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Mathematical model of the thermic field at welding with big productivity

Elena Muncut, Gheorghe Sima, Mortoiu Doina.

The university Aurel Vlaicu from Arad.

Keywords: Mathematical models, thermic fields, dump, digital signals.

The working contains notions concerning the thermic field product of permanent sources with big power and speed, the theoretical determination of variation temperature on weld, the thermic field in product of a source a furniture half ellipsis in a plate, distribution the thermic field falled across a formal double source in a half ellipsis body with casting in three all directiile(massive innards).

All these thing were caused the practice with of a help instalati wagons contains: A thermocouple, an which adapter transform the signal in volþi falled across the thermocouple in digital signal and transmited of a plates acquisition, carry maybe convert the signal received with a help program Genis in direct degrees with screen and which can follow evolution of the signal in time. All evolutia the thermic field is thus rendered temporally development of the process.

In afterwards am presented conditions and the way of mathematics transcription of thermic field to fuse together. It is dependent on:

- the thermic transfer through conductivity(binds his Fourier)
- the transfer convective(he binds his Newton)
- the transfer through radiation(binds his Stefan-Boltzmann).

The way of variation in space and the time of the temperature he took count of law Fuorier, for pointlike sursel, rule, plans and volume.

We present and give concerning the thermic field at product of the lastingly sources of big power and the speed. The thermic field in the components welding has an influences different about remanent tensions, Deformations and behavior to the lassitude of weld. The classic solutions of measure the temperatures permit mensuration of temperature, but don't permit the mensuration this value in point of weld. This method permits me the mensuration temperature in same time in 2D directii through with more receptore of the temperature(termocuple).

To ultimate by-path presented relationes obtained concerning analytics solution for conduction temperature on massive body(body infinit from mathematical viewpoint) subdued to a thermic formal double source ellipsis .

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1.Introduce

The work contains notions concerning the thermic field the product of the permanent sources of big power and the speed, determination of development the temperature in the welding joining , the thermic field ,the product of a source a furniture semielipsoidala in the plate and distribution the thermic field falled across a formal double source in a elipsoidal body with casting in three all directiile(massive innards.

All these thing were caused the practice with of a help instalati wagons contains: A thermocouple, an which adapter transform the signal in electrical signal falled across the thermocouple in digital signal and transmited of a plates of achiziti, carry maybe convert the signal received with of a help program Genis in direct degrees on screen and which can follow evolutia of the signal of the in temporally. All evolutia the thermic field is thus rendered temporally development of the process.

2. Notions looking the thermic field

The thermic field to fuse together is dependent on:

- the thermic transfer through conductivity (binds his Fourier).
- the transfer Convective(he binds his Newton.
- the transfer Through radiation(binds his Stefan-boltzmann).

The elements determinate ale of thermic field to fuse together the by-path:

- the energy liniara the thermic source $(V \cdot I \cdot \eta)/v$
- the property Termofizice ale of the material: Heat specify c, the conductivity thermic, specify masa ρ, diffusibility thermic $a = \lambda \cdot c^{-1} \cdot \rho^{-1}$.

Miss of heats through exterior: Coefficient of thermoconvection, coefficient of loss of heats.

- miss through fuse together the significant by-pathes for next elements:
- miss of heats plates.
- miss of heats of the bars.

Waves: The thickness Which plate misses the heats, the perimeter aria the which bar misses the heats, the cross-section the which bar misses the heats.

Equations of thermic field from his law Fourier has form:

- when I am envisaged the loss of heats in average surrounding $T = F(r;t) \cdot e^{-bt}$
- when amn't envisaged the loss of heats in average surrounding $T = F(r;t)$.

The way of variation in space and the time of the temperature is can caused through particularizarea of his law Fuorier.

In the case:

The pointlike sources(the welding punctiforma with covered electrode)

$$T_{(r,t)} = 2Q(c\rho)^{-1} \cdot (4\pi at)^{-1,5} e^{-\frac{r^2}{4at}} \quad 1.\ 1$$

The linear sources(the welding mâþã below flux energetically big liniara, but and the speed of fuse together big)

$$T_{(d,t)} = 2Q_L(c\rho)^{-1} \cdot (4\pi at)^{-1} e^{-\frac{d^2}{4at}} \quad 1.\ 2.$$

The sources of the plans(the welding of shipment, with electrode the band, applied with a speed sporita on all of a surface massive body).

$$T_{(r,t)} = 2Q_p(c\rho)^{-1} \cdot (4\pi at)^{-0,5} e^{-\frac{h^2}{4at}} \quad 1.\ 3$$

3. The thermic field the product of the permanent sources of big power and the speed.

In the case of welding tandem with two wires, can the source is much more than to welding MAGE clasic, but and the speed of fuse together is much more.

To this method the speed of heat propagate in the sense of fuse together Ox is much more than against the speed of fuse together, therefore is can neglected the heating propagation in this sense.

In the massive bodies is can considered as in the distance dt, the which source movement quick to distance, is liniar and hiting an element having a thickness.

From relation 2, the amount of heat introduced is:

$$Q_L = Q \cdot \delta^{-1} = P \cdot \delta^{-1} \cdot dt = P \cdot v^{-1} \quad 1.\ 4$$

And distance at first hand liniar to the current point M(y, z) he is, represents d from relation 2. Through the substitution in relation, result the thermic field from the massive body semifinit, fused together with a source of big power and the speed.

$$T(y;z;t) = P \cdot (2\pi\lambda v \cdot t)^{-1} \cdot e^{-\frac{y^2+z^2}{4at}} \quad 1.\ 5.$$

Therefor relation the origin of time considered in the moment in which the source found in the point of case plate presented, due to the speed and can of fuse together big the source, is can considered and here as the temporally dt the source is instantaneous, glide having the surface and hiting the element having this section from the point toward(+ y) and(therefore the amount of heat is:

$$Q_p = \frac{Q}{S} = \frac{P}{\delta \cdot v} \quad 1.\ 6.$$

This amount of heat must amplificata with the factor because in this case the source(the surface hasurata) found out amongst material(equivalent to case an infinite body) from to an end of a material(equivalent to case a body infinit.

Distance among the source glide and the current point M is measured on the axis y and echivaleaza with h from relation (3), through substitution, result the thermic field from the plate welding with a source of power and the big speed.

$$T(y,t) = P \cdot (\delta \cdot c \cdot \rho \cdot v)^{-1} \cdot (4\pi at)^{-0,5} \cdot e^{-\frac{y^2}{4at}} \quad 1.\ 7.$$

In the case plate cann't neglijate the loss in average surrounding and according as he showed, functions the thermic field must amplificata with the factor. In the case of cooling aerially.

The thermic field for welding with a hiting source and a big speed, to cooling be aerially, he is falled across relation:

$$T(y,t) = P \cdot (\delta \cdot c \cdot \rho \cdot v)^{-1} \cdot (4\pi a t)^{-0,5} \cdot e^{-\frac{y^2}{4at} - b_p \cdot t} \quad 1.8$$

I carry is a mobile system of reference Xoyz.

4. The determination Evolutiei the temperature of the in the zone structural transformations.

The thermic field in the welds components has an influences about the remanent tensions, deformations and behavior to the lassitude of the welds structures. Solutions classic of measure the temperatures I admit the mensuration of the temperature, but don't I admit the mensuration evolutions this in a the point of weld This method permits me the mensuration of the temperature in same time in 2D direction through the use the many receptori of the temperature(termocuple).

Is known as distribution of hiti is done in the likeness of of a surfaces of guys which Gaussian 2D explain the way of casting energy in the piece for fused together. This way represents an important step in direction for estimate of the temperature in the aria of the source of fuse together.

New introduced the model 3D in the shape of double elipsoidal of thermic field(the source litle reason).

For the solution the analytics proposed an adding algorithm the thermic field in the components in which he introduced litle energy. Is known a realization the model of FEM save longtime and reduces the remanent tensions.

Through the mensuration of the components of expand the thermic field ah(y), bh(z), chf(xfata), chb(xspate) is can demonstrated and practical the correctness of the theory.

Can described the way of introduce the thermic formal field in a semieliptica of the body semi(you use this term for the massive bodies) has to the base as the the source thermic is punctiforma and is subdued next ecuatii.

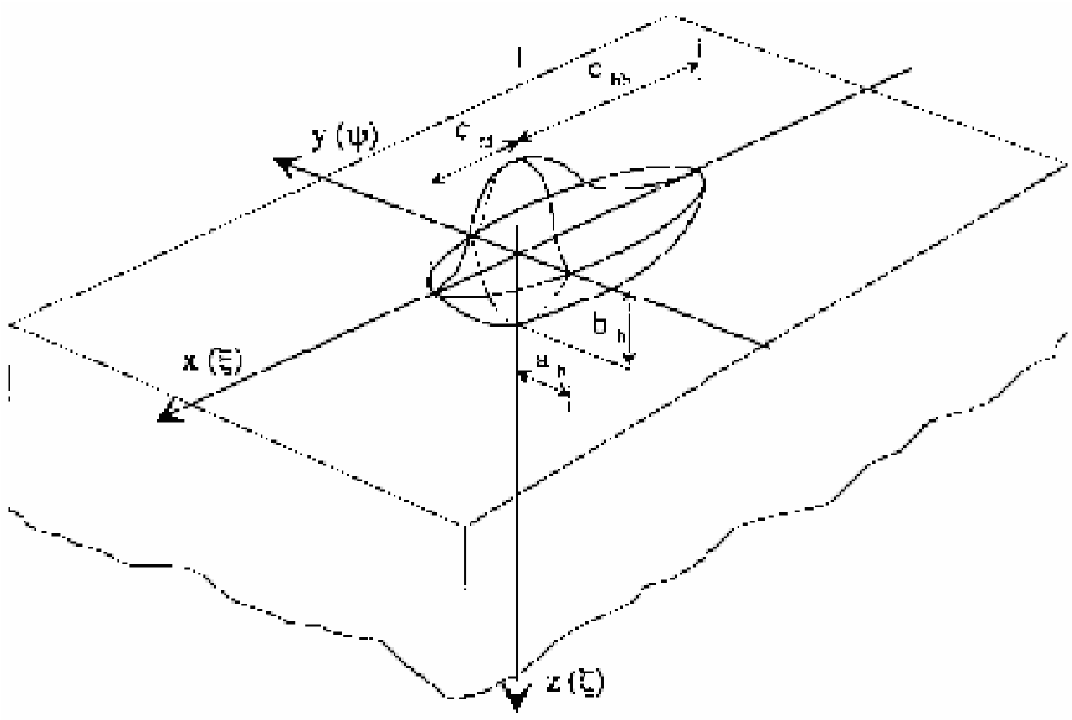
In a heat the point the in a contents elipsoid is falled across next the equation:

$$Q(x,y,z) = \frac{6\sqrt{3\eta \cdot V \cdot I}}{a_h b_h c_h \pi \sqrt{\pi}} \exp\left(-\frac{3x^2}{c_h{}^2} - \frac{3y^2}{a_h{}^2} - \frac{3z^2}{b_h{}^2} \right) \quad 1.9$$

Waves are the geometric parameters have the thermic source in the likeness of eliptica, and ch= chb= chf, x, y, z am the coordinates motional ale of thermic source, V, i and am the tension, current and the efficaciousness of the electric arc.

Abaft else multor established experiments as the the thermic field has a form eliptica egala in plan, but in order to satisfied yes experimental for the bulk suggested innards a double form elipsoidal wagons have axele the perpendiculars.

On the strength of the experiments he arrived at the conclusion as the two conjunct semielpsoide give new the source, new way of casting of hiting. This thing leads to a new way of description of hiting.



The figure 1 Modul of casting hiting in a massive body.

For a point of coordinates(x, y, z) contained in first elipsoid localized ahead the bow, ecuatia caldurii is described thus:

$$Q(x,y,z) = \frac{6\sqrt{3}r_f \cdot Q}{a_h b_h c_{hf} \pi\sqrt{\pi}} \exp\left(-\frac{3x^2}{c_{hf}{}^2} - \frac{3y^2}{a_h{}^2} - \frac{3z^2}{b_h{}^2}\right) \quad 1.\ 10$$

And for a point of coordinates(x, y, z) contained in second elipsoid, covers all sectiunea of the bow.

$$Q(x,y,z) = \frac{6\sqrt{3}r_b \cdot Q}{a_h b_h c_{hb} \pi\sqrt{\pi}} \exp\left(-\frac{3x^2}{c_{hb}{}^2} - \frac{3y^2}{a_h{}^2} - \frac{3z^2}{b_h{}^2}\right) \quad 1.\ 11$$

Waves:

- a_h, b_h, c_{hb}, c_{hf} the geometric parameters of thermic source in the likeness of double.
- $\eta \cdot V \cdot I$ the energy liniara introduced.
- r_f , r_b coefficients of proportionality presenting the contribution of ahead energy, respectively the back of compliant source 1.

Must envisaged two conditions can studied the thermic sources volumice, the value heat $Q(x,y,z)$ from ecuatia(1. 13) and(1. 14) be due to is equal in the plan. In order to obtained this condition shall exist next compulsion. Directing to the value of two the sum two numbers :

Respectively $r_f + r_b = 2$, $\frac{r_f}{c_{hf}} = \frac{r_b}{c_{hb}}$, $r_b = 2c_{hb}/(c_{hf} + c_{hb})$

Noticed as this considered of casting in the shape of double the source of heat involve five unknown parameters: Efficiencies of the bow and the geometric parameters of thermic source in the likeness of four double. Last parameters can be obtained the practices. Is known as between the size of the source and geometric parameters ale joint exist a dependencies, through these mensuration is can caused.

5. The thermic field the product of a source a furniture semielipsoidala in a plate.

The analytics for determination of the temperature produced of a source in a furniture the plate is a base on solutions of thermic field of the product of the thermic instantaneous sources, described of next relations for heating tub in report with a system of fixed coordinates:

$$dT_{t'} = \frac{\delta Q dt'}{\rho c\left[4\pi a(t-t')\right]^{3/2}} \cdot \exp\left(-\frac{(x-x')^2 + (y-y')^2 + (z-z')^2}{4a(t-t')}\right) \quad 1.\ 12$$

Where the leatle diffusibility

- c the heat specify.
- λ the leatle conductivity.
- ρ the density(Kg /m3.
- t, t' the times.
- $dT_{t'}$ the derivative of the temperature in the moment t' owed heat of thermic source.

The coordinates of thermic field introduced of the source to the moments.

If consider solution of analytics thermic instantaneous formal sources semi as particular of output thermic sources reason. Ecuations(1. 9) I carry describes distribution heat of guys Gaussian is can replace in relations(1. 12) through integration on volume (1. 12).

$$dT_{t'} = \frac{1}{2}\int_{-\infty}^{+\infty} dx' \int_{-\infty}^{+\infty} dy' \int_{-\infty}^{+\infty} dz' \frac{dt'}{\rho c\left[4\pi a(t-t')\right]^{3/2}} \cdot \frac{6\sqrt{3}\cdot Q}{a_h b_h c_{hf}\pi\sqrt{\pi}} \exp\left(-\frac{3x'^2}{c_h^2} - \frac{3y'^2}{a_h^2} - \frac{3z'^2}{b_h^2}\right) \exp\left(-\frac{(x-x')^2 + (y-y')^2 + (z-z')^2}{4a(t-t')}\right) \quad 1.\ 13.$$

Abaft solution of the integral, this can be write below next the form:

$$dT_{t'} = \frac{3\sqrt{3}Qdt'}{\rho c\pi\sqrt{\pi}} \cdot \frac{1}{\sqrt{12a(t-t')+a_h^2}} \cdot \frac{1}{\sqrt{12a(t-t')+b_h^2}} \cdot \frac{1}{\sqrt{12a(t-t')+c_h^2}} \cdot \exp\left(-\frac{3x^2}{12a(t-t')+c_h^2} - \frac{3y^2}{12a(t-t')+a_h^2} - \frac{3x^2}{12a(t-t')+b_h^2}\right) \quad 1.\ 14$$

Relation 3. 14 show the temperature in a crest very short lapse dt', and to the moment t' again amount of energy introduced Qdt' in a massive body. When consideram a source of which which heat moved with the steady speed v from on time $t' = 0$, $t' = t$. For this reason:

$$T - T_0 = \frac{3\sqrt{3}Q}{\rho c\pi\sqrt{\pi}} \cdot \int_0^t \frac{dt'}{\sqrt{12a(t-t')+a_h^2}\sqrt{12a(t-t')+b_h^2}\sqrt{12a(t-t')+c_h^2}} \exp\left(-\frac{3(x-vt')^2}{12a(t-t')+c_h^2} - \frac{3y^2}{12a(t-t')+a_h^2} - \frac{3z^2}{12a(t-t')+b_h^2}\right) \quad 1.\ 15$$

Where T is the temperature to the moment and is the temperature initial in the point(x, y, z.

To considerate afterwards the special cases when the thermic sources semi become:

Thermic semispherical sources. If, therefore the thermic sources semi changed to thermic sources semisfere with the ray and relation 7 becomes:

$$T - T_0 = \frac{3\sqrt{3}Q}{\rho c\pi\sqrt{\pi}} \cdot \int_0^t \frac{dt'}{\left[12a(t-t')+r_h^2\right]^{3/2}} \cdot \exp\left(-\frac{3(x-vt')^2 + 3y^2 + 3z^2}{12a(t-t')+r_h^2}\right) \quad 1.\ 16$$

Relation 1.16 can be simplified afterwards substituting, waves represents the parameter of casting:

$$T - T_0 = \frac{Q}{\rho c} \cdot \int_0^t \frac{dt'}{\left[4a\pi(t-t')+3\sigma^2\right]^{3/2}} \cdot \exp\left(-\frac{(x-vt')^2 + y^2 + z^2}{4a(t-t')+3\sigma^2}\right) \quad 1.\ 17$$

In the of a case pointlike fixed sources if, ecuatia 1. 17 Is reduced and the way of casting of the temperature for a fixed source becomes:

$$T - T_0 = \frac{Q}{\rho c} \cdot \int_0^t \frac{dt'}{\left[4a\pi(t-t')\right]^{3/2}} \cdot \exp\left(-\frac{(x-vt')^2 + y^2 + z^2}{4a(t-t')}\right) \quad 1.\ 18$$

This the solution is falled across Carslaw and Jaeger(11) reported to relations1. 12.

The thermic sources with heating distributions of guys Gaussian. If bh= 0, therefore the sources with heating distributions semielipsoidal transformed in a surface of guy his formal of a Gaussian elliptical disk. In this case ecuation 1. 15 becomes:

$$T - T_0 = \frac{3Q}{\rho c\pi} \cdot \int_0^t \frac{dt'}{\sqrt{4a\pi(t-t')}\sqrt{12a(t-t')+a_h^2}\sqrt{12a(t-t')+c_h^2}} \exp\left(-\frac{3(x-vt')^2}{12a(t-t')+c_h^2} - \frac{3y^2}{12a(t-t')+a_h^2} - \frac{z^2}{4a(t-t')}\right) \quad 1.\ 19$$

When, therefore the elliptical thermic disk transformed in a circular disk the and ecuation 1. 19 becomes:

$$T - T_0 = \frac{3Q}{\rho c \pi} \cdot \int_0^t \frac{dt'}{\sqrt{4a\pi(t-t')}\left[4a(t-t') + 2\sigma^2\right]} \cdot \exp\left(- \frac{(x - vt')^2 + y^2}{4a(t-t') + 2\sigma^2} - \frac{z^2}{4a(t-t')} \right) \quad 1.\ 20$$

Ecuation 1. 20 represents solutions of Eagar and Tsai(12). for distributions the thermic field falled across a formal double source in a elipsoidal body with casting in three all directiile(massive innards).

The study for this guy of bodies, because welding of big productivity used with to fuse together the blackboards of big thickness You consider as the thermic sources on the move formats for thermic fixed sources with casting of guys Gaussian.

In living relations 1. 9 For pointlike sources in ecuations 1. 12 and solving the integral on volume for both ahead fronts and back of the source.

$$dT_{t'} = \frac{1}{4} \cdot \frac{6\sqrt{3}Qdt'}{\rho c a_h b_h \pi \sqrt{\pi}\left[4\pi a(t-t')\right]^{3/2}} \cdot \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} \exp\left(- \frac{(x-x')^2 + (y-y')^2 + (z-z')^2}{4a(t-t')} \right)$$
$$\left(\frac{r_f}{c_{hf}} \cdot \exp\left(- \frac{3x'^2}{c_{hf}^2} - \frac{3y'^2}{a_h^2} - \frac{3z'^2}{b_h^2} \right) + \frac{r_b}{c_{hb}} \cdot \exp\left(- \frac{3x'^2}{c_{hb}^2} - \frac{3y'^2}{a_h^2} - \frac{3z'^2}{b_h^2} \right) \right) dx'dy'dz' \quad 1.\ 21$$

Ecuation 1. 21 can be simplified implificata farther as the:

$$dT_{t'} = \frac{1}{2\rho c \pi} \cdot \frac{3\sqrt{3}Qdt'}{\sqrt{\pi}\sqrt{12a(t-t') + a_h^2}\sqrt{12a(t-t') + b_h^2}}$$
$$\exp\left(\frac{A}{\sqrt{12a(t-t') + c_{hf}^2}} + \frac{B}{\sqrt{12a(t-t') + c_{bf}^2}} \right) \quad 1.\ 22a$$

Waves:

$$A = r_f \cdot \exp\left(- \frac{3x^2}{12a(t-t') + c_{hf}^2} - \frac{3y^2}{12a(t-t') + a_h^2} - \frac{3z^2}{12a(t-t') + b_h^2} \right) \quad 1.\ 22b$$

$$B = r_b \cdot \exp\left(- \frac{3x^2}{12a(t-t') + c_{hb}^2} - \frac{3y^2}{12a(t-t') + a_h^2} - \frac{3z^2}{12a(t-t') + b_h^2} \right) \quad 1.\ 22c.$$

Similarly, when a litles source an wagons moved with the steady speed from the moment of time to the moment, accelerate the temperature in this lapse is the equivalence with the sum All the conditions the source in the move of this crossing of the time:

$$dT_{t'} = \frac{3\sqrt{3}Q}{2\rho c \pi \sqrt{\pi}} \cdot \int_0^t \frac{dt'}{\sqrt{12a(t-t') + a_h^2}\sqrt{12a(t-t') + b_h^2}}$$
$$\left(\frac{A'}{\sqrt{12a(t-t') + c_{hf}^2}} + \frac{B'}{\sqrt{12a(t-t') + c_{bf}^2}} \right) \quad 1.\ 23a$$

Waves:

$$A' = r_f \cdot \exp\left(-\frac{3(x - vt')^2}{12a(t - t') + c_{hf}^{\,2}} - \frac{3y^2}{12a(t - t') + a_h^{\,2}} - \frac{3z^2}{12a(t - t') + b_h^{\,2}} \right) \quad 1.\ 23b$$

$$B' = r_b \cdot \exp\left(-\frac{3(x - vt')^2}{12a(t - t') + c_{hb}^{\,2}} - \frac{3y^2}{12a(t - t') + a_h^{\,2}} - \frac{3z^2}{12a(t - t') + b_h^{\,2}} \right) \quad 1.\ 23c$$

Conclusions: Relations 1. 23a feather to 1. 23c give us solutia the analytics for the conduction of in a temperature of massive body (body infinit from mathematical viewpoint) subdued to a source litle formally a double elipsoidala.

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