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The calculation of a thermal field in the surface of a processed partunder the influence of a low-temperature plasma

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Abstract: This paper presents the results of the calculation the thermal field distribution on the surface of processed partunder the influence of a moving heat source (of the low-temperature plasma).

1. Introduction:

The most widespread task in the treatment with low-temperature plasma is to obtain specified characteristics (depth, width, heat treatment, etc.)depending on parameters of the heat source, i.e. the current, the arc voltage, the conveying speed, and other parameters of the regime. Moreover, as a rule, a necessity appears to receive the heat treatment with certain physical and mechanical properties [1].

2. Purpose:

In selecting of thetreatment conditions is necessary to analyze of the nature heat distribution in detail, the evaluation of the characteristics of the thermal field is determined by the quality of thedetailreceived.A method for determining the interconnection of parameters in complex processes is a mathematical modeling. This method is based on the fact that the study is not subject to the phenomenon of interest to us or a process, the study is subject a mathematical model - the image of a real object or display, building by means of mathematical relationships that establish a link between the defining characteristics of the object. Another important factor is the relatively low cost of the computational experiment as compared to physical.

3. Simulation:

Due to high temperatures and flows with a high concentration power the detailed experimental study and visualization of the temperature field distribution on the surface ofprocessed part is associated with considerable difficulties.The visualization of the temperature distribution on the surface of processed part is necessary for quality control, and the heat treatment process. In the MathCadwas created by the distribution model of the temperature field on the surface of processed part by moving the heat source.
Initial data for this model is the thermal characteristics and size of the material, the heat treatment parameters like the current, the voltage and the efficiency of the plant, which in turn affect the capacity of the heat source q, the processing speed.
The heating period in a moving coordinate system is not only a functionthe coordinates but also of the time. The temperature field in the heating stage is described by the formula [3]

$$\Delta T(x, y, t_H) = \frac{q}{4\pi\lambda\delta} e^{-\frac{vx}{2a}} \int_0^{t_H} \frac{1}{t} e^{-\left(\frac{v^2 t}{4a} + \frac{r(x,y)^2}{4at}\right)} dt \quad (2)$$

whereλ - the thermal conductivity;
tH - the duration of the heat source;
q - the power the heat source;
v –the conveying speed of the heat source;
a - the thermal diffusivity.
The results of the model of the temperature distribution on the surface of processed part shown in Figure 1.

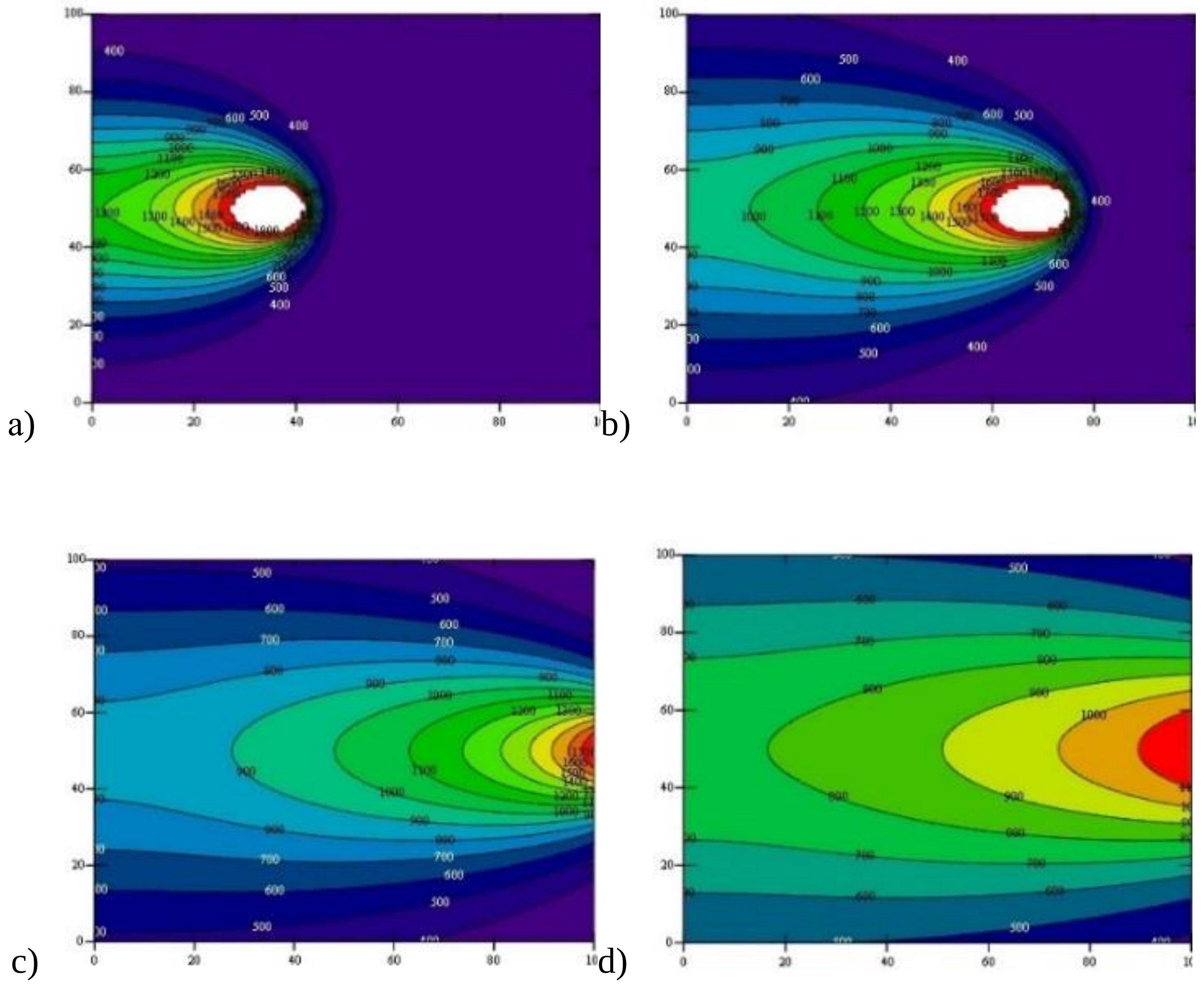

Figure1. Computer modeling of the temperature field distribution on the surface of processed part in the program Mathcad. a - after 1 c, i - after 2 c, c - after 3 c, d - after 4 c.

According to the calculated data revealed that on the surface of the metal steel 40formed a region in which the temperature is about 2000 K. Then conducted field tests confirm the theoretical calculations (Fig. 2)in particular band is observed with melting the metal from the plasma. Having a graphical representation of the temperature field on the metal surface of the heat affected zone is defined and the structure of the metal after influence of the heat source.

Figure 2. Traces of melting on the surface of processed part after the low-temperature plasma treatment.

4. Conclusion:

On the basis of the above mentioned model, after receiving the picture of the distribution of the temperature field on the surface of processed part have the opportunity to choose the desired mode of processing, without conducting field experiments to determine the optimal treatment regime.

References

[1] *The calculation of of temperature fields during welding and surfacing*: Textbook / AY Medvedev; Ufimsk state aviation tehn Univ - Ufa 2009 142 p
[2] Deacons V V 2000 MathCAD 2000: *Training. Course* SPb .: Publishing House, Peter 592 p.
[3] VN Volochenko VM Yampolsky VA Vinokourov etc .1988 The theory of welding processes: *Proc. for high schools on special. "Equipment and technology of welding production"* M.: Higher HQ 559 pp.
[4] Samigullin A D 2015 *The study of gas-dynamic and energetic parameters of the bulk plasma generator*/ Socio-economic and technical systems: research design optimization Number *4 (67)* pp 30-38
[5] AT Gabdrakhmanov, Israfilov IH, Galiakbarov AT, AD Samigullin 2013 *The study of motion of an electric arc in a pulsed plasma generator* IRTC IMTOM 2013 Forum Part 2 pp 37-40
[6] Israfilov I H Galiakbarov A T Bashmakov D A Gabdrahmanov A T Samigullin A D 2014 *Pulse* plasma surface thermostrengthening of machine *parts IOP Conference Series: Materials Science and Engineering* Volume ***69*** *012037*
[7] *I K Israfilov, A T Galiakbarov, D I Israfilov 2014* The analysis of the bottom electrode thermal streams during work process in a melting furnace IOP Conference Series: Materials Science and Engineering **69** 012015
[8] A D Samigullin, A T Galiakbarov and R T Galiakbarov 2016 Study of the petroleum schedules thermal cleaning process from asphalt, ressin and paraffin deposits using low- temperature plasma Journal of Physics: Conference Series **669** 012017
[9] Israphilov I H, Bashmakov D A, Galiakbarov A T, Mandrik P A 2014 The mathematical description of the thermal combined laser and plasma impact on a material *Contemporary Engineering Sciences* V 12. pp 569-576
[10] I H Israphilov, D I Israphilov, D A Bashmakov, A T Galiakbarov, A D Samigullin 2015 *Calculation of thermal processes in bottom electrode* Contemporary Engineering Sciences Vol 8 p 13-20

[8] Israfilov Z K and Kashapov N F 1991 *Steadying the instability of a glowing discharge in a longitudinal air stream*. Journal of Engineering Physics60 364–368

[9] Fayrushin I, Kashapov N and Dautov I 2014 *Calculation of distribution of potential and electron concentration in the dust-electron thermal plasma with the axial geometry particles* //IOP Conference Series: Materials Science and Engineering J. Phys.: Conf. Ser.567 012009

[11] Gavrilova V A, Fazlyyyakhmatov M G and Kashapov N F 2013 *Protective matching polymer powder coating of piezoelectric element* // Contemporary Engineering Sciences.J. Phys.: Conf. Ser.479 012010