

Electromagnetic Grinding of Gas-Thermal Sprayed Coating

Elektromagnetické brúsenie plynотermicky spevnených povrchov

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Abstract

Process of magnetic-electric grinding (MEG) of the gas-thermal sprayed coatings was considered. The special installation for MEG was created. Influence of electro physical parameters of MEG on a roughness of surface and productivity of process was established.

Keywords: magnetic, electric, grinding, reinforced surface

Abstrakt

Príspevok je venovaný procesu magnetické-elektrického brúsenia plynотermických povlakov. Bolo vyvinuté experimentálne zariadenie MEB. Je vyšetrovaný vplyv elektrofyzikálnych parametrov MEB na kvalitu obrobenných povrchov a kapacitu procesu.

Kľúčové slová: magnetický, elektrický, brúsenie, spevnený povrch

1 Introduction

The process of the gas-thermal spraying of covers on working surfaces of details of machines allows to create, depending on materials and technology of bonding, stratum with certain properties.

As a result, resistance is much higher stability against corrosion, erosion, cavitations and other service properties of details of machines is increased, but the specific properties of covers include fragility of a marked stratum, insufficient strength of its tripping with metal of work piece, high hardness. These features complicate the process that follows.[1,2]

The process of magnetic-electric grinding (MEG) of hardened surfaces has been investigated. The material of the cover was SORMAIT GN1 and gas-thermal sprayed coating SR-4.

The magnetic-electric grinding is a method of combined processing of conductive materials which combine abrasive micro cutting processes with electro erosive effect of a technological current and magnetic field [3]. The physical essence of MEG consists: mechanical contact of the abrasive conductive tool to a surface of a details, closing of electrodes (tool-details) by products of grinding on local spots of contact, fusing a small contact connectives by a heat of electro currents and formation of the categories with the consequent electro erosive phenomena happening under the operation of an external magnetic field [4,5]. The combination of these processes determines the specification of MAG in formation of surfaces micro geometry.

2 Materials, Equipment and Methods of Researcher

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

in the correspondence with the circuit represented on Fig.1. A conductive abrasive wheel 7 through sliding contact 6 and treated sample are connected accordingly to negative and positive poles of the rectifier 3. The magnetic field is formed with inductive spools 5 and magnetic conductor 8. The regulation of a force of a current in a circuit and magnetic induction was made by LATR's 1 and 9. The following research parameters of the process were accepted: rough of the surface Ra (Y1), μm after processing and picking up of a material Q (Y2), $\text{mm}^3\cdot\text{min}^{-1}$ of cover. The following factors were variables: technological current I, A, magnitude of a magnetic induction B, T, cutting speed v_c , $\text{m}\cdot\text{s}^{-1}$, depth of grinding a_p , mm, feed f, $\text{mm}\cdot\text{s}^{-1}$.

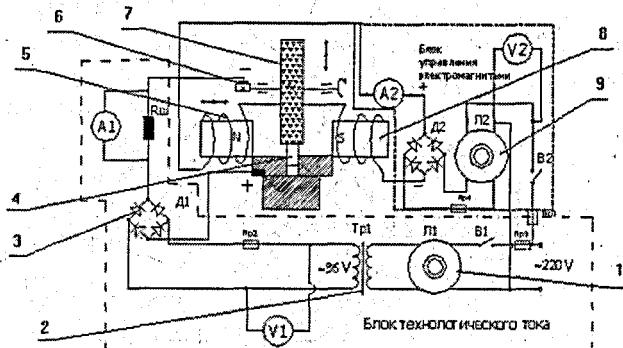


Fig. 1 The schematic diagram of magnetic-electric grinding
Obr. 1 Zásadná schema magneticko-elektrického brusenia

The data of the experience are represented in Table 1.

Table 1 The variable factors and their levels

Tab. 1 Premenné faktory a ich úroveň

Level of a factor	I, A	B, T	$v_c, \text{m}\cdot\text{s}^{-1}$	a_p, mm	$f, \text{mm}\cdot\text{s}^{-1}$
	X ₁	X ₂	X ₃	X ₄	X ₅
-a	2,48	0,20	2,32	0,12	8,41
-1	8	0,14	8,3	0,4	10
0	12	0,24	12,5	0,6	13,33
+1	16	0,34	16,5	0,8	16,67
+a	21,51	0,47	22,48	1,08	16,67

For the description of required dependence of MEG the various complexes were used.

The complex of the order is a equal:

$$K_a = \frac{IBa_p}{f} \left(\frac{v_c}{f} \right)^\alpha, \quad (1)$$

where α - any number.

The complex of the order 0 and minus 1 is the following :

$$K_0 = \frac{IBa_p}{f}; K_{-1} = \frac{IBa_p}{v_c}. \quad (2)$$

The models were constructed due to the order complexes:

$$Y = a_0 + a_1 K_0 + a_2 K_{-1} + \dots + a_{i-1} K_{i-1}. \quad (3)$$

The account of factors of the regression equations of a

response function and their statistical analysis was made with Microsoft EXCEL on the PC.

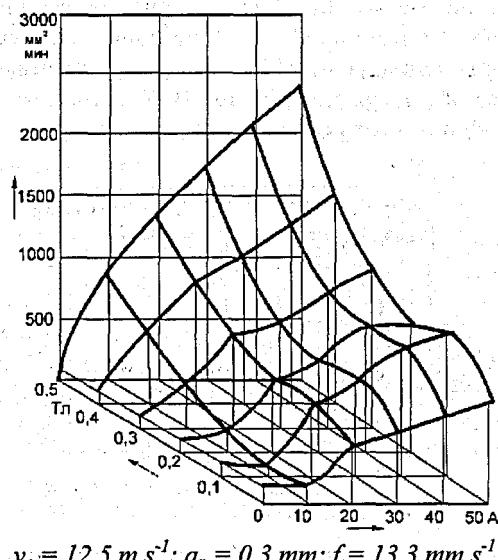
Influence of technology factors of MEG on productivity Q of the process and also the optimization of the mode were made of an obtained mathematical model:

$$Y_2 = Q_C = 360 + 95I.B - 23f/I.B + 11,5IB/f^2 \cdot v_c \cdot a_p^3 - 31,3a_p \cdot f + 51^2 a_p^2 / a_p^2 f^3 \quad (4)$$

The dependence «productivity - technological current - magnetic induction», is represented in a Fig. 2.

According to the schedule, we can observe, that the main influence on productivity renders the electro physical parameters. At constant magnetic induction 0,2 Tesla with magnification of a technological current from 10 up to 40.

The productivity rises owing to realization of large potencies in inter-electrode gap. The linear dependence of productivity on a technological current is usually observed.



$$v_c = 12,5 \text{ m.s}^{-1}; a_p = 0,3 \text{ mm}; f = 13,3 \text{ mm.s}^{-1}$$

Fig. 2. Dependence of productivity of MEG of strengthened surfaces, from a force of a current and magnetic induction

Obr. 2. Závislosť kapacity MEB povrchov povlakovaných sormitom GNI na prúd a magnetickú indukciu

The acceleration of the ejection of erosion products, micro melt and shaving by a directed magnetic field happens to increase of a magnetic induction from 0,05 up to 0,4 Tl at a constant technological current in a zone of grinding. In this case significant part of energy is spent on fusing of micro ledges of a surface of a details, instead of fusing of a shaving and erosion products, that increases productivity of grinding. The space diagram of associations «productivity - technological current - magnetic induction» has a maxima of productivity $Q = 1500 \text{ mm}^3 \cdot \text{min}^{-1}$. The roughness of the treated surfaces of covers $R_a = 1,1 \dots 0,35 \mu\text{m}$.

Diminishing the submission f of the influence of a technological current by a treated surface is increased, that results to the productivity of magnification. The depth of cutting a_p should be within the limits of 0,05 ... 0,2 mm not to delete a hardened stratum.

$$v_c = 12,5 \text{ m.s}^{-1}, B = 0,11 \dots 0,51 \text{ Tl}, a_p = 0,3 \text{ mm}, f = 13,3 \text{ mm.s}^{-1}$$

The mathematical model of a grain from technological modes MEG is the following:

$$Y_1 = Ra = 0,474 + 0,206I^2BV - 0,307IB/v_cH + 0,16I^3/v_c \cdot f + 0,066B \cdot f^{0.5}/a_p^{0.5} \quad (5)$$

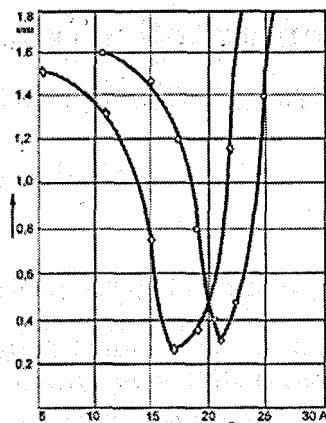


Fig. 3 Dependence of the roughness of gas-thermal spraying surfaces, from electro physical and kinematics parameters

Obr. 3 Závislosť drsnosti povrchov povlakovaných sormitom GNI na elektrofyzikálne a kinematické parametre

In a Fig. 3 the dependence of the roughness on electro physical and kinematics parameters is represented. At large velocities MEG the operation of a technological current force decreases in connection with a diminution of maximum and average thickness of a shear, cutting with a grinding grain. The failure of a spot of contact of directed interaction of a magnetic induction and peripheral velocity happens too. The average power of a technological current in a zone of contact interaction becomes less. Only part of shavings, elevated above the main metal, and heights are fused. At small velocities ($\delta = 3 \dots 5 \text{ m.s}^{-1}$) the current has time to destroy a shaving, and the magnetic field tries to smooth fused ledges of micro irregularities. In this case the roughness is reduced in comparison with usual grinding.

The analysis of outcomes of experiment shows, that with magnification of a velocity of grinding and magnetic induction the roughness is increased, but from a defined value. On the diagram of a fig. 3 the turning point of a grain $R_a = 0,3$ microns for a magnetic induction 0,15 Tl is obviously visible.

The interaction of a technological current and magnetic field is presented in the following way: with magnification of current force up to 21 and the dependence of a grain on the magnetic induction and velocity of grinding is changed. Influencing on the category of a grinding zone, the magnetic field in this range increases current fuses ability and locates it in narrow area. As a result all micro irregularities fuse and the melt under an operation of the external magnetic field spreads on a surface of a details reducing the roughness.

4 Conclusion

1. The technological modes MEG (current force, magnetic induction, peripheral velocity, thickness of a stratum, magnitude of submission) and their interaction during the grinding process.
2. MEG increases productivity of processing in comparison with processing by traditional grinding by abrasive wheels.
3. According to experimental data the equations of a regressions establishing dependence of productivity and a grain of a surface from the main parameters of MEG are obtained.
4. The influence of electro physical parameters to productivity of process MEG with following modes of processing is established: $I = 20 \dots 38 \text{ A}$, $B = 0,2 \dots 0,35 \text{ T}$, $v_c = 12,5 \text{ m.s}^{-1}$, $a_p = 0,05 \dots 0,3 \text{ mm}$, $f = 13,3 \dots 15,5 \text{ mm.s}^{-1}$. The influence of electrophysical parameters to the roughness of

a surface with following modes of processing is established:

$$I = 10 \dots 15 \text{ A}, B = 0,2 \dots 0,3 \text{ T}, v_c = 12,5 \text{ m.s}^{-1}, a_p = 0,05 \dots 0,2 \text{ mm}, f = 13,3 \dots 15,5 \text{ mm.s}^{-1}.$$

5. The technology MEG is one of the perspective methods of grinding of gas-thermal spraying covers and hardened surfaces.

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tívnosti výskumnnej alebo realizačnej práce.

- Centrum excelentnosti pre laserové spracovanie materiálov vo Varšave v rámci projektu Lapromat
- Virtuálne laboratórium pre výrobné technológie (VRL KClP), centrom je Caise des Dépôts et Consignations v Paríži, 23 organizácií z 14 krajín, 10 mil euro
- Inovatívna výroba strojov a systémov (I Promis), centrom je univerzita Wales, Cardiff, 26 organizácií z 14 krajín, 7,5 mil euro
- Mnoho materiálová mikro výroba: Technológie a apli-kácie (4M), centrom je opäť univerzita Wales, 27 organizácií z 15 krajín, 7,5 mil euro,
- Sieť excelentnosti: prekonanie fragmentácie európskeho výskumu, v oblasti mnohofunkčných tenkých filmov (EXCEL). Centrum Arcelor Laboratories, Belgicko, 12,4 mil eur, 13 účastníkov zo 7 krajín,
- Vedomostná báza mnohokomponentných materiálov pre trvalú a bezpečnú prevádzku (KMN-NOE), Centrom je Ústav pre základný technologický výskum, Polsko, 36 účastníkov z 14 krajín - dva ústavy z SR (Ústav materiálového výskumu Košice a Ustarch SAV Bratislava), 8,1 mil euro.

Integrované projekty sú veľké a ambiciozné projekty, ktoré by mali významne posunúť súčasný stav poznania v EÚ. Mnohé z nich sa zaoberajú aj problematikou výrobných systémov ale aj napr. tvárenia a obrábania. Napr.:

- Integrovaný výrobný systém pre masovú výrobu miniatúrnych výrobkov (MASMICRO), Štátne univerzity STRATHCLYDE, UK, 32 účastníkov z 12 krajín, 21,5 mil euro,
- Nové materiály pre extrémne prostredie (EXREMAT IP), Marx-Planck-Institute Nemecko, 38 účastníkov (zo SR UMMS SAV), z 12 krajín, 30 mil euro,
- Optimalizácia povrchov pre tribológiu, Fundation Tekniker, Španielsko, 30 účastníkov z 12 krajín, 19,5 mil euro
- Pokroková multifunkčná korózna ochrana pomocou nanotechnológie, Institut für Neue Materialien, Nemecko, 30 účastníkov z 13 krajín, 13,4 mil euro
- Nová generácia výrobných systémov, Fundacion Fatronik, Španielsko, 26 účastníkov z 8 krajín, 22 mil euro

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3 Výrobné technológie v 7. rámcovom programe

Jedna z priorít bude obsahovať aj problematiku materiálov, nových výrob a integrácie technológií z hľadiska priesmyselných aplikácií.

Jej obsahom bude

- získavanie nových vedomostí o vysoko výkonných materiáloch pre nové výrobky a postupy, materiály založené na vedomostach a vlastnosťami „na mieru prispôsobené“ ich použitiu
- vyššia spoľahlivosť pri návrhu a simulácii
- vytvorenie podmienok a kapacít pre výroby založené na vedomostach
- rozvoj výrobných kapacít pre prispôsobiteľnú, cieľovo prepojenú výrobu založenú na vedomostach,
- rozvoj nových technologických konceptí využívania konvergencie technológií,
- integrácia nových vedomostí a technológií v nano oblasti a v oblasti nových materiálov a výroby vo vybraných sektورoch a v medzi sektorových aplikáciách

3 Záver

Rámcové programy EÚ pre výskum a technický rozvoj predstavujú reálnu možnosť financovania projektov zameraných na problematiku nových výrobných technológií. Nové členské aj asociované krajinu EÚ majú možnosť zapojiť sa do spoločných medzinárodných konzorcii a prispievať k tvorbe nových poznatkov, výrobkov a technologických procesov. Aj v oblasti nových technológií môžu prispievať k vytváraniu spoločného európskeho výskumného priestoru. 7. Rámcový program, ktorý bude zahájený v roku 2007 dáva možnosť využiť konferenciu Nové smery vo výrobných technológiách na vytváranie medzinárodných tímov a prípravy spoločných projektov.

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