RESEARCH STUDIES ON THE NUMERICAL APPLICATON OF THE WEAR PARAMETER AT THE CONTINUOUS CASTING MACHINE CRYSTALLIZER

Vasile Bratu

University Valahia of Targoviste, Bd. Carol I, Nr. 2, 130024, Targoviste, Romania

Email: v_bratu22@yahoo.com

Abstract: *This paper summarizes the results of the numerical applications at industrial level for the wear parameter and also shows its evolution under the influence of the main technological parameters*

1. INTRODUCTION

The occurrence of the surface defects or the shape defects of the continuously casted small size semi-products are due mostly to high usage levels of the crystallizer [1]. The longitudinal crack on the edge, star cracks and even the section deformation specific to the small squared sections (which may become rhombic) are due to high usage levels of the crystallizer [2].

The longitudinal cracks on the semi-product while leaving the crystallizer may lead to the thread piercing and even to the breakdown of the continuous casting.

While drawing up the industrial correlations and establishing the parameter implications on the quality of the continuous casted billets at S.C. MECHEL S.A. the large share of defects due to advanced wear of the crystallizer was found.

Some of these were even the causes of the breakdowns (thread piercing). Therefore, we propose ourselves drawing up a numerical application at industrial level in order to achieve:

- continuous monitoring of the working side of the crystallizers;
- avoiding the surface defects due to the high usage levels of the crystallizers;
- avoiding the breakdowns due to the occurrence of the surface defects from the crystallizer.

2. DRAWING UP THE NUMERICAL APPLICATION AT INDUSTRIAL LEVEL

To draw up the numerical application relation (1) is used, by which we establish the thickness of the Cu board [1]:

$$\delta_{Cu} = \lambda_{Cu}\left(\frac{D_a}{\lambda_a^3}\right)^{0,2} \cdot \left(\frac{\eta_a}{V_a^2 \cdot C_{pa}}\right)^{0,4} \cdot \frac{T_S - T_2}{T_2 - T_{am}} \quad (1)$$

where:

δ_{Cu}- the thickness of the crystallizer wall;

λ_{Cu}- the thermal conductivity of the crystallizer wall;

λ_a – water thermal conductivity;

D_a – the equivalent diameter of the flow channel;

V_a - specific mass flow of the water;

η_a – dynamic viscosity of water;

C_{pa}- specific heat of the water.

T_2 – the temperature of surface 2;

T_s – the temperature of the solidified alloy;

T_{am} is the average temperature:

$$T_{am} = \frac{T_e + T_i}{2} \qquad (2)$$

where: T_e – water temperature at the output of the crystallizer;

T_i – the water temperature at the input of the crystallizer;

In order to have a more explicit image of the wear of the copper tube, the wear parameter of the crystallizer will be calculated as the difference between the initial thickness of the copper tube and its thickness at the calculation moment.

$$P_{uzură} = \delta_{Cui} - \delta_{Cu} \qquad (3)$$

To draw up the numerical application of the wear parameter at industrial level we considered the data collected from the continuous casting machine crystallizer from S.C. MECHEL S.A.

Based on the mathematic model equations [1] for the calculation of the parameter δ_{Cu} we draw up a series of computer program calculations in VISUAL C ++ and a graphic interface: "Crystallizer wear parameter "[3] shown in figure 1.

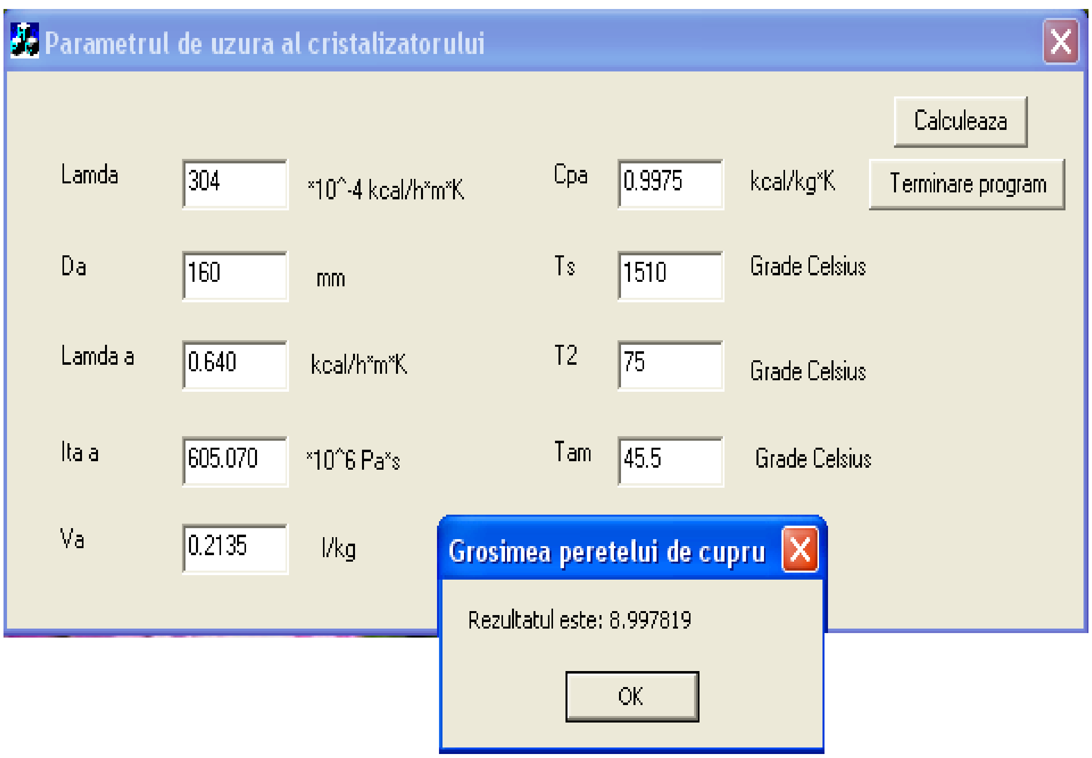

Fig. 1 Graphic interface "Crystallizer wear parameter"

In the graphic interface the following data are introduced: λ_{Cu}, D_a, λ_a, η_a, V_a, C_{pa}, T_s, T_2, T_e, T_i shown in table 1 and 2, respectively, resulting the value δ_{Cu}.

We find out that after the continuous casting of the five heats shown in table 2 we have an average wear parameter per crystallizer heat of 13,836 μm.

For the five sequence casted heats shown in table 1 we reach, after calculation, an average wear parameter per heat 14,276 μm. It is clear that this value increase of the wear parameter is due also to the fact that the casting was performed continuously in three threads. So it is normal to obtain a greater value of the wear parameter.

Table 1

No heat	λ_{Cu}, kcal/h·m·K	D_a, mm	λ_a, kcal/h·m·K	η_a, 10^{6}P·s	V_a, l/kg	C_{pa}, kcal/kg·K	T_s, °C	T_2, °C	T_m, °C	δ_{Cu}, mm
1	0,0304	160	0,64	605,07	0,2135	0,9975	1510	75	45,5	8,99782
2	0,0304	160	0,64	605,07	0,2087	0,9975	1505	75	45	8,97889
3	0,0304	160	0,64	605,07	0,2064	0,9975	1490	75	45	8,96382
4	0,0304	160	0,64	605,07	0,2135	0,9975	1525	75	45	8,94034
5	0,0304	160	0,64	605,07	0,2111	0,9975	1510	75	45	8,92824

Table 2

No heat	λ_{Cu}, kcal/h·m·K	D_a, mm	λ_a, kcal/h·m·K	η_a, 10^{6}P·s	V_a, l/kg	C_{pa}, kcal/kg·K	T_s, °C	T_2, °C	T_m, °C	δ_{Cu}, mm
1	0,0304	160	0,64	605,07	0,2064	0,9975	1550	59	20,5	9,76548
2	0,0304	160	0,64	605,07	0,2016	0,9975	1555	60	21,5	9,73601
3	0,0304	160	0,64	605,07	0,2135	0,9975	1550	60	25	9,72476
4	0,0304	160	0,64	605,07	0,2016	0,9975	1550	60	20	9,70232
5	0,0304	160	0,64	605,07	0,2016	0,9975	1545	60	19,5	9,66863

In figure 2, the graphic representation of the specific flow of the crystallizer cooling water influence on the crystallizer wear parameter is shown.

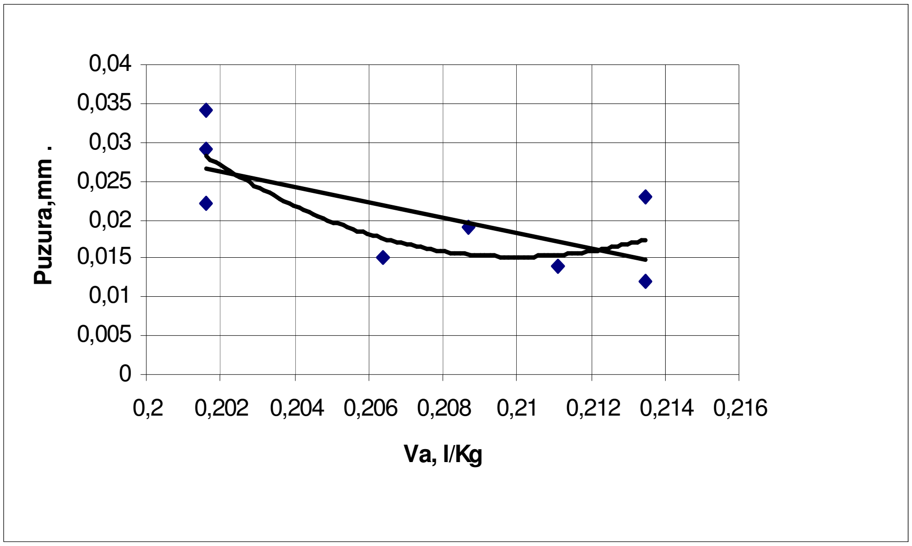

Fig. 2 Specific flow of the crystallizer cooling water influence on the crystallizer wear parameter

From figure 2 we find out that the decreasing of the wear parameter value occurs when the specific flow of the crystallizer cooling water increases, so the wear parameter is favourably influenced by the increase of the specific flow of the crystallizer cooling water..

3. VALDATION OF THE RESULTS OF THE NUMERICAL APPLICATION

Since the model embedded in the numerical application involves a simplified hypothesis, in order to validate it there were taken data from copper profiles from five crystallizers (respectively the copper tube thickness which were interchanged after a certain number of continuous casting heats.

In order to validate the model, there were compared the results obtained after measuring the copper wall of the crystallizers with which a certain number of heats were casted.

In table 3 the measured data are shown:

Table 3

Nr. cryst.	Nr. Continuously casted heats	δ_{Cu} measured,mm	Average wear parameter, µm
3	122	8,4	13,114
4	148	8	13,513
8	103	8,7	12,62
7	139	8,2	12,949
9	242	7,5	10,330

After comparing the measurements results with the calculations through the graphic interface ¨Crystallizer wear parameter¨, accepted errors varying from 2% and 8%. were found .

In conclusion, the calculation made though the mathematic model and the graphic interface are according to the results of the measurements.

4. CONCLUSIONS:

By continuously monitoring the wear parameter value of the crystallizer with process computer through the graphic interface "crystallizer wear parameter" there can be prevented the occurrence on the semi-product of the defects by changing crystallizer.

Decreasing the wear parameter value of the crystallizer occurs when the specific flow of the crystallizer cooling water increases

Through this application the metallurgist engineer may have access to data regarding the crystallizer wear parameter in every moment of the casting and he can decide if the casting on one thread may be interrupted or not depending on the consequences on the quality of the semi-product.

In conclusion, the defects caused by the high usage level of the crystallizers may be totally eliminated

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