Optimal Eroding Surface Regions of the EDM Rough Regimes

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ABSTRACT:

The machining parameters of the EDM process are assembled in different rough and different fine machining regimes. The selection of the rough regime depends on the size of the eroding surface. The optimal regions of the eroding surfaces for different rough regimes are established according to the following criteria: material removal rate, relative electrode wear and surface integrity. The obtained regions are compared with the regions given by the machine manufacturer. The established optimal regions will be used by the system for automatic selection of the rough regime.

Keywords: *Electric discharge machining, optimal eroding surface regions.*

1. Introduction

The EDM machining parameters are grouped into different machining regimes. Some of them are suitable for rough and some for fine machining. When machining with EDM, the appropriate machining regime must be selected. Like in all machining processes, also in EDM machining rough and fine machining regimes are distinguished. During rough machining relatively high material removal rate and bad surface roughness are achieved where as during fine machining good surface roughness and relatively low material removal rate are achieved. The fine machining regime is selected according to the required surface integrity on the other hand rough machining regime is selected according to the eroding surface [3]. The presented paper deals with the selection of the rough regime. The task of this work was to find the optimal eroding surface regions for three types of roughing regimes. The technological tables assembled by the manufacturer of the EDM machine include regions of optimal sizes of the eroding surfaces for each rough regime.

2. Experimental Arrangement

The experiments were done on an IT E 200M-E machine with isoenergetic generator. The workpiece material was hardened steel 210CR12 with hardness HRc = 60. The electrode material was electrolytic copper and the dielectric was Erozol 25, which is suitable for all machining regimes. The electric current signals in the gap were acquired by the measuring system presented in Fig. 1 with a sampling rate of 83333 kHz. The experiments were undertaken with three different roughing regimes. Each of the regimes is suitable for certain range of eroding surface sizes A_r as shown in Table 1, where the setup parameters for all regimes are presented, too. Regimes are taken from technological tables. Each technological table contains regimes for rough, intermediate and fine machining, which are suitable to machine the given size of eroding surface by the selected flushing of the gap and the selected electrode wear. Table 08, table 12 and table 16 contain regimes suitable to machine workpieces with flushing of the gap and very small electrode wear is achieved. Table 08 contains regimes, which should be applied on eroding surfaces smaller than 25 mm^2 and roughing machining regime from table 08 is denoted as regime t08. Table 12 contains regimes, which should be applied on eroding surfaces in the range from 25 mm^2 to 900 mm^2 and roughing machining regime from table 12 is denoted as regime t12. Table 16 contains regimes, which should be applied on eroding surfaces larger than 900 mm^2 and roughing machining regime from table 16 is denoted as regime t16. The setup parameters are denoted as follows: free voltage u_i, pulse current I_e, discharge duration t_e and pulse interval t_o. Each machining regime was applied on 9 electrodes with plane machining surfaces but different diameters, the sizes of eroding surfaces were defined by the diameter of the electrode. The experiments were repeated three times, thus three sets of experiments were done with each machining regime. The output of each experiment is the electric current signal carrying more than 500 discharges. During the experiments the signals were saved into files and kept for further processing.

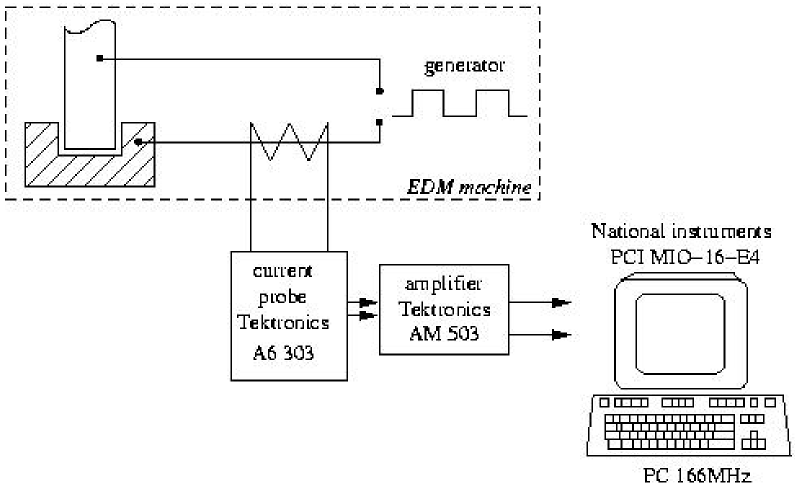


Figure 1 Experimental arrangement.

3. Process Stability

Prediction is that optimal eroding regions are given upon a stability of the process, which is measured by percentage of arc discharges [1,2]. There are two reasons for arc discharges. First reason is dirty slot between electrode and the workpiece and second reason is to high density of electrical current in the slot [3]. In this work amongst arc discharges many other parameters were measured to fined real optimal eroding surfaces.

The percentage of arc discharges, which determine the process stability is given in Fig. 2. Smaller percentage of arc discharges determines more stable process and consequently higher material removal rate. If percentage of arc discharges is less than 15 %, the process is stable. Regime t08 becomes stable when eroding surface is larger than 20 mm^2. The percentage of arc discharges is around 5 % on surface of 90 mm^2 and increases up to 15 % by increasing the size of the surface. Regime t12 achieves 34 % of arc discharges on the surface of 5 mm^2 and then falling down on 7 % on the surface of 2300 mm^2. On the surface of 70 mm^2 regime t12 becomes stable because percentage of arc discharges falls under 15 %. Regime t16 which has 43 % of arc discharges on the surface of 5 mm^2, becomes stable on the surface of 80 mm^2 and then decreases to 5 % when machining the surface of 2300 mm^2.

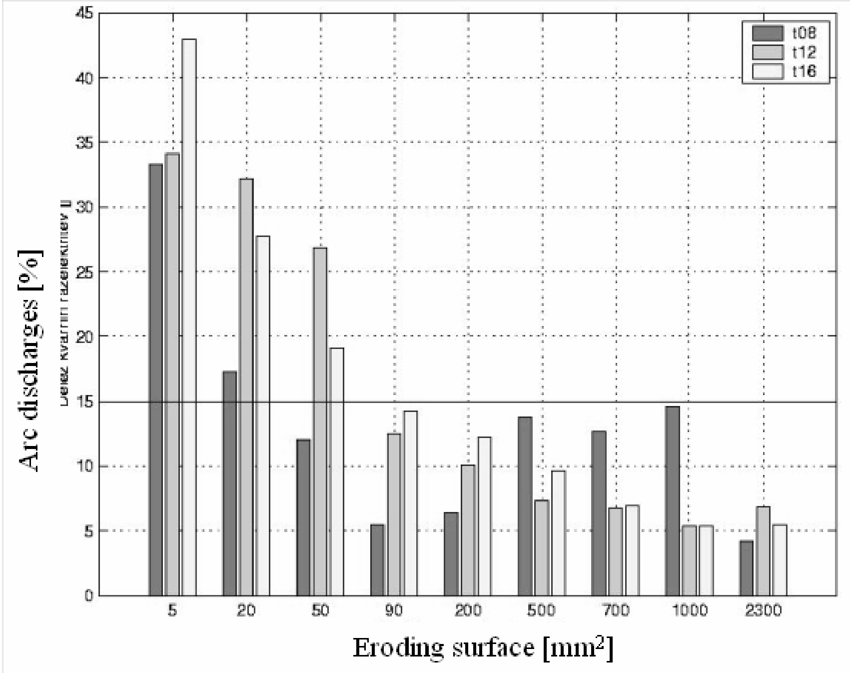


Figure 2 Arc discharges.

4. Measurements

4.1 Surface Texture

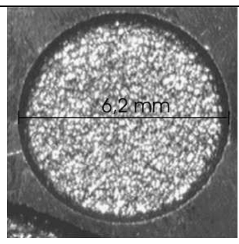
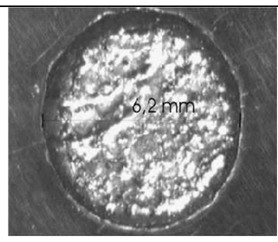
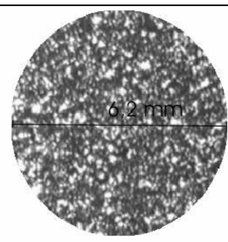
A surface of 30 mm^2 machined with the regime t08 is shown in Table 1 a). The regime t08 is roughing regime appropriate to machine any size of surface, but it is optimal regime to machine surfaces smaller than 25 mm^2. It gains a relatively high discharge frequency, but the power of each discharge is small, that is why relatively fine surface is achieved.

To machine the surface given in Table 1 b) regime t16 was used. The size of the eroded surface is the same as in previous case, but the machining regime suitable to machine surfaces bigger than 900 mm^2 was applied. The regime t16 has lower discharge frequency, than regime t08, but the energy of the discharge is far greater then in the case of regime t08. The surface is remelted and the boundaries between single craters are not clear as in two other examples (Table 1 a), c)).

Regime t16 was also applied on appropriate size of eroding surface and the result of surface texture is shown in Table 1 c). The craters are noticed as well as in Table1 a).

In all cases the surface texture is random, but in case of high power density in the gap the boundaries of the craters are remelted.

Table 1 Surface texture.

	a)	b)	c)
Regime	t08	t16	t16
Size of eroding surface [mm^2]	30	30	1250
Surface texture			

4.2 Surface roughness

Fig. 3 shows surface roughness achieved during the experiments. First have a look on the surface roughness when machining with regime t08. When the size of eroding surface is 20 mm^2 the surface roughness measured by parameter Ra is around 4 µm. On larger surface (50 mm^2) the surface roughness parameter Ra is 5 µm. That is easily explained because the density of electric power is smaller when machining bigger surfaces. The craters are more apart and the surface is rougher then on smaller surfaces where the craters are remelting each other and the surface is smoother.

Regime t12 acts very similar on small surfaces. Surface roughness is getting bigger if surface is increasing, but then on surfaces with more than 50 mm^2 surface roughness decreases.

Regime t16 achieves surface roughness more or less the same on all sizes of the eroding surfaces and it is around 10 µm.

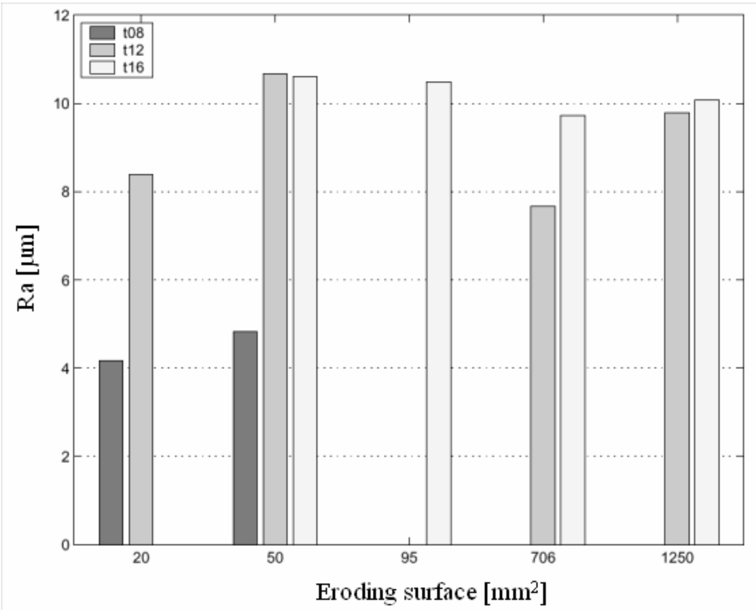


Figure 3 Surface roughness of workpieces.

4.3 White layer

In the Fig. 4 the white layer thickness is shown in respect to different machining regimes and different sizes of the eroding surfaces. The regime t08 produces the smallest white layer thickness (about 15 µm) compared to the other machining regimes since it achieves the smallest power in the gap.

The regime t12 is achieving the biggest white layer thickness (around 48 µm) on the smallest eroding surfaces, due to the highest power density. On larger surfaces the white layer thickness is decreasing, but only to the size of the 95 mm^2. On surfaces larger than 95 mm^2 the white layer thickness is increasing again.

The same behavior can be noticed in the case of regime t16.

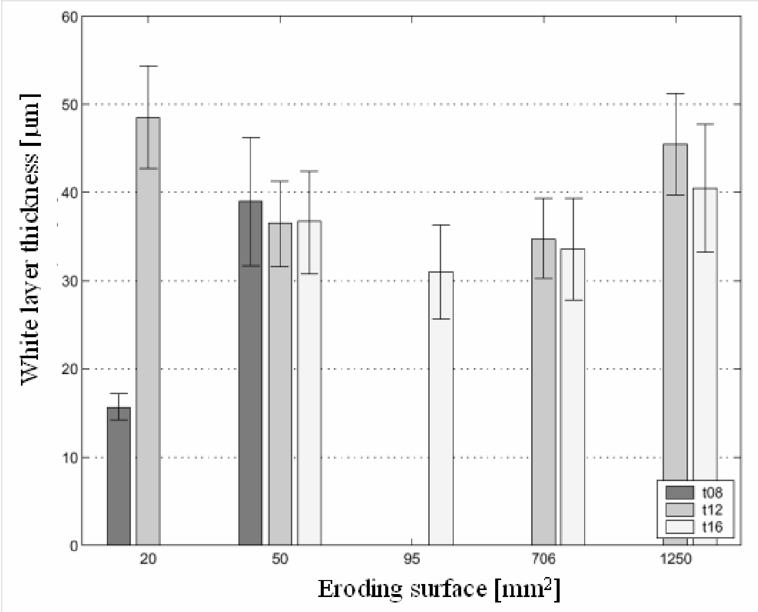


Figure 4 White layer thickness.

4.4 Classification and number of cracks

The number of cracks on the surface when machining with different regimes is shown in Fig. 5.

For better comparison number of cracks are given per one millimeter. Cracks were classified in three classes: deep, thick and thin. The most important are deep cracks. That is why the number of deep cracks must be minimized, because all other cracks together with white layer are removed by fine machining regimes, which follows after rough machining regimes. The deep cracks are not removed because they are deeper than the white layer.

The regime t08 is causing the smallest number of cracks on the smallest surface, but on larger surfaces the number of cracks raises and is bigger than those made with regime t12.

The regime t12 is also making small number of cracks on the smallest surface but then the number raises with the size of the surface.

The same results are achieved by the regime t16.

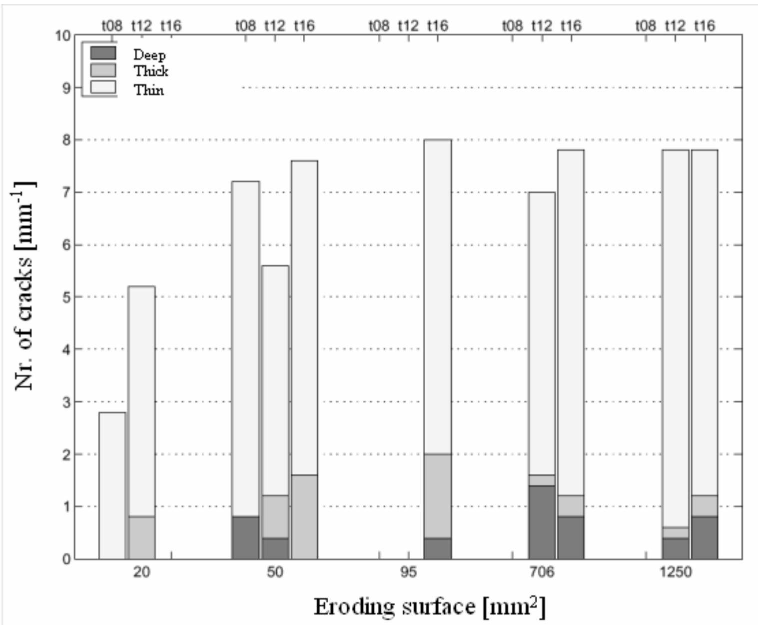


Figure 5 Classification and number of cracks.

4.5 Material removal rate

In Fig. 6 material removal rate is shown for our three regimes and on our tested eroding surfaces.

The regime t08 has a maximum material removal rate at surface of 30 mm^2 and that is one of the main reasons to establish 30 mm^2 as a boundary value of the size of the eroding surface, between regimes t08 and t12.

Removal rate of the regime t12 is increasing till the eroding surface of 706 mm^2. On larger surfaces the removal rate is uniform.

On the surface region of 50 mm^2, the regime t16 achieves higher material removal rate than regime t12. In the case of the regime t16 the removal rate does not become uniform on the tested sizes of the eroding surfaces.

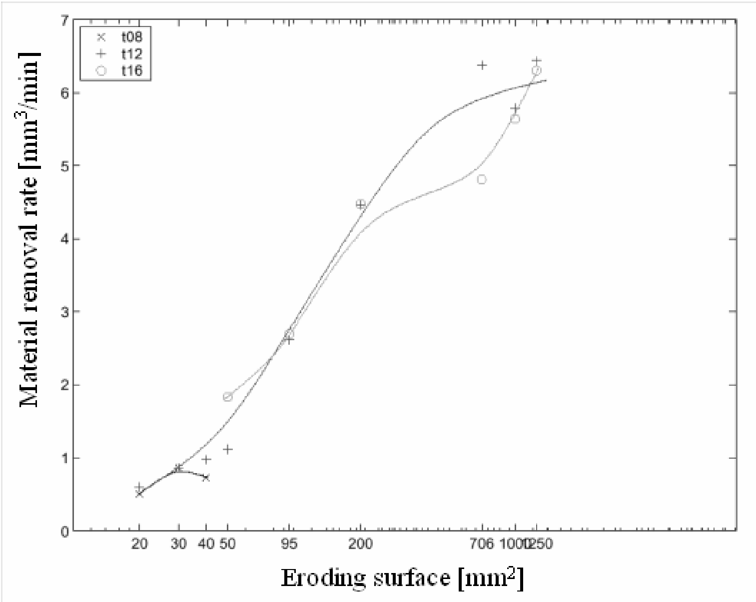


Figure 6 Material removal rate.

4.6 Relative wear of the electrodes

The relative electrode wear is presented in Fig. 7 when using different regimes on different sizes of the eroding surfaces.

The regime t08 is causing the smallest relative wear of the electrode, when machining surfaces with the area less than 40 mm^2. Little decreasing of the wear can be noticed when using regime t08 on larger surface areas, somewhere around 0.003 at surface areas between 20 and 40 mm^2.

The regime t12 is causing four times higher relative electrode wear than regime t08 on the surface of 20 mm^2, but then again on the surface of 40 mm^2 it causes almost the same relative electrode wear as regime t08. Comparing regimes t12 and t16, the former is better when machining surfaces smaller than 50 mm^2. For machining the surfaces larger than 95 mm^2 both regimes are appropriate since the relative electrode wear is around zero.

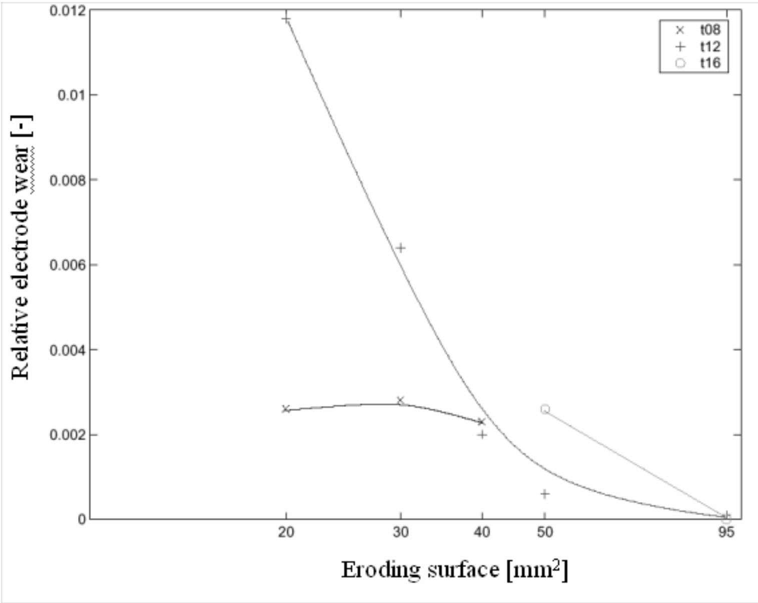


Figure 7 Relative wear of the electrodes.

5. Boundaries between the regimes

Now there is enough data to place borders between the three regimes. The regime t08 has the biggest material removal rate at 30 mm^2 and when the size of electrode surface equals to 40 mm^2 the regime t12 has a smaller electrode wear than the regime t08. Therefore 40 mm^2 is the boundary between regimes t08 and t12. The boundary between the regimes t12 and t16 can be found somewhere between 706 and 1250 mm^2. Since the electrode wear is negligible when machining surfaces of that size, the material removal rate and the white layer thickness have the biggest influence on the boundary between those regimes. That is why the boundary between regimes t12 and t16 is the region of eroding surfaces from 706 mm^2 to 1250 mm^2. The boundaries are given in Fig 8.

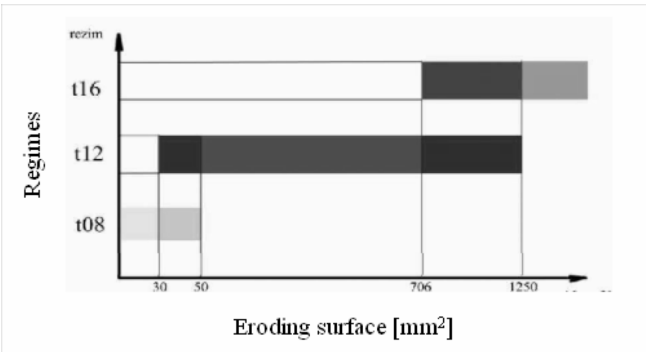


Figure 8 Useful surfaces for given regimes.

6. Conclusions

The boundaries given in technological tables are not correctly placed. The boundary between regimes t08 and t12 should be set from 25 mm^2 to 40 mm^2, since regime t12 is not stable enough when machining surfaces smaller than 40 mm^2. The boundary between regimes t12 and t16 is in technological tables set to 900 mm^2. But according to our results it should be the region from 706 till 1250 mm^2.

7. Literature

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