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Anti-Arc-Automatic

Protiobločni sistem avtomatskih strojev za elektroerozijsko grezenje (EDM-3A)

Automatic System Against Arcs in Electrical Discharge Machining – Sinking (EDM-3A)

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V delu so predstavljeni rezultati uspešnosti delovanja protiobločnega avtomatskega sistema strojev za elektroerozijsko grezenje. Sistem deluje na ustavitvi dovajanja energije v razelektritvah, ki bi postale obločne. Sistem zagotavlja predvsem v slabih razmerah dela povečan odvzem ob zmanjšani obrabi elektrode in preprečuje poškodbe na površini obdelovanca in elektrode.

The paper presents the results obtained by the antiarcs automatic device which was developed to be installed on electrical discharge machining sinking devices. The system is based on stopping the energy supply to a discharge which is going to develop into an arc. It is especially effective in bad working conditions. It increases metal removal rate, decreases tool wear and prevents workpiece and electrode surface damage.

0 UVOD

Pri obdelavi z elektroerozijskim grezenjem potekajo razelektritve neustaljeno med elektrodo in obdelovancem v dielektrični tekočini. Vsaka normalna razelektritev da v elektroerozijskem procesu svoj delež k odvzemu materiala.

Normalno se razelektritve lokalizirajo. Do naslednje razelektritve pride blizu prejšnje, ker so tu najugodnejše razmere za vžig naslednje razelektritve. Pri slabem odvajanju produktov erozije iz reže med elektrodo in obdelovancem pride do premočne koncentracije razelektritev.

V tem primeru razelektritve ne potekajo med elektrodo in obdelovancem, temveč med elektrodo in produkti erozije, sprijetimi s površino obdelovanca. Tedaj se energija, ki jo dovaja generator, ne porabi za želeni odvzem materiala na obdelovancu, temveč za segrevanje in strjevanje lokaliziranih produktov erozije na obdelovancu. Rezultat tega je pojav obloka. Proces odvzemanja materiala na obdelovancu se ustavi in vsa dovedena energija povzroči poškodbo elektrode in obdelovanca. Zaradi obrabe se spremeni oblika elektrode, na obdelovancu se zaradi lokalnega dovajanja energije spremeni struktura v slojih pod obdelano površino in obdelovanec ni več uporaben.

Da to preprečimo, obstajata dve možnosti.

Prva, da povečamo premor med impulzi. S tem zmanjšamo nagnjenje k premočni lokalizaciji razelektritev, vendar hkrati zmanjšamo odvzem materiala in povečamo obrabo elektrode.

Druga, da prekinemo vse obločne impulze in ne dovajamo energije, ki je sicer potrebna za razvoj obloka.

0 INTRODUCTION

In EDM sinking, discharges take place randomly in the dielectricum between the electrodes. Each of the successive normal discharge contributes to the overall material removal.

In normal conditions, the discharges are localized. A successive discharge occurs in the vicinity of the former one. In the case of bad flushing conditions, the concentration of discharges becomes too strong.

In this case the discharges do not occur between the electrode and the workpiece, but rather take place between the electrode and the removed particles attached to the workpiece surface. The energy is thus dissipated and spent on heating locally solidified particles instead of being efficiently used for the basic process of material removal. The resulting effect is the creation of arcs. The process of material removal stops and all the energy is spent on unwanted processes, causing workpiece damage. Due to excessive wear, the electrode geometry as well as the workpiece structure of the layers underneath the surface, change and do not meet the required quality of surface integrity specifications.

There are two possibilities of preventing these effects:

One is to augment the intervals between the pulses. The tendency of over-strong localization of the discharges is prevented. The inevitable side effect is a reduction of material removal and a rise in electrode wear.

The second possibility is to interrupt all arcs and cut the energy required to create arcs.

1 PROTIOBLOČNI AVTOMATSKI SISTEM

Naš sistem temelji na uporabi druge možnosti – ustavitve obločnih impulzov – ki zahteva 99-odstotno zanesljivost napovedi obločnih razelektritev. Taka razelektritev je prekinjena v nekaj µs.

Mejo med normalno in obločno razelektritvijo je mogoče določiti za vsak posamični režim (sl. 1.) [1]. Splošno veljavne meje med normalnimi in obločnimi razelektritvami ni. Npr. pri grobi obdelavi ima normalna razelektritev takšno napetost na reži, kakršno ima pri fini obdelavi že obločna razelektritev. Do sedaj ta problem ni bil rešen. Mi smo ta problem rešili z napovedjo, ki, odvisno od trenutnih razmer v reži in nastavljenega režima z 99-odstotno zanesljivostjo, ugotovi, kdaj moramo dovod energije ustaviti, ker se bo sicer razelektritev nadaljevala v obločno razelektritev.

Algoritem za delovanje protiobločnega avtomatskega sistema je realiziran v elektronski napravi EDM–3A, ki krmili elektroerozijski proces v področju:

– časa impulzov: ti = 6 do 1000 µs
– impulznega toka: ie = 2 do 150 A
– pri elektrodnih dvojicah:
  grafit + - jeklo
  baker + - jeklo
  jeklo + - jeklo

2 PREIZKUS NAPRAVE EDM–3A IN PRIMERJAVA NJENE UČINKOVITOSTI S SEDANJIMI REŠITVAMI KRMILJENJA ELEKTROEROZIJSKEGA PROCESA

Uporabniki elektroerozijske obdelave v težkih razmerah zmanjšujejo verjetnost nastanka oblokov s povečevanjem premora med impulzi ali preventivnim odklopom impulzov. To lahko nastavi operater stalno za čas obdelave. V praksi se uporabljajo tudi krmilni sistemi, ki na različne načine analizirajo elektroerozijski proces in nato povečujejo premor med impulzi ali odklapljajo impulze po razelektritvah, ki jih spoznajo za nenormalne [2] do [5]. Pri tem seveda ne morejo ugotoviti, ali bi bili odklopljeni impulzi normalne razelektritve. S takim krmiljenjem je zmanjšan dovod energije in s tem odvzem materiala.

Naša naprava omogoča največji mogoči dovod energije in s tem odvzema material v vsakem posameznem primeru obdelave. Z odklopom obločnih razelektritev pretrga dovod energije le v tistem delu razelektritve, ki postaja obločna in pri obdelavi povzroča nenormalen potek elektroerozijskega procesa in poškodbe na obdelovancu in elektrodi (sl. 3, 4). Tako dosežemo za 15 do 100 odstotkov večji odvzem kakor s sedanjimi krmilnimi sistemi na napravah za elektroerozijsko grezenje.

1 AUTOMATIC-ANTIARCUS-SYSTEM

Our system is based on the second concept – interruptions of arcs – which demands the possibility of 99 % reliability in arc prediction. Such a discharge is interrupted within some µs.

There is no general rule to distinguish a normal discharge from an arc. However, the difference between the two can be determined for any chosen regime (Figure 1) [1]. In the case of a rough regime, for example, the gap voltage of the normal discharge is equal to the voltage of the short circuit discharge in the fine regime. This problem has not yet been solved. We overcome this problem with the use of a prediction system. Depending on the current conditions in the gap and the regime setting, it can predict with 99 % reliability when the energy supply should be interrupted or else the discharge will develop into an arc.

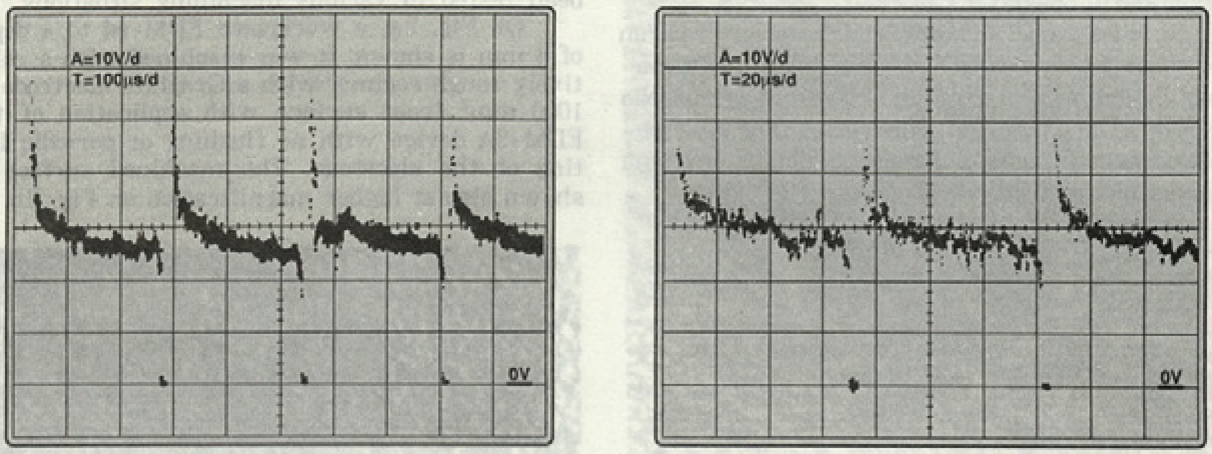
The identification algorithm is built into an electronic device EDM–3A which controls the EDM process in the region of:

– impulse time: ti = 6 to 1000 µs
– impulse current: ie = 2 to 150 A
– using electrode couples:
  Graphite + - Steel
  Cooper + - Steel
  Steel + - Steel

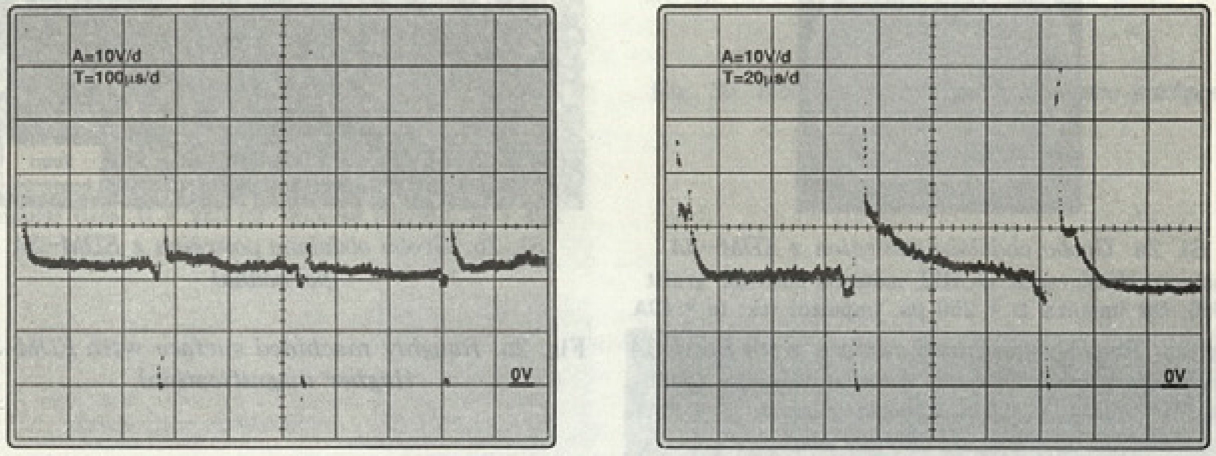
2 EXPERIMENTAL VERIFICATION OF THE EDM–3A DEVICE COMPARED TO EXISTING SOLUTIONS OF EDM PROCESS CONTROL

In rough machining conditions, users of EDM devices reduce the occurrence of a short circuit discharge by augmenting the interval time or by preventive exclusion of pulses. This can be set by the operator for the whole duration of the machining time. A variety of systems exists, which are based on ommitting pulses after discharges which have been identified as abnormal [2] to [5]. By so doing it can not be defined if the impulses that were left out would have generated normal discharges. This kind of control diminishes the energy supply as well as the material removal.

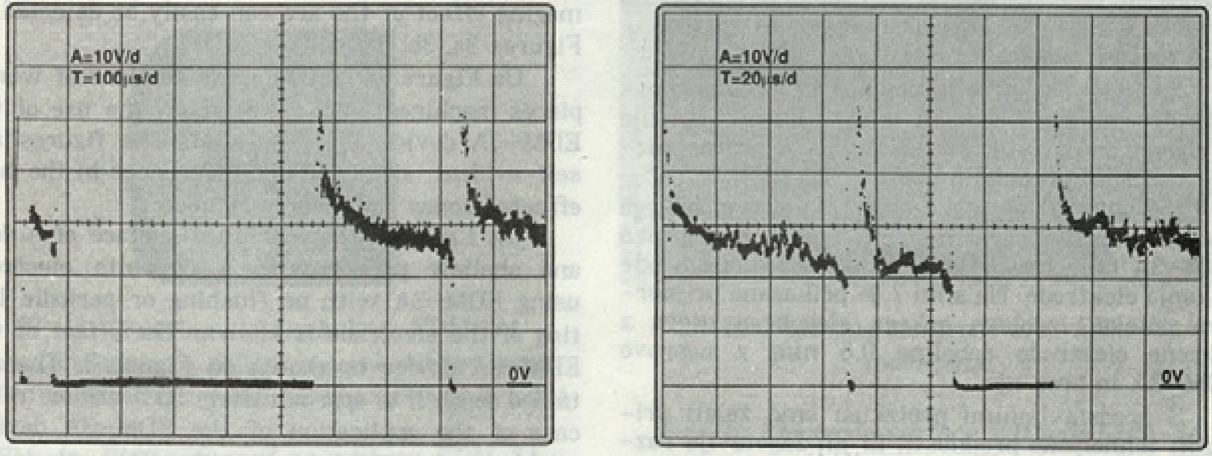
Our device EDM–3A allows the highest possible supply of energy and thus also the highest material removal in each case of machining regime. By interrupting solely the arc energy, abnormal machining conditions both workpiece and electrode damage are avoided (Fig. 3, 4). In this manner, a 15 to 100 % higher material removal rate is obtained, compared to existing EDM sinking control devices.



Sl. 1a. *Oscilogram normalnih razelektritev*
Fig. 1a. *Oscilogram of normal discharges*



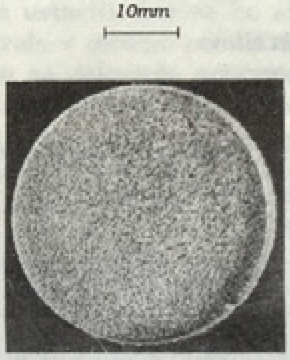
Sl. 1b. *Oscilogram obločnih razelektritev*
Fig. 1b. *Oscilogram of arcs*



Sl. 1c. *Oscilogram s pretrgano obločno razelektritvijo*
Fig. 1c. *Oscilogram of the interrupted arc*

Napravo EDM—3A smo preizkusili na različnih primerih obdelave.

Na sliki 2a je prikazan obdelovanec, erodiran do globine 4 mm z relativno grobo obdelavo z grafitno elektrodo čelne površine 1000 mm^2 z uporabo naprave EDM—3A brez izpiranja in tudi brez periodičnega odmikanja elektrode. Obdelana površina je prikazana tudi pri večji povečavi (sl. 2b).



Sl. 2a. *Grobo obdelana površina z EDM—3A*
material obdelovanca: OCR12, material elektrod: grafit G800, čas impulza: ti = 250 µs, impulzni tok: ie = 40A

Fig. 2a. *Roughly machined surface with EDM-3A*
workpiece 1.2080 , elektrode material: Graphite G800, impulse time: ti = 250 µs, impulse current: ie = 40A

Na sliki 3a je prikazan obdelovanec, erodiran z enakim režimom obdelave in elektrodo (sl. 4a) kakor na sliki 2, z izklopljeno napravo EDM—3A. Do pojava obloka je prišlo že kmalu po začetku obdelave. Na sliki so vidne posledice obloka na obdelovancu in elektrodi. Obdelana površina na obdelovancu (sl. 3b) in elektrodi (sl. 4b) je prikazana tudi pri povečavi.

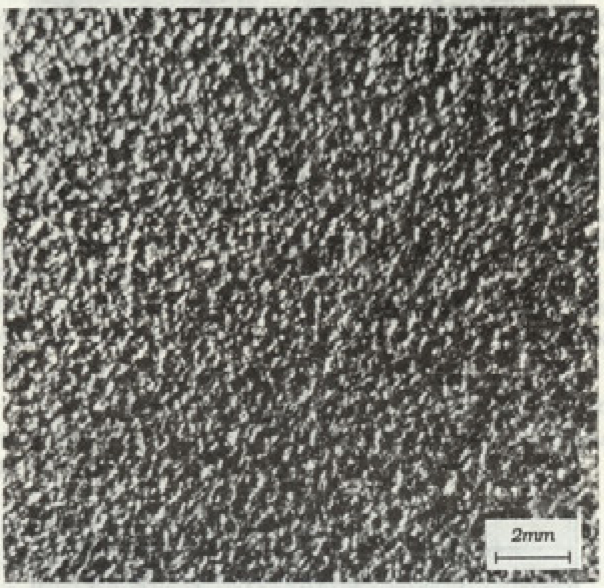
Na sliki 5a je prikazan prerez obdelane površine z napravo EDM—3A in na sliki 5b brez nje za obdelovanca s slik 2 in 3. Vidna je očitna razlika v globini prizadetih plasti.

Na sliki 6 je prikazana izdelava globokega ozkega utora z grafitno elektrodo z napravo EDM—3A brez izpiranja in brez periodičnega odmikanja elektrode. Na sliki 7 je prikazana primerjava poteka, izdelave ozkega globokega utora z bakreno elektrodo debeline 0,8 mm z napravo EDM—3A in brez nje.

S predstavljenimi preizkusi smo želeli prikazati tehnološke prednosti, ki jih zagotavlja razviti sistem EDM—3A. Sistemi EDM—3A so se že uveljavili v praksi in so vgrajeni na naprave EDM v Sloveniji, na Švedskem, v Nemčiji in ZDA.

The performance of the EDM—3A device has been tested in various machining situations.

On Fig. 2a, a workpiece EDM-ed to a depth of 4 mm is shown. It was machined with a relatively rough regime, with a Graphite electrode of 1000 mm^2 front surface with application of the EDM-3A device with no flushing or periodic lifting of the electrode. The machined surface is shown also at higher magnification on Fig. 2b.



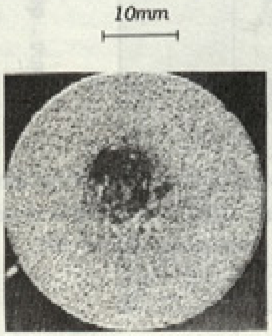
Sl. 2b. *Grobo obdelana površina z EDM—3A (povečana)*

Fig. 2b. *Roughly machined surface with EDM-3A (higher magnification)*

Figure 3a shows the workpiece machined at the same machining setting and the same electrode (Fig. 4a) but without the use of EDM—3A device. The occurrence of the arc was detected at the very beginning of the machining. The damaging effect of the arc can easily be detected on Figures 3a, 3b, 4a, 4b.

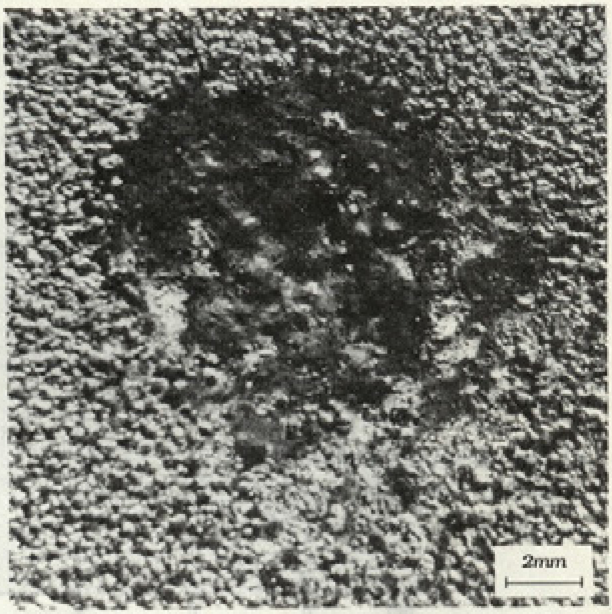
On Figure 5a and 5b cross sections of workpieces machined with and without the use of the EDM—3A device are presented. The figures are self-evident, since the big differences in the heat effected zones can clearly be seen.

On Figure 6 the machined surface of a deep and shallow pocket with a Graphite electrode using EDM—3A with no flushing or periodic lifting of the electrode is shown. The effect of the EDM—3A device is shown on Figure 7. The attained depth h is approximately 30 % higher in the case of the application of the EDM—3A device, within the same machining time. The experiment was carried out with a Copper electrode of 0.8 mm diamater.



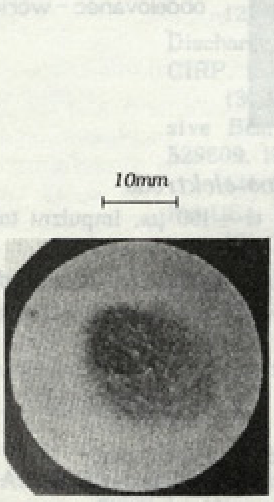
Sl. 3a. *Grobo obdelana površina brez EDM–3A*
material obdelovanca: OCR12, material elektrod: grafit G800, čas impulza: ti = 250 μs, impulzni tok: ie = 40A

Fig. 3a. *Roughly machined workpiece surface without EDM-3A*
workpiece 1.2080, electrode material: Graphite G800, impulse time: ti = 250 μs, impulse current: ie = 40A



Sl. 3b. *Grobo obdelana površina brez EDM–3A (povečana)*

Fig. 3b. *Roughly machined workpiece surface without EDM-3A (higher magnification)*

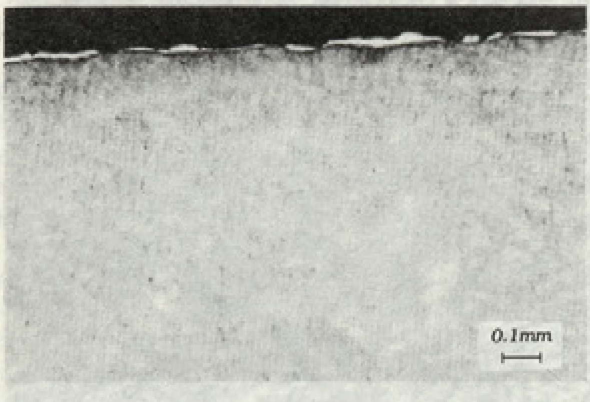


Sl. 4a. *Površina elektrode brez EDM–3A*
material obdelovanca: OCR12, material elektrod: grafit G800, čas impulza: ti = 250 μs, impulzni tok: ie = 40A

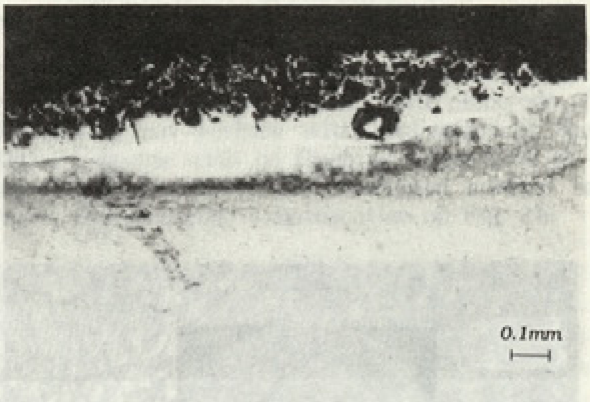
Fig. 4a. *Electrode surface without EDM-3A*
workpiece 1.2080, electrode material: Graphite G800, impulse time: ti = 250 μs, impulse current: ie = 40A

Sl. 4b. *Površina elektrode brez EDM–3A (povečana)*

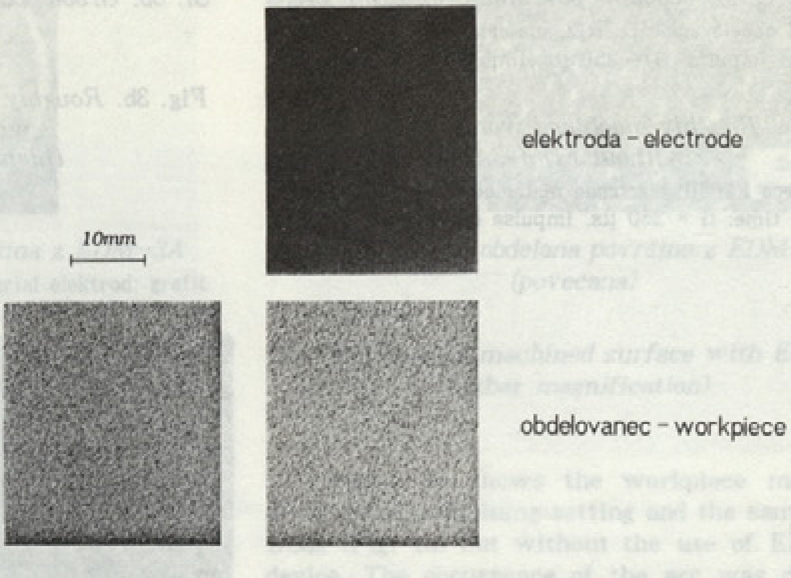
Fig. 4b. *Electrode surface without EDM-3A (higher magnification)*



Sl. 5a. *Prerez obdelane površine z EDM–3A*
Fig. 5a. *Machined workpiece cross section with EDM-3A*



Sl. 5b. *Prerez obdelane površine brez EDM–3A*
Fig. 5b. *Machined workpiece cross section without EDM-3A*



Sl. 6. *Prerez globokega ozkega utora z grafitno elektrodo*
material obdelovanca: OCR12, material elektrod: grafit EDM3, čas impulza: ti = 150 μs, impulzni tok: ie = 60A

Fig. 6. *Cross section of the narrow pocket machined with a graphite electrode*
workpiece 1.2080, electrode material: Graphite EDM3, impulse time: ti = 150 μs, impulse current: ie = 60A

3 SKLEP

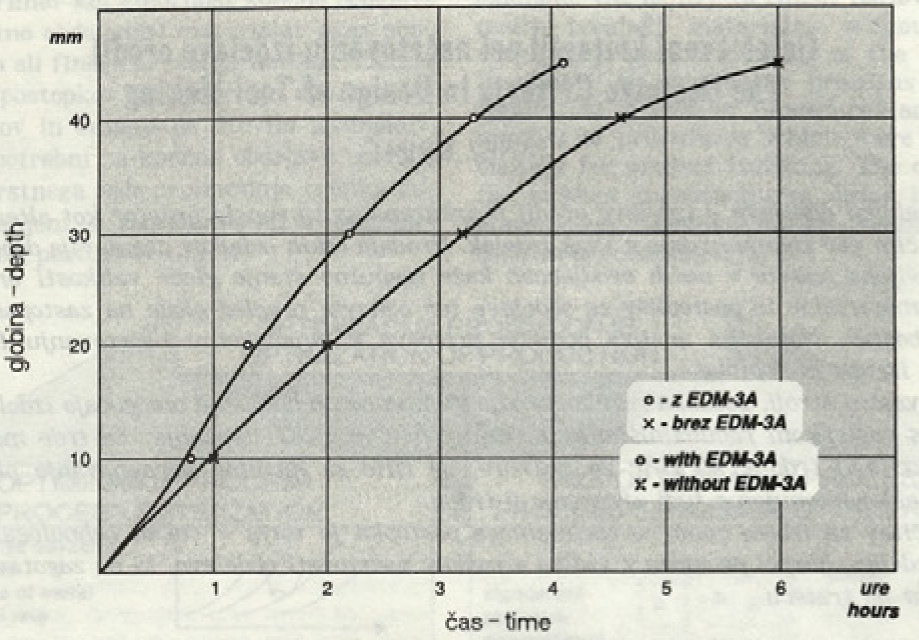
Izvedba procesa brez obločnih razelektritev omogoča največjo mogočo izkoriščenost elektroerozijske naprave za elektroerozijsko grezenje.

Sistem EDM–3A prepreči le dovod škodljive energije. V dobrih razmerah dela postopka ne moti. Sistem EDM–3A je popolnomam avtomatski sistem. Samo avtomat daje absolutno varnost proti oblokom, ker avtomatične enote ne moremo napačno nastaviti.

3 CONCLUSION

The application of the EDM–3A device enables a process without arcs, thus assuring high effectiveness of EDM sinking devices.

The system EDM–3A interrupts the supply of the damaging part of the energy. In favorable process conditions, it does not unecessarily disturb the process. The system in completely automatic and assures complete prevention against arcs.



Sl. 7. *Prikaz poteka izdelave ozkega utora z bakreno elektrodo z EDM–3A in brez njega*
material obdelovanca: OCR 12, material elektrod: ECu, čas impulza: ti = 300 μs, impulzni tok: ie = 23 A

Fig. 7. *Depth versus time of machining a narrow pocket with and without EDM-3A*
workpiece 1.2080, electrode material: ECu, impulse time: ti = 300 μs, impulse current: ie = 23A

4 LITERATURA
4 REFERENCES

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