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MACHINABILTY OF SLEIPNER COLD WORK STEEL WITH WIRE ELECTRO DISCHARGE MACHINING

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Abstract: *Machining techniques in the industry generally, modern processing techniques, that come between wire discharging machine, especially mold, defense, aircraft and aerospace industry, is often used. Processing, which is difficult with conventional manufacturing methods, the complex surface forms, the different material types, hard and is capable of handling high dimensional accuracy and surface roughness [1]. This manufacturing technique were carried on Uddeholm Sleipner cold-work tool steel, variable parameters with On time duration, feed rate, and the current value, as fixed parameters off time duration, voltage, pressure of fluid circulation, velocity of wire, wire tension and wire diameter. Surface roughness of the surface was shown changes as a result of the experimental parameters, diameter and circularity deviation values were studied.*

Keywords: *Surface roughness, wire electro discharging machining operation, Sleipner cold work tool steel*

1.INTRODUCTION

Wire discharge machining method, which is one of modern processing techniques, located within the dielectric fluid in a continuous stream from the work piece based on a brass or bronze wire arc cutting the material removal by means of the principle of non-contact method of working with energy flow. Arc is contained in the amount of power varies depending on the amount removed from the chip. Work pieces need to be conductive material for machining at wire discharge machine, however, hardness values are not affect the ability of chip removal and indispensable, especially generalized the mold making industry has been one to use. Hardened work pieces with complex geometries have precision dimensional tolerances during machining, although it is possible to achieve the desired surface roughness values. As shown in Figure 1 and do not have the classic processing geometric patterns, straight or angled forms can be machined with high precision, free of burrs in the surface roughness. It is not further possible to implementation of the geometric forms by conventional machining methods. In reviewing the literature, Khan and Saifuddin[3], were examined wear of copper and aluminum electrode, on stainless steel and carbide formed during processing electro-erosion.

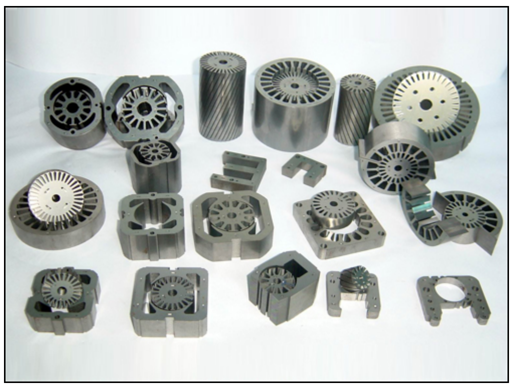

Figure1. Sample cutting with wire electro discharging machine [2]

As a result of the study shown that aluminum electrode was left a smoother surface than copper electrode, on stainless steel and carbide. Guu [4], was worked on imaging surface of implemented electro discharge machining AISI D2 tool steel by atomic force microscopy

(AFM). Prabhu ve Vinayagam [1], was researched AISI D2 tool steel material surface characteristics implemented electric discharge Machining process with Single wall carbon nano tubes. Observed that the surface roughness and micro-fractures increased proportionally with the power.

Ay and Aydoğdu [5] were worked experimental investigation of the effects of cutting parameters on the dimensional changes of the part size, by wire erosion technique. Wire erosion technique cutting parameters were optimized by Taguchi optimization technique and with predictive values reached regression model. Medfai et al. [6], studied electro-modeling parameters of the effective cutting on erosion technique. Electrode wire erosion process as a basis, the work piece, dielectric fluid, as the number of pulses generated by current and voltage are able to shown [7]. During to continuously flow of the wire, the arc is discharged through the dielectric fluid on the material. Electrical discharge process, where applied on material particle rupture that occurs depending on the density of population. Electrical discharge creates impact pressure that away the molten material ensued dielectric blast, and most of need to be evacuated over the material removes particles [8]. Residues the nature of the crater has the effect of surface roughness. In addition, U and V coordinates of the upper nozzle are sliding with the angle by cutting part of providing great flexibility to allow the reshape of the work piece [9]. The principle of the wire erosion is shown in Figure 2.

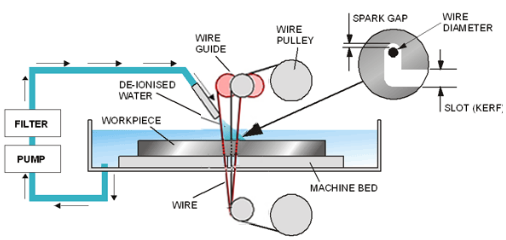

Figure 2. Schematic of wire erosion process [10]

Machine manufacturers cannot be expected to give processing parameters all kinds of the material. Therefore, manufacturers share common steel processing parameters with users [11].So, processing parameters are expressed as tool steels, and tool steel grades overlooked. Known as cold work tool steel industry, which is one of Uddeholm Sleipner tool steels, cold work tool steel with respect to steel degrees in various areas productions successfully implemented. Cutting of hard and thin sheet metal in industrial applications (such as patterns of lamination) and used in making molds requires high lifetime and low-maintenance processes. Metal cutting and forming applications of up to 3mm iron and steel plants, in short, used in sheet metal forming. Sleipner tool steel, due to the frequency of usage locations, used in applications where the high abrasion resistance required. Industrial applications, known as chipping, micro-cracks in the edge of running the tools and are mainly grown in a short time with each other to cause the breaking of combining high resistance against cutting the corner piece [12], high toughness, the high compression strength, good resistance to tempering and surface processes that require compliance with used in applications where [13].In this study, wire EDM pulse on time, table feeding, and the current value of the parameter values for on Sleipner cold work tool steel material were investigated. Parameters, pulse off time, voltage, fluid circulation pressure, wire speed and wire diameter of the experiments were carried out according to fixed parameters. As a result of experiments, surface roughness, dimensional accuracy and the amount of deviation from circularity values were measured and evaluated.

2. EXPERIMENTAL STUDIES

2.1. Materials and Specimen Preparation

Experimental study of the material used in the Sleipner Uddeholm cold work tool steel chemical composition of the product is given in Table 1.Sleipner degree of tool steel in the manufacturing sector are chosen often used in such as long lasting and multi-purpose sheet metal forming and plastic injection mold. The materials used are processed from ingot material was then surface leveling. Parallelism of the specimens was applied only after the pilot hole for WEDM.

Table 1. The chemical composition of Uddeholm Sleipner cold work tool steel material, (% ratio)

C	Mn	Cr	Mo	V	Si
0,90	0,5	7,8	2,5	0,5	0,90

High wear resistance, high resistance to bending rim, high toughness, good compression strength, high hardness, resistance to tempering heat treatment, the high dimensional stability, as well as good out of wire erosion technique in the literature regarding the processing of this material has been important factor in the selection of material related to the absence of much research. Sleipner cold work tool steel hardness is 225 HV. The physical properties of the product are shown in Table 2.

Table 2: Physical properties of Uddeholm Sleipner cold work tool steel

Temperature °C	20	200	400
Density (g/cm^3)	7,73	7,68	7,60
Coefficient of thermal expansion	-	11,6x10-6	12,4x10-6
Thermal Conductivity (W/M°C)	-	20	25
Modulus of elasticity (MPa)	205000	190000	180000
Specific Heat (j/Kg °C)	460	-	-

30x240x24 mm prepared test samples are shown in Figure 3.

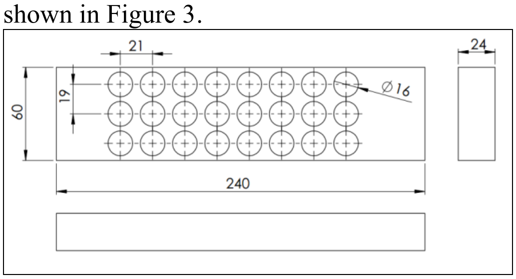

Figure 3. Experimental specimen

Wire erosion with the image taken during the experiment shown in Figure 4.

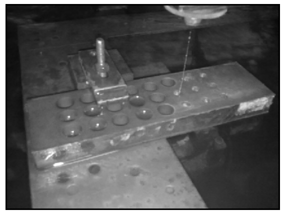

Figure 4. Form of the experimental wire electro discharging machining

Ø 0,30 mm diameter CuZn40 brass electrode ,tensile strength of 1000 N/mm2, wire used in wire electro discharging machine.

2.2. Drilling Operations

Experimental study is executed on Makino U32 model device and machine specifications are shown in Table 3.

Table 3. U32 Makino wire EDM model specifications

Working range (mm)	Accuracy (mm)
X=350 Y=250 Z=220 U=+/-15 V=+/-15	0,002

The effect of processing wire erosion machines, on time duration, feed rate, and current values are set to indicate 10% variability. The base values, Makino machine manufacturer that we use an experimental study, the values given for the processing of tool steels. But some of the values given by the top or bottom values of the parameters of the machine supported because they constitute the base values could not be the middle value. The machine manufacturer's values, variable values and a list of constant values are shown in Table 4.

Table 4. The parameters used in the experiment

Fixed Parameters			
Velocity Of Wire, VW (m/min)	12	Off time (µs)	17
Wire dimension, WD (mm)	0,3	Voltage, V, (V)	40
Wire Tension, WT (kg)	9	Circulating cooling fluid pressure, CP (kg/cm2)	5

Variable Parameters

On time (µs)	12,39	Feed rate (mm/min)	4
(on time is variable.	13,77	(Feed rate is variable.	4,45
Current 34 A and feed	15,3	On time15 µs and	4,95
rate 4,75 mm/min	17	Current 34 A	5,5
parameters are		parameters are	
choosen)		choosen)	
Current (A)	28,43	Machinery manufacturer suggested parameters	
(Current is variable.	31,59	On time (µs)	17
On time 15 µs and	35,1	Feed rate, SF	5,5
Feed rate 4,75		(mm/min)	
mm/min parameters	39	Current, IP (A)	39
are choosen)			

Values determined for experiments were executed all specimens as Ø16mm hole forms for each variable is given and a total of 12 holes as 3 patterned on 4 distinct specimen groups processed, and these measurements were investigated in holes (dimensional deviation, circularity deviation and average surface roughness) were included.Graphics formed the data obtained from experiments. After finishing machining, holes and the surfaces was measured by the CMM (Coordinate Measuring Machine) with the diameter of the hole geometry of the amount of deviation and deviation from circularity. Hole surface roughness was measured with, the surface roughness the device. The measured parameters are given in Table 5 below.

3. EXPERIMENTAL RESULTS AND DISCUSSION

3.1. Assessing the Quality Surface

In experimental study, against the varied parameters, removed different amount of chips and different temperature values intensities were constituted .The reason why is unable to leave the particles are fully determined, and this has resulted in the formation of the topographical surface structure differences. Depending on the values of the parameters used in the experiment of the surface roughness (Ra) charts are presented in the chart below.

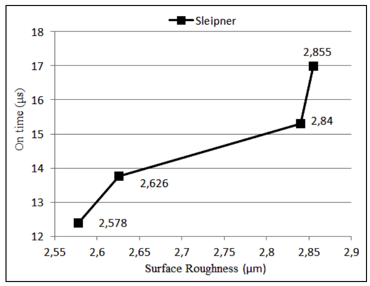

Figure 5. Effect of surface roughness against on time duration (IP : 35,1A - SF:4,95mm/min - V:40V - Off time:17µs - CP: 5kg/cm2 - VW: 12m/min - WD: 0,3mm - WT: 9kg)

Proportional increase in surface roughness with the increase of on time duration in Figure 5 is shown. Although a 10% increase the variable parameter the on time duration, the first 1%, the other is the increase in the amount increased by 8% and 5% on results. Increase the size of the crater of on time duration increases, so also means increasing roughness. Graphics also defends this thesis.

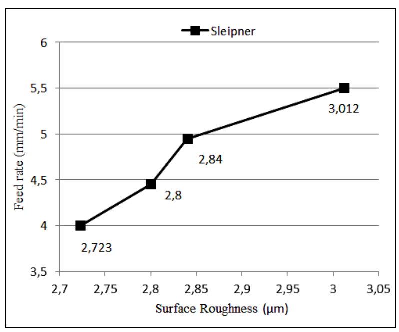

Figure 6. The effect of surface roughness against feed rate (IP : 35,1A – On time: 15,3µs - V:40V - Off time:17µs - CP: 5kg/cm2 - VW: 12m/min - WD: 0,3mm - WT: 9kg)

Table 5. The results of experiments parameters depending on the WEDM

Test Code	Feed rate (mm/min)	Current A (A)	On time (µs)	Diameter Deviation (mm)	Circularity Deviation (mm)	Surface Roughness (µm)
TS-1-1	4,95	35,1	15,3	0,013	0,002	2,83
TS-1-2				0,009	0,004	2,882
TS-1-3				0,021	0,013	2,809
TS-2-1	4,45	35,1	15,3	0,004	0,014	2,795
TS-2-2				0,009	0,004	2,909
TS-2-3				0,014	0,006	2,697
TS-3-1	5,5	35,1	15,3	0,025	0,016	3,021
TS-3-2				0,26	0,019	3,004
TS-3-3				0,19	0,007	3,012
TS-4-1	4,95	31,59	15,3	0,013	0,001	2,627
TS-4-2				0,018	0,004	2,751
TS-4-3				0,021	0,06	2,561
TS-5-1	4,95	39	15,3	0,016	0,005	2,923
TS-5-2				0,023	0,004	2,914
TS-5-3				0,02	0,009	3,005
TS-6-1	4,95	35,1	13,77	0,007	0,008	2,844
TS-6-2				0,003	0,003	2,633
TS-6-3				0,007	0,012	2,4
TS-7-1	4,95	35,1	17	0,012	0,005	2,986
TS-7-2				0,023	0,007	2,863
TS-7-3				0,024	0,011	2,716
TS-8-1	4,95	28,43	15,3	0,016	0,028	2,621
TS-8-2				0,027	0,037	2,577
TS-8-3				0,025	0,029	2,519
TS-9-1	4	35,1	15,3	0,008	0,011	2,729
TS-9-2				0,009	0,006	2,729
TS-9-3				0,005	0,008	2,718
TS-10-1	4,95	35,1	12,39	0,006	0,006	2,564
TS-10-2				0,005	0,008	2,588
TS-10-3				0,005	0,007	2,578

At figure 6, surface roughness value of table feeding 2%, 1% and 6% increase in is observed. Means that the cutting speeds of feed rate. So how much slower the cutting speed, surface roughness could be obtained by a cut in the more critical. Against the parameters, that the rate of increase of surface roughness on the precision represents the cold work tool steel.

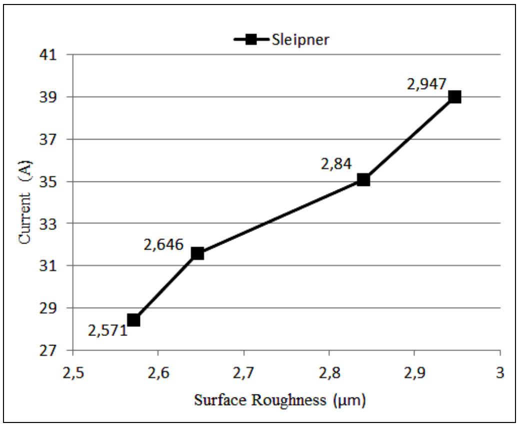

Figure 7. The effect of surface roughness against current value (SF:4,95mm/min – On time: 15,3µs - V:40V - Off time:17µs - CP: 5kg/cm2 - VW: 12m/min - WD: 0,3mm - WT: 9kg)

Figure 7 shows 2%, 7% and 1% increase were considered the effect of surface roughness in raises the current of the main power machine.Despite a 10% increase in the parameter, the values remained below the rate of increase in these values. In addition, Lower values was observed that less roughness. Increase the the current level means increase applied power , but higher level of power revealed not show the same sensitivity to roughness.Generally speaking, wire EDM machines, against the varying parameters, surface roughness usually proportionally rise.

3.2. Evaluation Of Dimensional Accuracy And Circularity Deviations

Material machining, product design is considered to achieve the desired geometric tolerance, and in the process of making it the first time to perform the operation and the biggest target of the manufacturer. This way will increase work efficiency, reduced undesirable expenses and losses. Experimental studies, the tolerance values obtained from different cutting speeds are shown graphically in Figure 8.

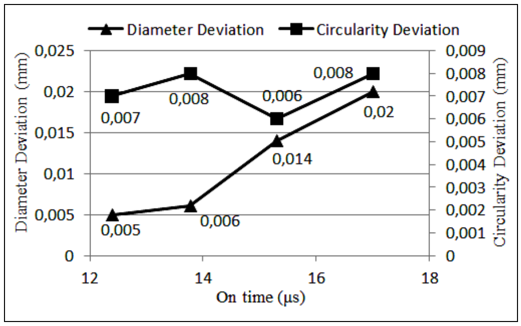

Figure 8. The effect of surface roughness against on time duration (IP : 35,1A - SF:4,95mm/min - V:40V - Off time:17µs - CP: 5kg/cm2 - VW: 12m/min - WD: 0,3mm - WT: 9kg)

Parameters as in Figure 8 analyze the individually with on time duration value, increase of 20% at the beginning and following varies increase of 42% and 133% was seen. Up to 14% after increase of deviation from circularity, the increase in the second and the third parameter the amount has increased by -25% and 33%. Therefore, increasing on time deviation from circularity of such a tendency was observed to increase the not observed diameter deviation .However, the value obtained during 15,3 µs, the formation of a better level than the other data are noteworthy.

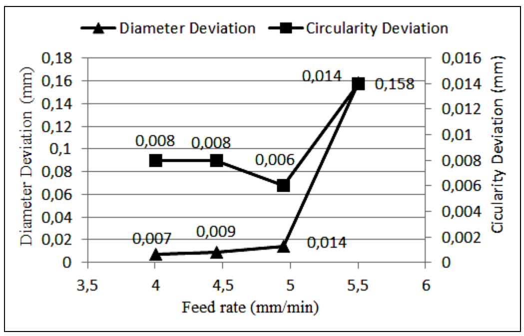

Figure 9. The effect of surface roughness against feed rate (IP : 35,1A – On time: 15,3µs - V:40V - Off time:17µs - CP: 5kg/cm2 - VW: 12m/min - WD: 0,3mm - WT: 9kg)

Values increase in Figure 9, the feed rate from 4.45 mm/min value to 5.5 mm/min value, an increasing is observed around 1028% at diameter of deviation. This increase in value in advancing the critical threshold value table shows that in this range. The circularity deviation values are not show certain stability appears as a graphic and 4.45 mm/min value of the most successful results obtained from the observed value. Deviation diameter 4.45 mm/min to 5.5 mm/min during the transition from a value of 133% increase was seen that this value is between these two values indicates the critical threshold.

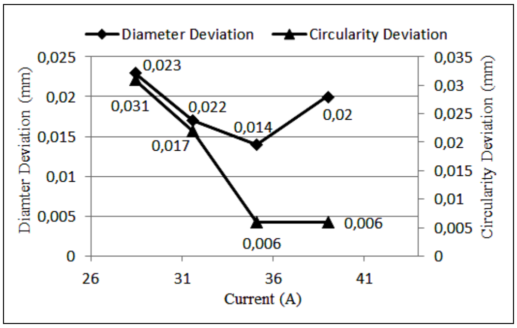

Figure 10. The effect of surface roughness against current (SF:4,95mm/min – On time: 15,3µs - V:40V - Off time:17µs - CP: 5kg/cm2 - VW: 12m/min - WD: 0,3mm - WT: 9kg)

Figure 10 shows the increase of current parameters, before the amount of deviation of diameter decrease of 5% and 37%, then an increasing in the amount of 42% is observed. Despite the increase in the value of deviation from circularity parameter of around 46% and 65% reduction seen in the status of the value of 39A and maintains this value.

In this case, around the current 35.1 A in the case of both types of deviation from the current parameter form the most ideal value. Looking at the increasing values of some parameters which were obtained from graphs of deviations observed increases or decreases.Thus would not be accurate deviations from making judgments on the overall. Compared to normal micro-structure of the material with a cut after cutting edge micro-structures are not a significant change. Hardness of the material, prior to the cutting process 225 HV, while the measurement of hardness increased to 241.4 HV after cutting. These measurements before and after the cutting around approximately 6.45% has been observed that a very small increase in rate. Analyzed images of the surface microstructure of machined material, the surrounding regions very close to the cutting site,due to the structural changes induced by heat quickly cooled down to the stiff structure, composed of fragility. It was revealed that be limited to a region near the surface of the cutting. Towards the main structure of the surface, the hardness reduction is observed.

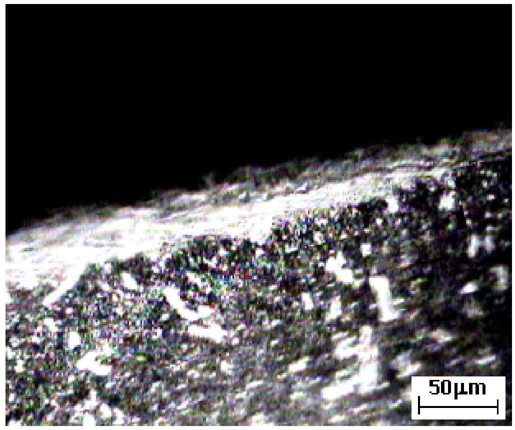

Figure 11. After the operation, the view of the material microstructure

Different heat and cool down during the implementation of the different effects of cutting parameters, has important effects on the metallurgical properties of the material examined. Compared with other cutting methods in the literature with wire EDM cutting of the material is limited to almost no change in mechanical properties. Micro-structure changes , depending on the heat affected zone and facing high temperature and instant cooling wide of the regions in the material are important [14].

Investigated between the eight different methods, heat affected zone evaluation will be conducted on the basis of changes in micro-structure if the method is the most negative "oxygen flame cutting" is the most positive method of AWJ (Abrasive Water Jet) is seen. Among the methods used, with oxygen flame cutting method, the maximum change in hardness of the material caused by the negative method is regarded as the highest. Different methods, depending on the effect on metallurgical properties of the material after cutting are also changing the mechanical properties of the material. In experimental studies confirm different the measured hardness values in different ways cut surfaces, from the original values of the materials. All cutting methods applied to the material causes a change in hardness. Methods are also different depending on the characteristics of hardness changes. This change depends on the cooling conditions and the temperature of the heat generated during cutting. In this study, the cutting parameters selected (IP : 35,1A - SF:4,95mm/dak - V:40V - Off time:17µs -

CP: 5kg/cm2 - VW: 12m/dak - WD: 0,3mm - WT: 9kg) from the hole toward the center of the cutting edge of the material from 1mm to 10mm intervals (obtained from the parameters selected from six to twelve randomly over the hole) which has been obtained by measurements of the arithmetic mean value is taken. Founded values in Figure 12 are given.

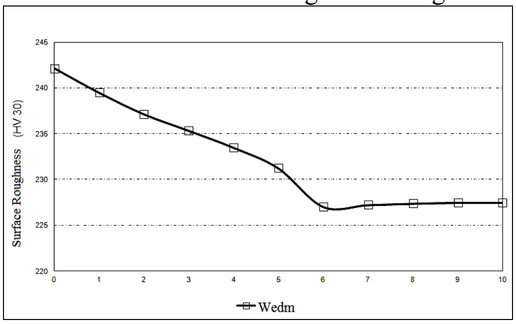

Figure 12. Cutting edge to the center, the hardness variation

Cutting method, depending on the hardness of the center of the surface changes were evaluated taking into consideration width of heat affected zone, a change can be considered almost non-existent with the cutting method AWJ observed that the most effective method. Abrasive water jet cutting method was not occurred heat affected zone and this method clearly is shown once again, the cutting can be done without causing any change in mechanical properties of metallurgical materials. Laser and plasma methods is shown as the biggest competitor of AWJ cutting, the surface hardness in the center of the heat affected zone constant change is wider than the method indicates AWJ. This condition AWJ of according to this method seems to be a significant advantage in [15]. Thermal cutting methods in the light of all this data in the minimum affecting the mechanical properties of materials, wire edm is no doubt that of cutting method.

4. CONCLUSIONS

Cold work tool steel wire EDM drilling experiments with different parameters on the values obtained in the light of the conclusions reached are summarized below.

Based on studies on Sleipner cold work tool steel of 15.3 µs 13.77 µs on time values generally were obtained more positive results. the use of a parameter between the two values Will bring showed successful results.

Increase in feed rate parameters examined in general, there was an increase proportionally the roughness and deviations. from 4.95 mm / min to 5.5 mm / min was observed that however the increase extremely high the results obtained during. The critical threshold parameter between these two values is understood and the optimum usage 4.45 to 4.95 mm / min, is envisaged to.

The increase of current parameters, surface roughness increased, but decreased deviation from circularity. Not show a steady increase or decrease in diameter but the deviation of 35,1 A was the most successful results. In general, 35,1 A appears as the most ideal parameter .

Analyze the the system overall, the use of the variable parameters chosen directly affects the quality of the surface characteristics and values and how important it is shown that selection optimum conditions.

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