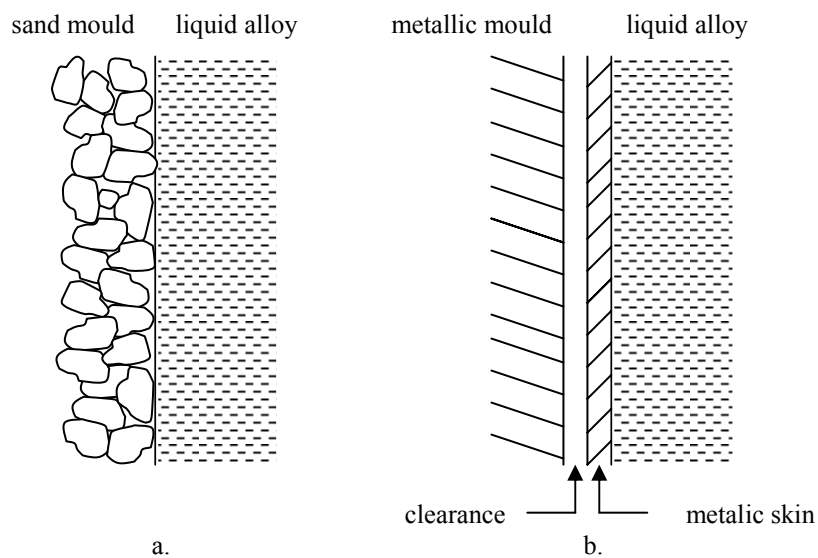


Fig. 2. The transfer of the heat by radiation inside clearance:
a. sand mould; b. metallic mould

The radiation transfer may be diminished if the mould is inclined (fig.3).

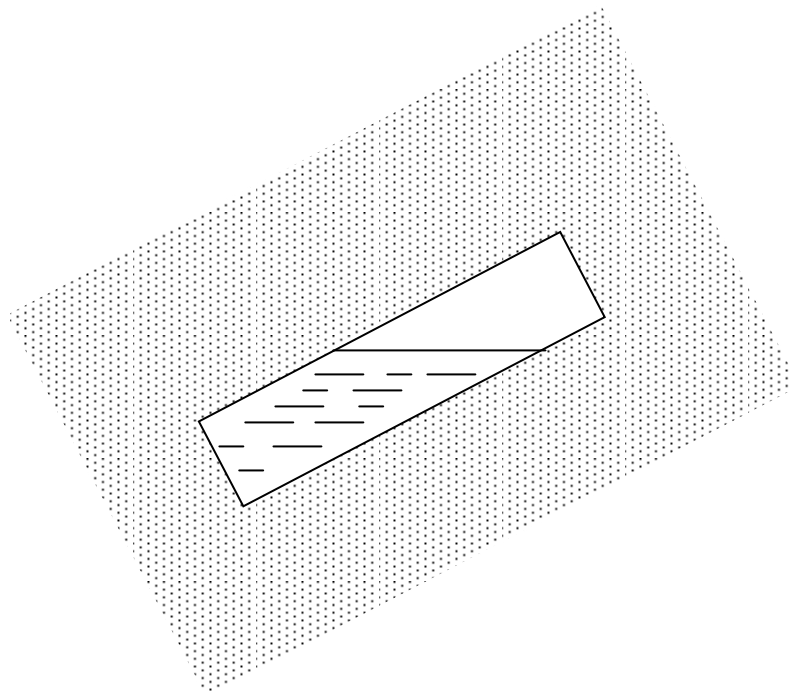


Fig. 3. The diminishing of the radiation transfer when the mould is inclined

During the pouring, the radiation transfer and the convection transfer are preponderant.

After the mould is filled, the heat transfer from the alloy to the mould is made by two ways:

- convection;
- conduction.

The heat transfer from the surface of the cast to the surface of the mould may be made in two cases:

- when between the cast and the mould does not appear clearance (fig. 2.a); the heat transfer is made by conduction;
- when between the cast and the mould appears clearance (fig. 2.b); the heat transfer is made by convection, but mainly by radiation.

The flux of heat transferred by radiation in the clearance (q_{cl}) is given by the following relation:

$$q_{cl} = \varepsilon_{cl} \cdot C \cdot \left[\left(\frac{T_c}{100} \right)^4 - \left(\frac{T_m}{100} \right)^4 \right] + \frac{\lambda_{cl}}{x_{cl}} \cdot (T_c - T_m) \quad (6)$$

where: x_{cl} is the dimension of the clearance;

λ_{cl} – the conductivity coefficient of the clearance;

3. CONCLUSIONS

The heat transfer during obtaining a cast is made by conduction, convection and radiation. To make prediction of the temperature of the cast is necessary to determine analitically the temperature field.

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