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RESEARCH CONCERNING THE INFLUENCE OF THE COOLING PARAMETERS ON THE SPEED OF THE CASTING IN CONTINUOUS CASTING OF STEEL

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Abstract: The paper presents the results of research conducted in the form of semi-finished steel casting for the manufacture of pipes that are intended to transport hydrocarbons. The research was aimed at determining the influence of the parameters that affect the process of cooling (hardening) on the liquid steel casting speed. Were included in the study the temperature of the steel at the entry into the cristalizor, steel overheating and cooling water flow in different areas, considered independent parameters and casting speed dependent parameter. The data obtained was processed in MATLAB, multiple correlations were obtained and are presented in both graphical and analytic form. The analysis conducted shows a comparison between the results obtained by three types of equations for each correlation which were analyzed from a technological point of view.
Keywords:steel casting, matlab, casting speed, steel cooling, pipes, EBT

INTRODUCTION

Since the six decade of the last century, in the practice of steel casting was imposed the continuous casting, whose share increased gradually replacing the conventional casting or ingot form. Continuous casting steel industry in developed countries, the share of continuous casting is at least 95% of the total number of cast steel. The difference up to 100% is represented by cast steel ingots intended for processing by forging.

Continuous casting was introduced quickly in practice because of the advantages they represent, namely: metal production is over 99% in sequential casting, investments, labor price is lower, significant reduction of thermal power and electricity, high degree of mechanization and automation etc. . Particular attention should be paid toof the speeds of molding, drag and solidification point.

STUDY OF THE PROBLEM

The research conducted was aimed to establish the correlation equations between parameters characterizing the continuous casting of steel, temperature at the entrance to the crystallizer, steel overheating, cooling water flow in the crystallizer and different areas of the secondary cooling. Along with these parameters were followed the values of casting speed, on the casting of round blanks ϕ270mm.

The steel was produced in an electric arc furnace EBT type, capacity 100t treated in installations L.F. (Ladle - Furnace), and VD (vacuum-degassing) and then poured in a continuous casting plant with five threads.

MATHEMATICAL DATA MODELING

The data processing was made in the computing program MATLAB, using three types of correlation equations. The results are presented both analytical and graphical form, each correlation being analyzed technologically indicating optimal values for the independent parameters.

The analysis conducted shows a comparison between the results obtained by three types of equations for each correlation.

» Equation 1:

$$z_1 = a_{(1)}\, x^2 + a_{(2)}\, y^2 + a_{(3)}\, xy + a_{(4)}\, x + a_{(5)}\, y + a_{(6)}$$

» Equation 2:

$$z_2 = a_{(1)} + a_{(2)}\, x + a_{(3)}\, x^2 + a_{(4)}\, x^3 + a_{(5)}\, y + a_{(6)}\, y^2 + a_{(7)}\, y^3 + a_{(8)}\, y^4 + a_{(9)}\, y^5$$

» Equation 3:

$$z_3 = a_{(1)} + a_{(2)}\, \log(x) + a_{(3)}\, \log(x)^2 + a_{(4)}\, \log(x)^3 + a_{(5)}/y + a_{(6)}/(y^2) + a_{(7)}/(y^3) + a_{(8)}/(y^4) + a_{(9)}/(y^5)$$

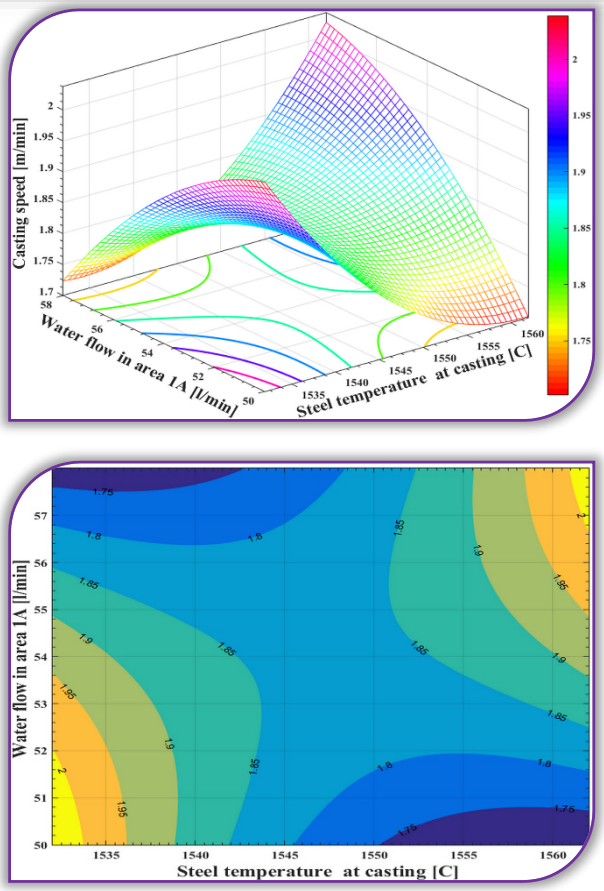

Figure 1. Casting speed= f (Steel temperature at casting, Water flow in area 1A, equation 1);

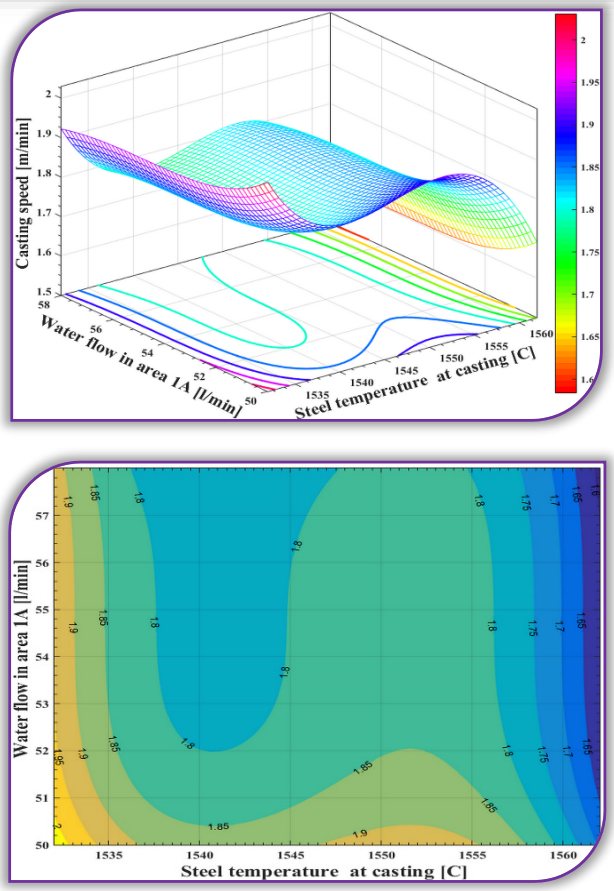

Figure 3. Casting speed= f(Steel temperature at casting, Water flow in area 1A, equation 3)

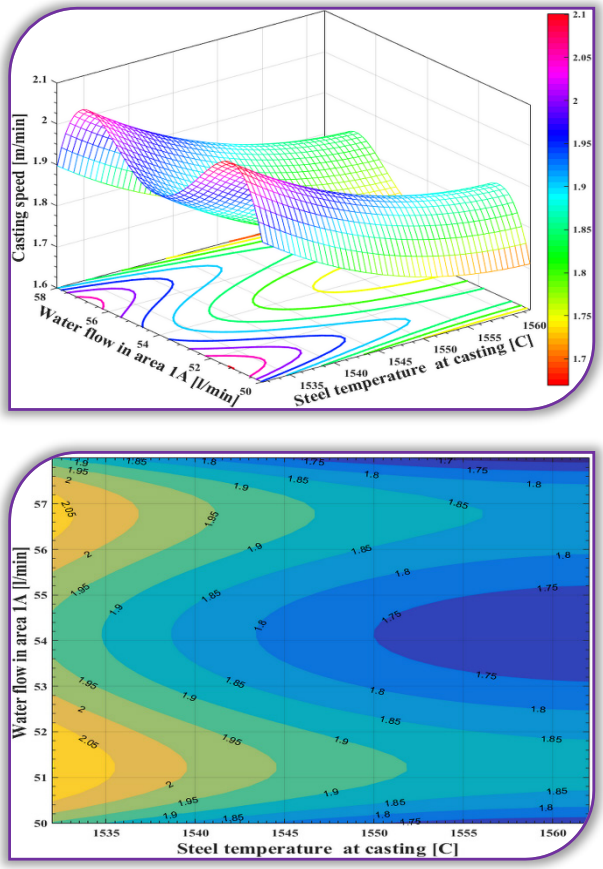

Figure 2. Casting speed= f (Steel temperature at casting, Water flow in area 1A, equation 2)

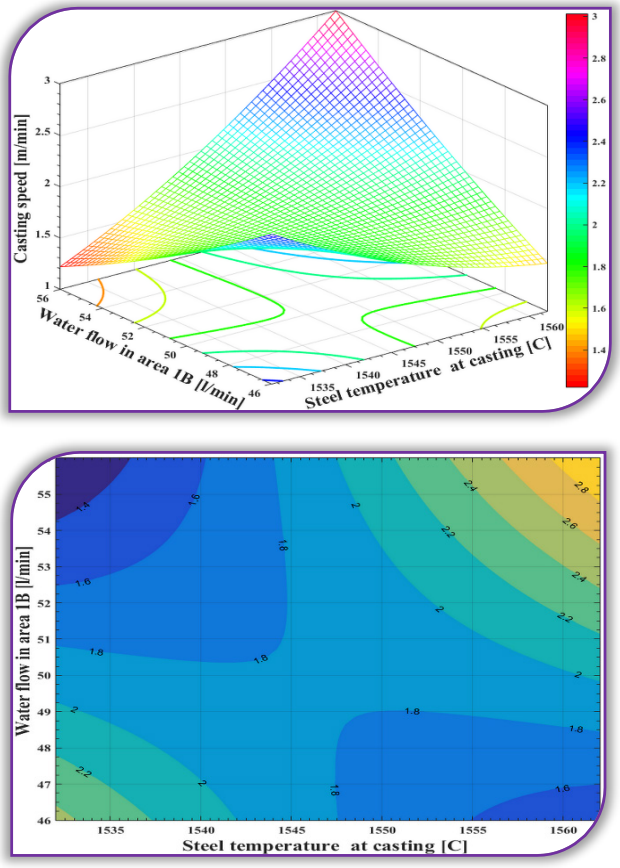

Figure 4. Casting speed= f (Steel temperature at casting, Water flow in area 1B, equation 1)

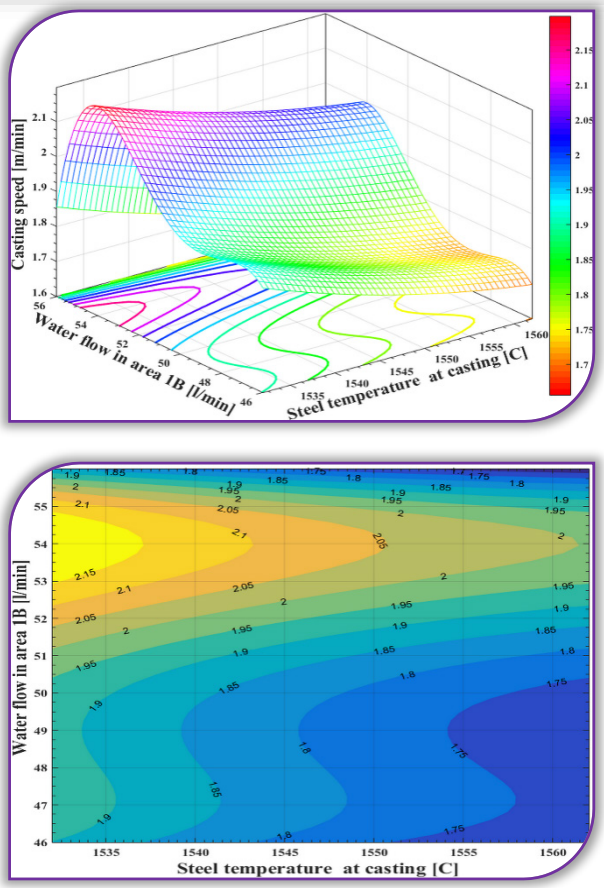

Figure 5. Casting speed= f (Steel temperature at casting, Water flow in area 1B, equation 2)

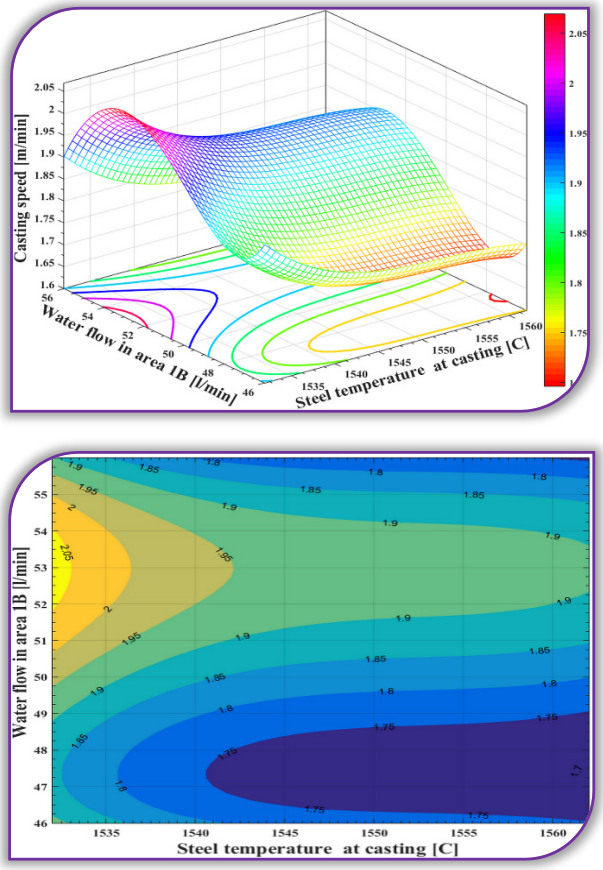

Figure 6. Casting speed= f (Steel temperature at casting, Water flow in area 1B, equation 3)

$$z_1 = 0.00039\,x^2 + 0.00344\,y^2 + 0.00264\,xy + 1.35823\,x + 3.72223\,y + 1153.39115 \quad (1)$$
$$R^2 = 0.5287$$

$$z_2 = 7.52129\,x + 0.00460\,x^2 + 14.07756\,y^2 + 0.52186\,y^3 + 0.00724\,y^4 \quad (2)$$
$$R^2 = 0.61243$$

$$z_3 = 11890 + 48574\log(x) + 66145\log(x)^2 + 300000\log(x)^3 + 16829/y + 92059/(y^2) + 16786/(y^3) \quad (3)$$
$$R^2 = 0.5441$$

$$z_1 = 0.00065\,x^2 + 0.00258\,y^2 + 0.00925\,xy + 47158\,x + 14.56371\,y + 2274.28489 \quad (4)$$
$$R^2 = 0.71748$$

$$z_2 = 1.59968\,x + 0.00092\,x^2 + 3.71578\,y^2 + 0.14897\,y^3 + 0.00223\,y^4 \quad (5)$$
$$R^2 = 0.79421$$

$$z_3 = 21424 + 87475\log(x) + 11905\log(x)^2 + 54000\log(x)^3 + 44161/y + 22154/(y^2) + 36930/(y^3) \quad (6)$$
$$R^2 = 0.70210$$

$$z_1 = 0.00023\,x^2 + 0.0253\,y^2 + 0.00013\,xy + 0.7328\,x + 2.7963\,y + 627.2682 \quad (7)$$
$$R^2 = 0.76230$$

$$z_2 = 36.6474\,x + 0.0239\,x^2 + 70.4148\,y^2 + 2.7289\,y^3 + 0.0396\,y^4 + 0.0002\,y^5 \quad (8)$$
$$R^2 = 0.86142$$

$$z_3 = 78060 + 31882\log(x) + 43407\log(x)^2 + 197000\log(x)^3 + 17588/y + 88439/y^2 + 14811/y^3 \quad (9)$$
$$R^2 = 0.79973$$

$$z_1 = 0.00063\,x^2 + 0.00037\,y^2 + 0.00755\,x\,y + 2.3735\,x + 11.6326\,y + 2150.4986 \quad (10)$$
$$R^2 = 0.6831$$

$$z_2 = 8.3524\,x + 0.0054\,x^2 + 13.7375\,y^2 + 0.4916\,y^3 + 0.0066\,y^4 \quad (11)$$
$$R^2 = 0.6212$$

$$z_3 = 44677 + 18249\log(x) + 24848\log(x)^2 + 113000\log(x)^3 + 38611/y + 21071/(y^2) + 38268/(y^3) \quad (12)$$
$$R^2 = 0.55463$$

Table 1. Data used for the graphical representations

Steel cast. Temp. [C]	Water flow in area: [l/min]				Casting speed [m/min]
	1A	1B	2	3	
1562	50	48	50	52	1.7
1551	50	48	50	52	1.7
1548	50	48	50	52	1.7
1546	52	50	52	54	1.9
1551	50	48	50	52	1.75
1552	53	48	52	55	1.7
1550	55	46	54	55	1.7
1546	56	49	53	58	1.73
1551	53	51	53	55	1.7
1546	53	50	52	54	1.8
1544	52	50	52	54	1.85
1540	58	56	58	60	1.85
1549	50	48	50	52	1.75
1546	56	53	56	58	1.85
1532	53	51	53	55	2.05
1551	56	50	50	52	1.88
1556	54	49	52	54	1.95

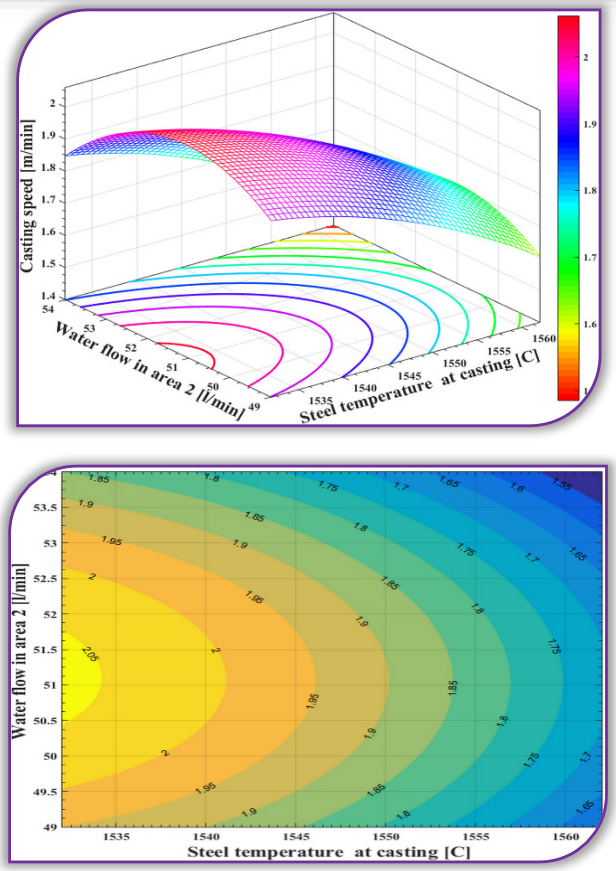

Figure 7. Casting speed= f (Steel temperature at casting, Water flow in area 2, equation 1)

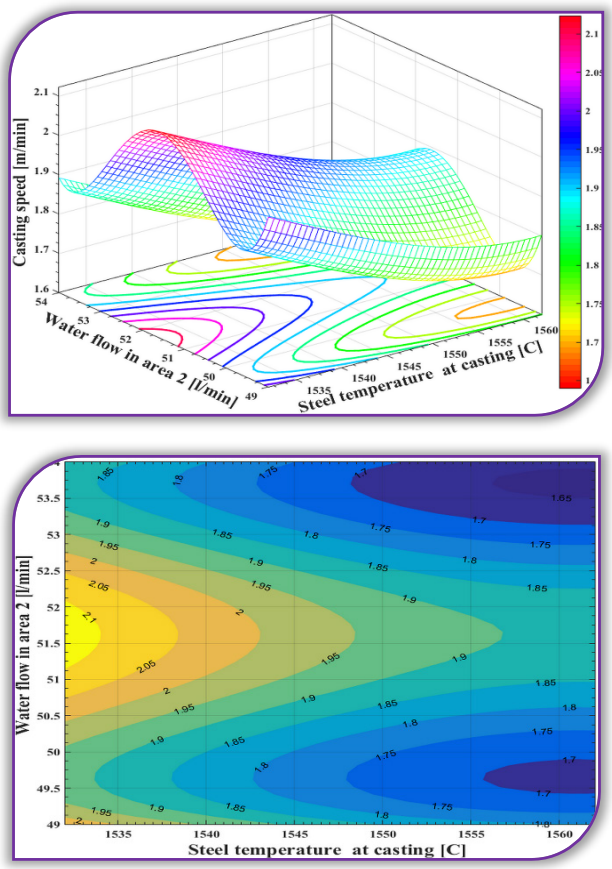

Figure 8. Casting speed= f (Steel temperature at casting, Water flow in area 2, equation 2)

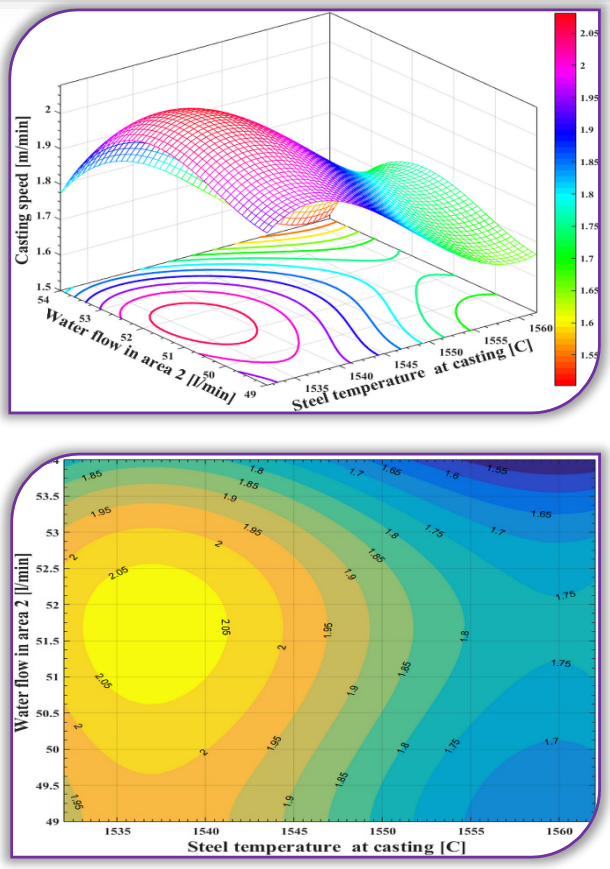

Figure 9. Casting speed=f(Steel temperature at casting, Water flow in area 2, equation 3)

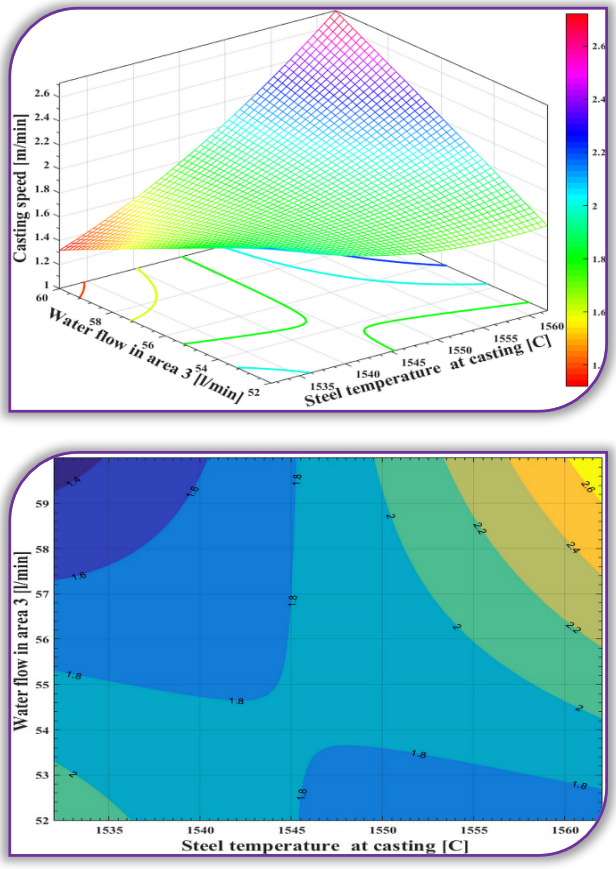

Figure 10. Casting speed=f(Steel temperature at casting, Water flow in area 3, equation 1)

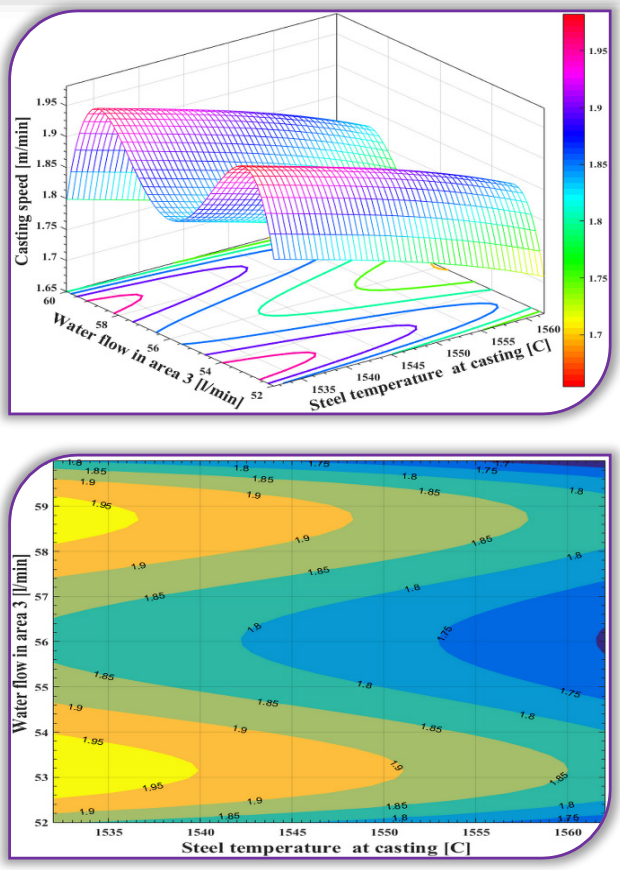

Figure 11. Casting speed=f(Steel temperature at casting, Water flow in area 3, equation 2)

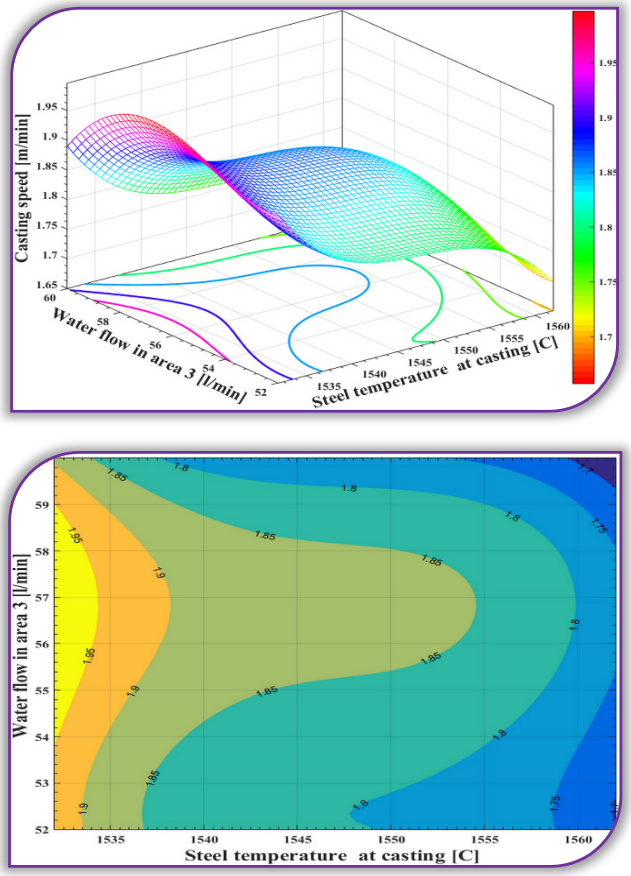

Figure 12. Casting speed= f(Steel temperature at casting, Water flow in area 3, equation 3)

TECHNOLOGICAL ANALYSIS OF THE RESULTS

After all the data gathering from the industrial experiments and then implementing them in the computing program MATLAB were obtained four groups of double correlation, using three types of correlation equations. All correlations obtained are presented as analytical and graphical representations in a technological meaning.

Regarding the casting temperature, graphs confirm that an increase in temperature causes a reduction in casting speed, which ensures optimum removal of heat from the system liquid steel-crystallizer, in the system crystallizer-cooling water, namely the system performing water-cooling from the secondary zone.

All four groups of data contain three types of correlations each and the influence of temperature has the same effect in all of them.

For example, Figure s 7, 8 and 9 establish that:

» in Figure 7 steel is at a temperature of 1550C and the flow rate of cooling water from zone 2 is 51l/min., the casting speed is 1.9m/min, and in Figure 8 is the same 1.9m/min;

» Figure 9 at the same values as Figure 7 has the casting speed of 1,95m/min, a difference of 2.62% compared to the two cases above, so in terms of practice imperceptible;

» mentioned that all four groups of data containing three types of correlations each similar results are obtained

CONCLUSIONS

Based on the research conducted the results obtained can be summarized as follows:

≡ between the parameters for the secondary cooling of the casting installation and the speed of the continuous casting of steel can be established technological correlations expressed analytically and graphically;

≡ based on graphical representations the casting speed can be chosen in advance depending on the temperature of the steel casting and water flow;

≡ the results can be used in practice for casting 180mm blanks.

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