Influence of Intervening Variables on Surface Roughness and Material Removal Rate During WEDM Process

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Abstract

Wire electrical discharge machining WEDM is one of the major non –traditional machining processes the application of WEDM has increased since 1970s', it has many application in the machining of conductive materials for production of aero space/ air craft, die/mold and medical parts ,this is due to high machining productivity, dimensional accuracy and surface quality ,in this study medium carbon steel 33 was machined by WEDM ,the experimental study determined the effect of pulse on time, pulse off time, servo feed rate on machined surface finish and material removal rate .the selected ranges of pulse on time ,pulse off time, servo feed rate were 8-11-14 sec,10-14-16 sec,2-3-5 mm/min respectively ,the results of present study determined that the most influential machining parameter on surface roughness was pulse on time, other parameters were less effective and the nearly only influential machining parameter on material removal rate was servo feed rate in the WEDM using brass wire of 0.25 mm.

Keyword: WEDM ,surface quality ,material removal rate.

تأثير توسط المتغيرات على الإنهاء السطحي ومعدل إزالة المعدن إثناء عملية القطع باستخدام السلك للتشغيل بالتفريغ الكهربائي

الخلاصة:

عملية التشغيل بالتفريغ الكهربائي باستخدام السلك للقطع هي إحدى العمليات الرئيسية للتشغيل اللاتقليدي وقد اتسعت تطبيقاتها منذ عام 1970 حيث تستخدم مع المعادن الموصلة لتشمل صناعة المركبات ا لفضائية -الطائرات –القوالب –والأجزاء الطبية وذلك لكونها تتميز بإنتاجية عالية ودقة إبعاد وجودة السطح0في هذا البحث تم استخدام طريقة القطع بالسلك باستخدام التفريغ الكهربائي لتشغيل معدن (ستيل 33) وقد اظهرت التجارب تأثير كل من عرض الشرارة – عدد الشرارات والتغذية على جودة السطح ومعدل ازالة المعدن وكانت المديات المستخدمة لكل من هذه المتغيرات 8-11-14 ثا-10 -14-16 ثا -2-3-5 ملم\دقيقة0 على الترتيب0 وكانت النتائج بأن اكثر المتغيرات تأثيرا على جودة السطح هو عرض الشرارة نسبة لباقي المتغيرات المدروسة0 وكذلك تشير الى ان المتغير الوحيد المؤثر تقريبا على معدل ازالة المعدن هو معدل التغذية مع العلم ان عملية التشغيل تمت بأستخدام سلك براص بقطر 0.25 ملم.

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INTRODUCTION

Wire electrical discharge machining (WEDM) is a nontraditional, thermoelectric process which erodes material from the work piece by a series of discrete sparks between a work and tool electrode immersed in a liquid dielectric medium .These electrical discharges melt and vaporize minute amounts of the work material, which are then ejected and flushed away by the dielectric fluid [1].The wire-cut EDM is a discharge machine that uses CNC movement to produce the desired contour or shape. It does not require a special shaped electrode, instead it uses a continuous-traveling vertical wire under tension as the electrode. The electrode in wire-cut EDM is about as thick as a small diameter needle whose path is controlled by the machine computer to produce the shape required.[2] . WEDM utilizes a continuously travelling wire electrode made of thin copper, brass, molybdenum or tungsten of diameter (0.05–0.3) mm, which is capable of achieving very small corner radii.[3]. Wire EDM application: electrical discharge wire cutting is used to make stamping dies, tools for lathes ,templates for use in tracer lathes ,electrodes for vertical EDM and extrusion dies . it can also be used for prototype production of parts to be made later by die stamping or CNC milling. [4] many machining parameters such as the average cutting speed ,machining cost ,accuracy and surface quality have been improved since the machining process commercially used, more developments are still required to answer the increasing demand of dimensional accuracy and complex geometrical parts by various industries[5] There are many parameter and variables that influence the EDM operation. The parameters which influence surface roughness are pulse-on time (ON), pulse-off parameters that were used influenced the result of the surface roughness. The time **(**OFF), pulse-peak current (*I*p), and wire tension (*W*T), cutting tool and material of work piece [6]. Research on wire EDM is an un ending process and many researchers are doing the experimental works and modeling to establish the response parameters depending on the necessity. Maneesh. K.etal, (2012). studied , the effect of WEDM parameters such as open circuit voltage, wire feed rate, pulse duration and spark gap voltage on machining characteristics of AISI D3 steel .[3]C.Bhaskar Reddy,etal, (2012). investigated the response parameters, viz., Material Removal Rate (MRR) and Surface Roughness (Ra) a by experimentation on EN19 & AISI 420 (SS420) Steels in Wire-EDM process. A comparison made between the two materials indicates that the EN 19 Material is more suitable for better MRR and AISI 420 for better Surface finish.[7]. Dharmender,etal, (2012) . Study the effect of different process parameters viz. peak current, pulse on time, pulse off time, Wire Tension on the response variable- Surface roughness using Brass wire electrode (0.25 mm diameter*)*.[8], Pujari. Srinivasa Rao,etal, (2012). Experiment was conducted under different conditions of pulse on time, pulse off time, peak current, flushing pressure of dielectric fluid, wire feed rate, wire tension, spark gap voltage and servo feed setting. The response of material removal rate is considered for improving the machining efficiency.[9] .the research

of this paper work is to study the wire EDM machining process performance be focused on the effect of wire EDM parameters [pulse on time ,pulse off time ,feed rate] on surface roughness and material removal rate for machining of steel 33.

Experimental design:

A .Experimental set up

All the experiments were conduced on 5 axis ACRA-W-A430 wire cut machine in this machine ,all axis are servo controlled an can be programmed to follow a CNC code which is fed through the control panel experiments were done on steel 33,the chemical composition of work piece material is given in Table (3),the size of the work piece 20cm x10cm x 3mm, the three WEDM parameters have three levels as control factors while the rest nine parameters conceder fixed parameters as given in Table (1),(2) ,each time one control factor is change while the rest control factor is fixed.

B .Data collection

Surface roughness measurements has been done using a stylus –type profilometer of taly surf 4 as shown in Figure (3) , surface roughness measurements are taken on work piece in fixed direction to obtain the average values of surface roughness ,in all the measurements of surface roughness cut-off is taken as 0.8 mm.

Results and Discussion :

The experiments are based on one factor experiment strategy in this only one input parameter was varied while keeping all others input parameters at constant values. During this experimental procedure six sets of experiments were performed after analyzing the result of the experiments performed, various facts came into light. The effect of pulse on time on surface roughness value is shown in Figure (6). The graph shows that surface roughness value increases with the increase in pulse on time ,this is because the increasein pulse on time increases the discharge energy and this increase produces a larger crater causing an increasing in the value of surface roughness. for the second set of experiments the effect of pulse off time on surface roughness value is shown in Figure (7). The graph shows that the surface roughness decreases with increase in pulse off time ,so the value of pulse off time can be selected in such a way that we get the desired surface roughness. Because the increase in pulse off time decreases the number of discharges which causes decreasing in the value of surface roughness. For the third set of experiments the effect of servo feed rate on surface roughness is shown in Figure (8). The graph shows that the surface roughness increases with the increase in servo feed rate .This is because increasing servo feed rate results in increasing total cutting energy relased by the wire producing bigger and depper crater causing increase in surface roughness. For the next set of experiments the effect of servo feed rate on material removal rate is shown in Figure (9). The graph shows that material removal rate increases with the increase in the servo feed rate ,so the servo feed rate can be adjusted to get the desired material removal rate .Because the increase in servo feed rate produces increase in cutting speed for whole WEDM process and material removal rate depends on cutting speed so material removal rate increases.

CONCLUSIONS:

Determination of pulse on time , pulse off time , servo feed rate on surface roughness and material removal rate in WEDM of steel 33 was carried out experimentally it was observed that :

1.The parameters {pulse on time and pulse off time} have no effect on the material removal rate.

2. The servo feed parameter has direct effect on the material removal rate ,as we increase servo feed rate the material removal rate also increases.

3. when the pulse off time is increased the surface roughness value decreases.

4. when servo feed rate increases the surface roughness value increases.

5. when the pulse on time increase the surface roughness value increases ,so ton have the most significant effect on surface roughness .

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Table (1) Wire EDM parameters and their levels

NO.	Parameters	symbol	Level1	Level2	Level3	Units
1	Pulse on time	T ON	8	11	14	sec
2	Pulse off time	T OFF	10	14	16	sec
3	Servo feed rate	WF	2	3	5	mm/min

Table (2) Fixed parameters

Fixed parameters	
Wire used	Brass wire of Φ 0.25 mm
Angle of cut	vertical
Height of the work piece	3 mm
Water pressure	4 kgf/cm^2
Wire feed	1 m/min
Wire tension	8 kg
voltage	94 volt
Spark gab	0.2 mm

Table (3) Chemical composition of material

Sample	C%	Si%	Mn%	P%	S%	Cr%	Ni%	Co%	Cu%	Fe%
Work piece matel	0.128	0.055	0.417	0.013	0.02	0.002	0.027	0.001	0.007	Bal.

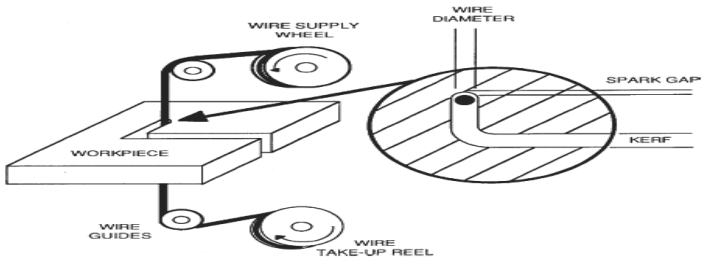

Figure (1) Schematic representation of wire EDM cutting process[8].

Figure (2) WEDM Cutting Machine

Figure (3) Talysurf4 (roughness measurements instrument)

Figure(4)Work piece material

Figure (5) Brass wire roll

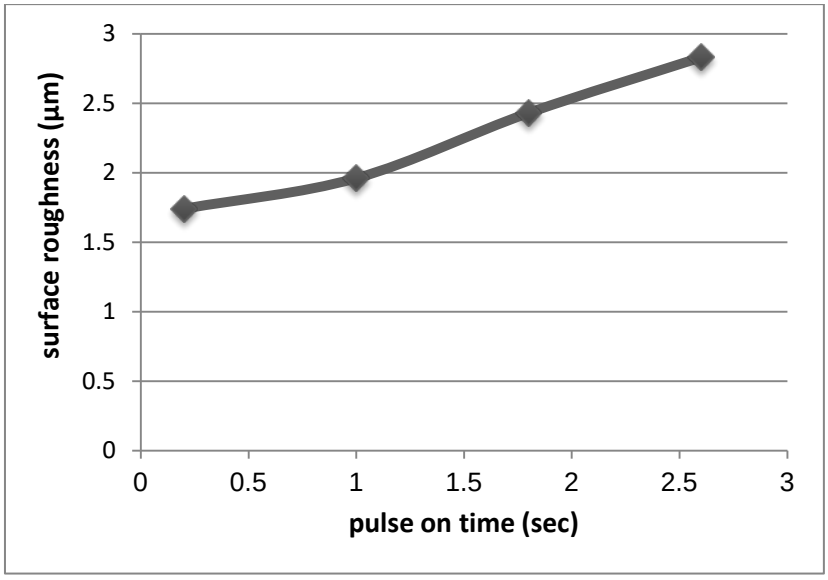

Figure (6) Effect of pulse on time on surface roughness using brass wire.

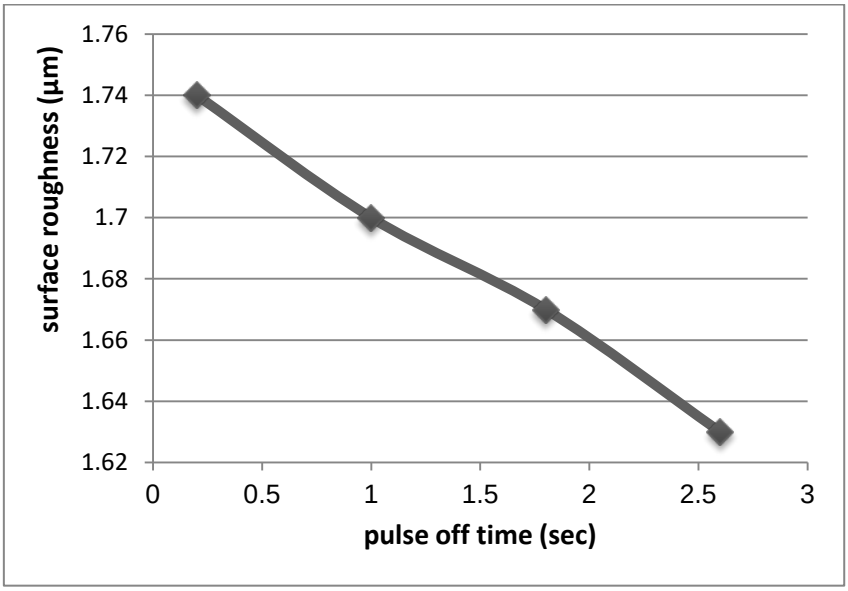

Figure (7) Effect of pulse off time on surface roughness using brass wire.

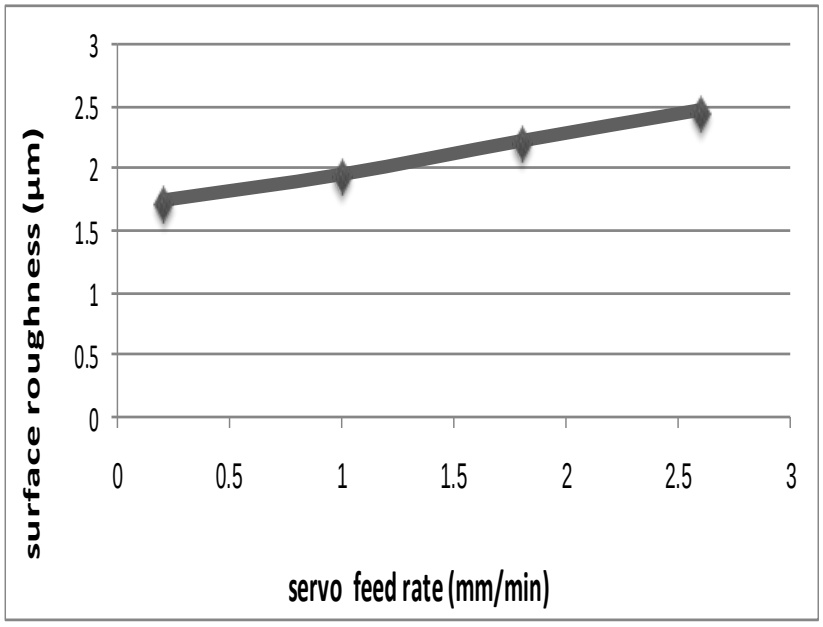

Figure (8) Effect of servo feed rate on surface roughness using brass wire.

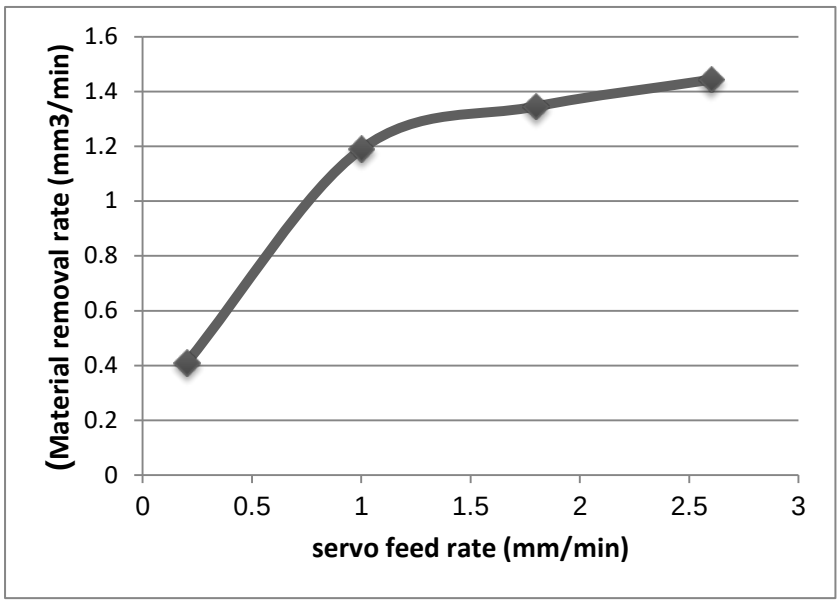

Figure (9) The Effect of servo feed rate on material removal rate using brass wire.