Thermal Influence and Thermal Zones of Magnetic-electric Grinding of Gas-thermal Sprayed Coatings

Vplyv základných faktorov magneticko-elektrického brúsenia na vývin tepla v zóne obrábania

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Abstract

The influence of major factors of magnetic-electric grinding on temperature in processing zone is considered. The schedules of dependence of temperature on technology factors MAG is obtained. The zones of thermal MAG influence are revealed.

Key words: magnetic, electric, grinding, thermal influence, Gas-Termal Sprayed Coatings

Abstrakt

Je skúmaný vplyv základných faktorov magneticko - elektrického brúsenia na vývin tepla v zóne obrábania. Je získaný graf závislosti teploty na technologických faktoroch MEB. Sú identifikované zóny termického vplyvu MEB.

Kľúčové slová: magnetický, elektrický, brúsenie, spevnený povrch

1 Introduction

The development of technologies of restoring of surfaces of machine detailses by gas-termal sprayed coatings having high strength, hardness and small viscosity, essentially increases a role of grinding for their processing.

The magnetic-electric grinding (MEG), represents a method of combined electrophysical processing, at which overlapping microcutting by abrasive grains occurs with electrocontact and electroerosive effects on a treated surface during the superposition on a zone of processing of a magnetic field. [1]

Processing the surface of material is subjected to significant temperature effects. From a degree of metal heat, character of distribution of a heat and strains of a treated surface stratum, the mechanical, technological and service properties of a surface structurally and phase transformations depend. Besides the productivity of grinding and quality of a surface stratum of metal depends on intensity of a course of thermal processes in a zone of cutting. Processing of hardened surfaces, the modification of mechanical properties of a material, loss of hardness, come off rigid cover, formation of termal cracks are possible.

Therefore, it is necessary to investigate thermal zones of MEG.

It is known, that heat in a zone of MEG has a number of controlled variables influences: [1]
- Mechanical energy of microcutting, shift and friction;
- Resistance of contact and metal;
- Time of passing of a technological current on a conductor;
- Potency of the microcategories;
- Depth of grinding;
- Velocity of cutting;
- Influence of an external magnetic field to a technological current and melt.

At MEG on a treated surface it is possible to select three zones of temperatures, fig. 1. [2]

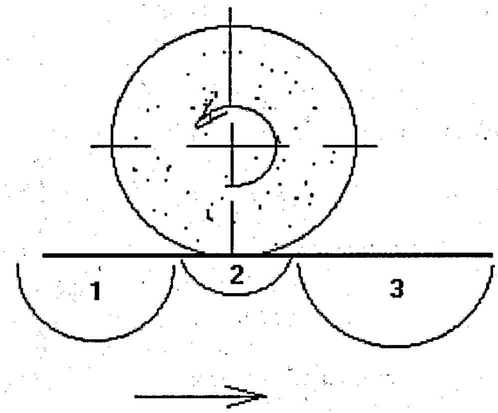

Fig. 1 Zones of temperatures on the Gas-Termal Sprayed Coating surface during MEG processing
Fig. 1 Zóny vývinu tepla pri magneticko - elektrickom brúsení povrchu

The first zone is a zone before processing. It is characterrized in temperature of an environment and thermal influence of a zone 2.

The second zone is an immediate zone of processing. It is characterized by thermal influence of a technological current, forces of friction, magnetic induction.

The third zone is a zone after processing. Is characterrized by process of cooling, convective heat exchange between a surface of details and environment, and also polymerphic transformations in a surface stratum of details.

Source of heat is the zone 2, (Fig. 1), representing one-dimensional driven source with a velocity V, source by intensity q and long l. see fig. 2. [3]

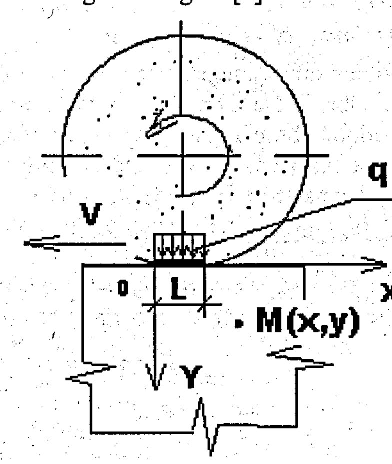

Fig. 2 Driven one-dimensional source of heat
Obr. 2 Pohyblivý jednorozmerový zdroj tepla

Temperature in a point M with coordinates (x,y) is determined in this case under the formula, [3]

$$\theta(x,y)=\frac{q\sqrt{wl}}{\lambda\sqrt{\pi x v}}\exp\left[-\frac{vy^2}{4wx}\right]$$

where:

q - intensity of the source of heat, (calories /cm*sec);
w - factor thermal conductivity of a bar material, (cm^2/ sec);
λ - thermal conductivity, (calories /cm*sec *°C);
V - velocity of movement of an abrasive circle, (cm/ sec);
x, y - coordinate of a point in which temperature is determined, (cm).

2 Materials, Equipment and Methods of Research

For MAG of hardened surfaces of details the special installation was created on the basis of the milling machine tool, model - NGF-100.

The tool was the conductive abrasive circle. The samples were flat and cylindrical details with cover ПГ-СР40М by a thickness of 0,5 mm. A measurement of temperature made by «Pirometre Raynger MX4 » in the point indicated on the scheme, fig. 3. Temperature of an environment conducting the measurement was T = 20 °C.

In table 1 the significances of technology factors MEG are indicated.

***Table 1** Significance of technology factors MEG that investigated temperature*
***Tab. 1** Hodnoty technologických faktorov MEB, pri ktorých sa vyšetrovala teplota*

Technological current I	Magnetic induction	Velocity of cutting	Longitudinal submission	Depth of grinding
I[A],	B [Tesla]	V [m/sec]	S [mm/sec]	H [mm]
2,5	0,05	8,4	6,6	0,05
5	0,1	13,2	11,36	0,075
10	0,2	21	12,5	0,1
15	0,3	33,6	15,6	0,15

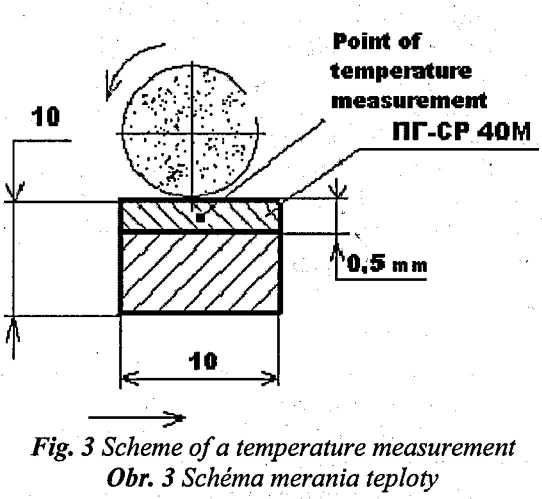

***Fig. 3** Scheme of a temperature measurement*
***Obr. 3** Schéma merania teploty*

3 Results of reserchs

The outcomes of measurements are indicated in the tables below.

From the schedule (fig. 4) is visible, that with magnifycation of a technological current *I* from *2,5 ... 15 A*, temperature in a zone of processing considerably increases from *74 °C* up to *135 °C*. It is explained by a large potency of the electrical categories in a zone of processing and thermal in-fluence formed during cutting electrocontact category. The temperature splash happens in a rather short space of time, further temperature begins droping slowly in connection with deleting of a cover stratum.

The availability on the schedule of sinuous splashes is explained by beating of a conductive abrasive circle.

***Table 2** Modification of temperature from a technological current*
***Tab. 2** Závislosť teploty na technologických faktoroch*

I (A)	Time of measure-ment, sec.	Point tempe-rature T,°C	Constant technological factors		
			S, (mm/turn)	H, (mm)	V, (m/sec)
2,5	20	74	0,01	0,075	33,6
5	20	87,5	0,01	0,075	33,6
10	20	105	0,01	0,075	33,6
15	20	109	0,01	0,075	33,6

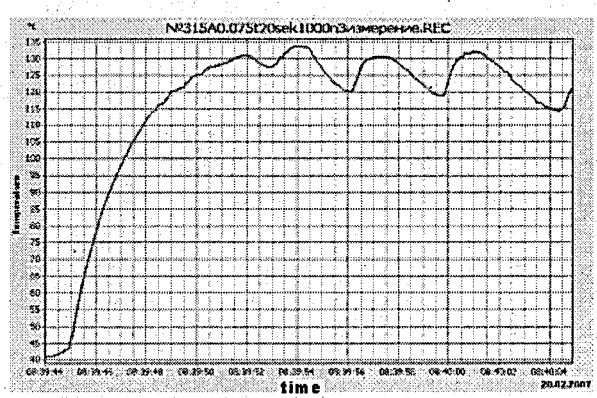

***Fig. 4** Schedule of dependence T(I)*
***Obr. 4** Harmonogram závislosti T(I)*

***Table 3** Dependence of temperature on a modification of a magnetic induction*
***Tab. 3** Merania teploty pri zmene magnetickej indukcii*

B (Tl)	Time of measure-ment, sec.	Point tempe-rature T,°C	Constant technological factors		
			I,(A)	H,(mm)	V,(m/sec)
0,1	20	58	5	0,05	33,6
0,2	20	52	5	0,05	33,6
0,3	20	39	5	0,05	33,6
0,4	20	37	5	0,05	33,6

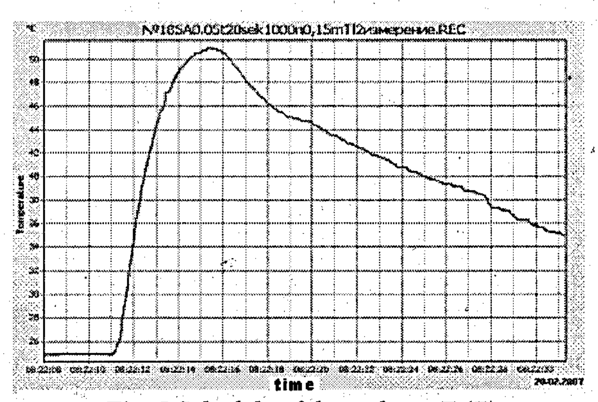

***Fig. 5** Schedule of dependence T (B)*
***Obr. 5** Priebeh závislosti T(B)*

The analysis of the schedules of dependence *T (B),* (fig. 5) shows, that cooling of a treated surface is exemple happens more heavily to superposition on a zone of processsing MEG of a magnetic field, it is explained that the acceleration of ejection of products of erosion and melting happen.

With magnification of longitudinal submission velocity *S (mm/sec)* operation time of natural and kinematic modes on a surface decrease. Therefore, the amount of heat transmitted of the surface also decrease. From the analysis of the schedules (fig.6) is visible, that the magnification of temperature happens spasmodically, for a short space of time. When the magnification number increases, temperature grows up to a defined value (fig. 6), and then begins to drop since deleting a stratum of a cover material.

Table 4 *Dependence of temperature on a modification of longitudinal submission*
Tab. 4 *Merania teploty pri zmene pozdĺžného posuvu*

S (mm /sec)	Time of mea-surement, sec.	Point tempe-rature T,°C	Constant technological factors		
			I,(A)	H,(mm)	V,(m/sec)
6,6	-	33,1	15	0,075	33,6
11,36	-	33,5	15	0,075	33,6
12,5	-	31,2	15	0,075	33,6
15,6	-	39,5	15	0,075	33,6

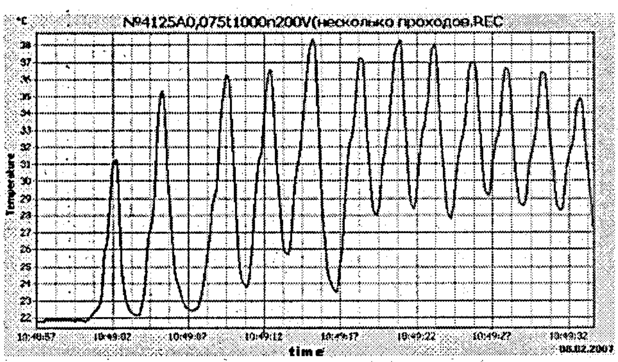

Fig. 6 *Dependence of temperature on longitudinal submission at MEG*
Obr. 6 *Závislosť teploty na pozdĺžny posuv pri MEB*

The schedule of dependence of temperature *T* from a velocity of cutting *V* is shown at Figure 7. When the magnifycation of a peripheral velocity of a conductive circle the potency decrease, but temperature grows at the expense of mechanical energy of microcutting, shift and friction. With magnification of a peripheral velocity the operation of a technological current decreases, that results in the temperature falling.

Table 5 *Dependence of temperature on a modification of a velocity of cutting*
Tab. 5 *Merania teploty pri zmene rýchlosti brúsenia*

V,(m/sec)	Time of mea-surement, sec.	Point tempe-rature T,°C	Constant technological factors		
			I,(A)	H,(mm)	S,(mm/turn)
8,4	20	36	10	0,075	0,01
13,2	20	93	10	0,075	0,01
21	20	106	10	0,075	0,01
33,6	20	80	10	0,075	0,01

With magnification of grinding depth the large potencies in interelectrode space to be realized. The square of grains contact with then surface also increases, ofter that, the amount contact increases, as a result temperature increases, see Fig. 8. The peaks of temperatures on the schedule are explained by the categories in a zone of processing at the expense of technological current passing.

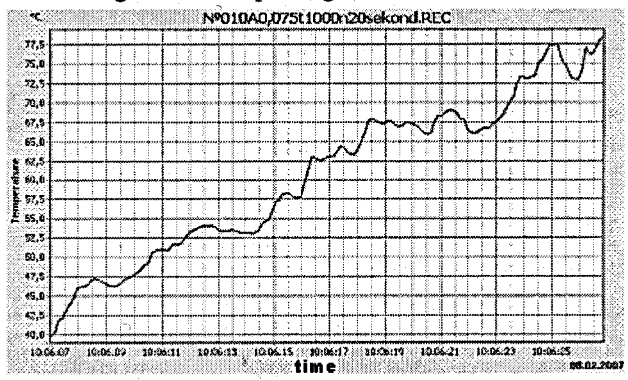

Fig. 7 *Schedule of dependence T(V)*
Obr. 7 *Priebeh závislosti T(V)*

Table 6 *Dependence of temperature on a modification of grinding depth*
Tab. 6 *Nameraná teplota pri zmene hĺbky brúsenia*

H (mm)	Time of mea-surement, sec.	Point Tempe-rature T,°C	Constant technological factors		
			I (A)	V, (m/sec)	S,(mm /turn)
0,05	20	91	10	33,6	0,01
0,075	20	128	10	33,6	0,01
0,1	20	98	10	33,6	0,01
0,125	20	102	10	33,6	0,01

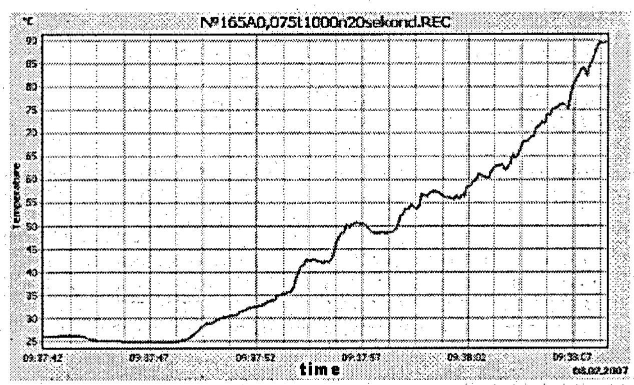

Fig. 8 *Schedule of dependence T (H)*
Obr. 8 *Harmonogram závislosti T(H)*

From outcomes of the researche the follow data are observed: the selection of a heat in a zone of MEG processing take place mainly at the expense of an operation of technological current.From the obtained schedules it is visible, that the influence of technological parameters of MEG on temperature in a zone of processing can be arranged in the following order I⇒H⇒V⇒S⇒B.

4 Conclusions

1. The thermal zones at MEG to have been determined.
2. The schedules of dependence of temperature *T* on technology factors of MEG, (I, B, S, t, V) have been obtained.
3. Experimentally is revealed, that the selection of a heat in a zone of MEG processing happens mainly at the expense of an operation of technological current.
4. The influence of technological parameters of MEG on temperature in a zone of processing can be arranged in the following order I⇒H⇒V⇒S⇒B.

5. Because of the theoretical accounts the equation connecting a technological current with physical properties of a treated material have been obtained.

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Pokračovanie príspevku zo str. 7/
Continuance Papers from Page 7

byly provedeny ve výrobní hale společnosti *Kovosvit Sezimovo Ústí a.s.*, které také patří dík za poskytnutí vhodného stroje a uvolnění zkušebního technika. Zkoušky trvanlivosti se uskutečnily za spolupráce s *Ústavem výrobních strojů a mechanismů Fakulty strojní ČVUT v Praze*, kterému děkujeme na poskytnutí prostor a frézovacího CNC centra Bridgeport.

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