SOME ASPECTS OF THE SRESSES APPEARING IN THE CASTS

SIMIONESCU GHEORGHE, CIUCESCU DORU

University of Bacau

Abstract: In the foundries is very important to understand and to control the stresses appearing in the casts. The stresses conduct to cracks, wherefrom the importance of the phenomenon. This paper is an attempt to present some aspects concerning the appearing of the stresses in the casts.
Keywords: shrinkage, elongation, compression, temporary stresses, residual stresses, mechanical stresses, thermal stresses, elastic state, plastic state, cracks.

1. INTRODUCTION

The appearance of the stresses in the casts is due to the braking of the shrinkage during the cooling. The stresses conduct to cracks. For this reason is very important to understand and to control the stresses appearing in the casts. This paper is an attempt to present some aspects concerning the appearing of the stresses in the casts.

2. STRESSES IN THE CASTS

In function of of the duration of their existence, the stresses in the walls of the casts may be of two types: temporary and residual. The temporary stresses determine in the alloy only elastic deformations that, after the cooling of the casts and the equalizing of the temperature, they are canceling theirself. The residual stresses determine in the alloy plastic deformations that do not disappear after the cooling of the casts and the equalizing of the temperature.
In function of the cause of the appearance, the stresses may be mechanical and thermal stresses.

2.1. Mechanical stresses

The mechanical stresses are produced due to the mechanical braking of the shrinkage at high temperatures. The mechanical braking may be provoked by the mould, cores, and elements of the feeding system or by feeder head. In the case of the piece from the figure 1, will be a brake of the shrinkage due both of the cores and of the sand placed between the flanges.

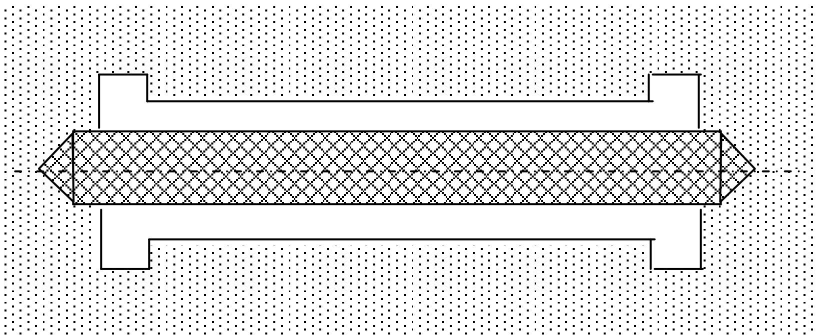

Fig. 1. The scheme to illustrate the braking of the shrinkage at a jack with flanges.

As a result of the braking process due to the mould, in the walls of the cast appear extension stresses, called mechanical stresses. This stresses may have very great values at metallic moulds.

The mechanical stresses a proportional with the coefficient of linear shrinkage α_1, with the modulus of elasticity E and with the difference of the temperature ($T_E - T_0$) and may be calculated by the relation:

$$\sigma = \alpha_1 E \, (T_E - T_0) \tag{1}$$

where: T_E is the temperature where the alloy pass from the plastic state in elastic state;
T_0 – the temperature till where the cast is cooled.

If it is considered that the plastic deformation and the compressibility of the mould are appreciated by the relative value of the rate ΔL / L (where L is the length of the cast between the flanges), then it is obtained:

$$\sigma = E \left[\alpha_1 (T_i - T_f) - \frac{\Delta L}{L} \right] \tag{2}$$

where: T_i is the initial temperature;
T_f – the final temperature.

The criterion of the mechanical stress is the comparison between the braked linear shrinkage and the free linear shrinkage:

$$\varepsilon_{lf} = \varepsilon_{lbr} + \varepsilon_{def} \tag{3}$$

where: ε_{lf} is the free linear shrinkage;
ε_{lbr} – the braked linear shrinkage;
ε_{def} – the deformation.

2.2. Thermal stresses

The appearing of the thermal stresses may be put in evidence taking into consideration the cooling of two bars with different widths S_1 and S_2 linked jointly each other (fig.2).

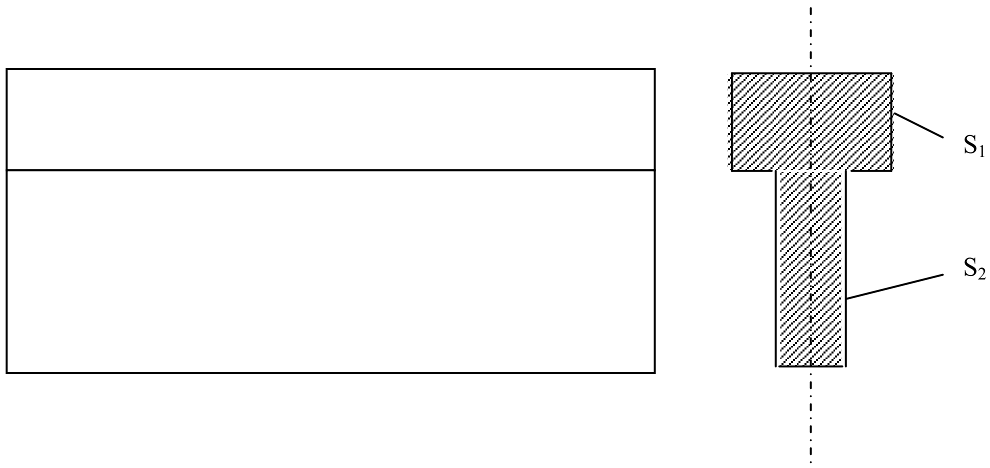

Fig. 2. A system with two bars linked jointly each other.

In the figure 3 are presented the cooling curves of the bars with widths S_1 and S_2. From the figure it is observing that, the thinner wall is cooling faster (curve 2) than the other wall (curve 1). During the cooling, between the two bars appears a difference that increases till a certain value and after decreases at zero.

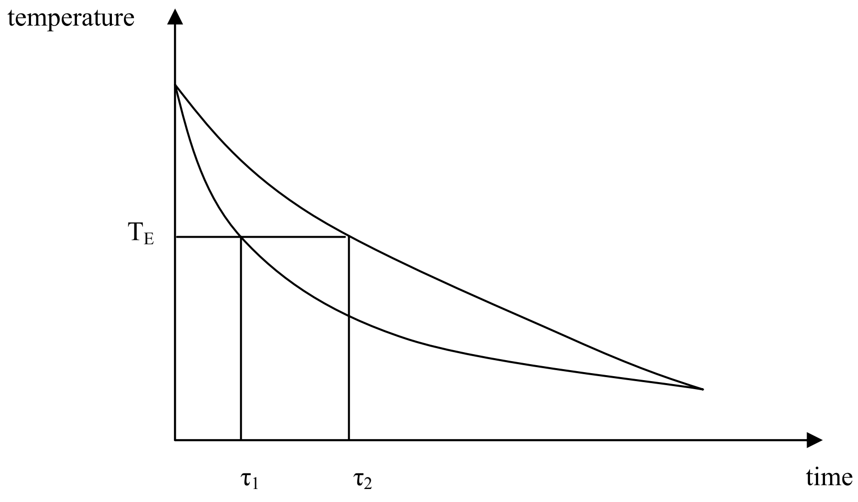

Fig. 3. The cooling curves of the two bars linked jointly each other.

If it is marked with T_E the temperature at which the alloy passes from the plastic estate to the elastic estate (fig. 3), than it is to be observed that the walls pas through this temperature in different moments. The bar 1 passes at time τ_1 and the bar 2 at the time τ_2.

To appreciate the shrinkage of the cast it may make the following remarks: 1) the beginning of the linear shrinkage T_{bsh} is the same in the whole width of the wall; 2) the phase transformations do not happen; 3) the coefficient of linear shrinkage α_1 is constant.

In this case, the length of the cast at a certain temperature $T < T_{bsh}$ is given by the relation:

$$l_i = l_0 \left[1 - \alpha_1 (T_{bsh} - T) \right] \quad (4)$$

To this length is corresponding the following linear shrinkage

$$\varepsilon_{lb} = \frac{l_0 - l_b}{l_0} = \alpha_1 (T_{bsh} - T) = \alpha_1 \Delta T \quad (5)$$

It is possible, also, to represent the elongation in function of time (fig.4).

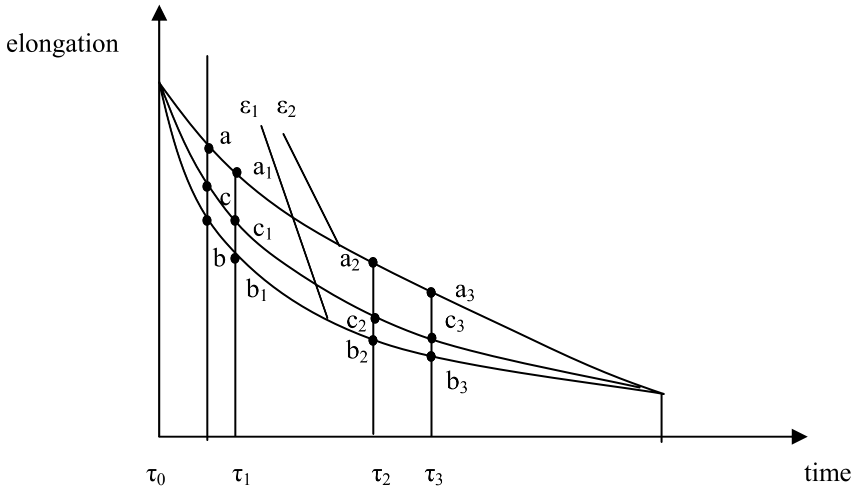

Fig. 4. The shrinkage of the two bars linked jointly each other.

Following the cooling of the two bars, it may be distinguished the stages:
-stage 1, when $t < t_1$: the both bars are in plastic estate;
-stage 2, when $t_1 < t < t_2$: the bar 1 is in elastic estate and the bar 2 in plastc estate;
-stage 3, when $t > t_2$: the both bars are in elastic estate.

The total value of deformation for the bar S_1 is as follows:

$$\varepsilon_1 = \alpha (T_1 - T_2) \frac{S_2}{S_1 + S_2} \tag{6}$$

Also, the stress of elongation is as follows:

$$\varepsilon_1 = E \alpha (T_1 - T_2) \frac{S_2}{S_1 + S_2} \tag{7}$$

In a similar way for the bar S_2:

$$\varepsilon_2 = \alpha (T_1 - T_2) \frac{S_1}{S_1 + S_2} \tag{8}$$

Also, the stress of elongation is as follows:

$$\varepsilon_2 = E \alpha (T_1 - T_2) \frac{S_1}{S_1 + S_2} \tag{9}$$

3. CONCLUSIONS

The thermal stresses are proportional with modulus of elasticity, the coefficient of shrinkage and with the difference of temperature.

In the thicker walls the stresses are of compression and at thinner walls the stresses are of compression.
The stresses are as greater as the difference of the thick of the walls is greater.

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