ICMSSM 2021

2021 7th International Conference on Mechanical Structures and Smart Materials

JUNE 14-15, 2021 CHANGSHA, CHINA

Determination of Optimum WEDM Parameters for Maximum Material Removal Rate when Arc Cutting SKD11 Tool Steel

Le Hoang Anh^{1,a}, Nguyen Manh Cuong^{2,b}, Dang Quoc Cuong^{3,c}, Nguyen Huu Quang^{4,d}, Trinh Kieu Tuan^{4,e}, Nguyen Hong Linh^{5,f}, and Nguyen Thanh Tu^{2,g}, and Nguyen Anh Tuan^{4,*} ¹Vinh Long University of Technology Education, Vietnam

²Thei Neuron University of Technology Education, Vietnam

²Thai Nguyen University of Technology, Thai Nguyen, Vietnam

³Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam

⁴University of Economics - Technology for Industries, Vietnam

⁵Electric Power University

^aanhlh@vlute.edu.vn, ^bnmcuong@tnut.edu.vn, ^cqcuong@ntt.edu.vn, ^dnhquang@uneti.edu.vn ^etktuan@uneti.edu.vn, ^flinhnh@epu.edu.vn, ^gnguyenthanhtucnvl@tnut.edu.vn *Correspondence: natuan.ck@uneti.edu.vn

a de la com

Introduction

This paper deals with a study on the effect of input factors on optimal WEDM process parameters when cutting circular arcs SKD11 steel. To do that, seven input parameters were considered. The impact of the input factors on the MRR were discovered. Also, a proposed model to determine the optimum WEDM parameters was given.

Experimental procedure

Table 1. Input parameters and their levels

Devenueter	Code	11		and a state of		
Parameter	Code	Unit	_ 1	2	3	1 4520
Cutting voltage	VM	V	6	9	12	100.0
Pulse on time	Ton	μs	6	9	12	122
Pulse off time	Toff	μs	8	12	16	Valence
Servo voltage	SV	V	24	29	34	1.5
Wire feed	WF	mm/min	8	10	12	COAS!"
Arc radious	R	mm	3	6	9	
Cutting speed	SPD	mm/min	2	4	-	The second s

Table. 2.	Experimental	plan	and	the	MRR
-----------	--------------	------	-----	-----	-----

No.	VM	Ton	Toff	sv	WF	SPD	R	MRR (mm ³ /min)	S/N
1	3	6	8	24	8	2	3	1.560	3.8625
2	6	6	12	29	10	2	6	3.176	10.0376
3	9	6	16	34	12	2	9	8.180	18.2551
4	6	9	8	24	10	2	9	8.460	18.4835
5	9	9	12	29	12	2	3	10.793	20.6628
16	9	12	8	34	10	4	3	12.437	21.8943
17	3	12	12	24	12	4	6	14.142	23.0653
18	6	12	16	29	8	4	9	12.722	22.0281

Acknowledgments: The work described in this paper was supported by Thai Nguyen University of Technology for a scientific project.

is better A SPD ton toff SV WF VM R 1650 11.31 15.91 16.17 15.87 15.13 15.86 17.70 18.70 17.33 17.13 17.23 16.75 17.72 21.28 18.05 17.98 18.19 19.42 17.70 A 6 3 2 0 15 bbl 3. Order of influence of input parameters on S/N Fig. 3. Effect of input parameters on S/N r Surce DF Seq SS Adj SS Adj MS F P C (%) 5PD 1 6.496 6.496 6.496 0.85 0.410 1.38 Toff 2 14.219 14.219 7.019 0.93 0.467 3.03 SV 2 9.822 9.822 4.911 0.64 0.574 2.09 WF 2 16.405 16.405 16.405 8.203 1.07 0.425 3.49 VM 2 56.310 53.10 28.155 3.67 0.124 12.00 R 2 13.706 13.706 6.853 0.89 0.478 2.92 Residual Error 4 30.659 20.692 7.673 6.543 Table 4. Analysis of Variance of Input Table 4. Analysis of Variance of Input Parameters on S/N							91.				Main El	fects Plot for Data Means	SN ratios	
$\frac{1}{1500} \frac{1}{131} \frac{1}{1591} \frac{1}{1611} \frac{1}{1581} \frac{1}{1511} \frac{1}{1581} \frac{1}{1513} \frac{1}{1586} \frac{1}{1700} \frac{1}{1733} \frac{1}{1713} \frac{1}{1713} \frac{1}{1713} \frac{1}{1723} \frac{1}{1713} \frac{1}{1713} \frac{1}{1723} \frac{1}{1713} \frac{1}{1713} \frac{1}{1723} \frac{1}{1713} \frac{1}{1713}$	is b	etter								12 46	* *	r w	2.9	5M - 1
$\frac{1}{1630} \frac{1131}{133} \frac{1591}{1591} \frac{1617}{1587} \frac{153}{153} \frac{1536}{1770} \frac{1770}{120} \frac{1870}{98} \frac{1775}{1772} \frac{18105}{1773} \frac{1713}{173} \frac{1723}{173} \frac{1753}{173} \frac{1537}{1757} \frac{1770}{120} \frac{1798}{1810} \frac{1819}{1942} \frac{1770}{170} \frac{1770}{120} \frac{1798}{1812} \frac{1812}{123} \frac{1322}{429} \frac{1366}{130} \frac{1}{7} \frac{1}{1} \frac{1}{4} \frac{6}{6} \frac{3}{3} \frac{2}{2} \frac{5}{5} \frac{1}{10} \frac{1}{1} \frac{1}{6} $	el a	SPD	Top	Toff	sv	WF	νм	R		а	/			7
17.70 18.70 17.33 17.13 17.23 16.75 17.72 21.28 18.05 17.98 18.19 19.42 17.70 1.20 9.98 2.14 1.81 2.33 42.9 1.86 7 1 4 6 3 2 5 bible 3. Order of influence of input parameters on S/N SPD 1 6 6496 6496 6496 6496 6496 6496 0.574 2.09 SPD 1 6 6496 6496 6496 6496 0.574 2.09 VF 2 16.405 16.405 8.203 1.07 0.425 3.49 VF 2 16.405 16.405 8.203 1.07 0.425 3.49 VM 2 56.310 56.310 28.155 3.67 0.124 12.00 R 2 13.706 13.706 6.353 0.89 0.478 2.922 Residual Error 4 30.692 30.692 7.673 6.54 Total 17 469.404 Table 4. Analysis of Variance of input parameters on S/N	<u> </u>	16.50	11.31	15.91	16.17	15.87	15.13	15.86	ation	• •	1.	11	1	1 -
$\frac{21.28}{1}$ 18.05 17.9 1.4 1.6 1.6 1.6 1.6 1.7 1.4 1.6 1.6 1.6 1.6 1.6 1.6 1.6 1.6		17.70	18.70	17.33	17.13	17.23	16.75	17.72	of SN	. *	11	-	1	11
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$			21.28	18.05	17.98	18.19	19.42	17.70	Mcan	. /				
The format is a second state of the format is a second state	a	1.20	9.98	2.14	1.81	2.33	4.29	1.86						
bit 1. Order of influence of input parameters on S/N Fig. 3. Effect of input parameters on S/N in Fig. 3. Effect of input parameters on S/N in SPD ^{Surce} PF Seq.5S Seq.5S Seq.5S Seq.22 Seq.22 Seq.22 Seq.23 Seq.33 Seq.33 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43 Seq.43		7	1	4	6	3	2	5						
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	ble	e 3. O	rder	of inf	luenc	e of i	nput	1	Sur.	d-m-reper Lager u b	• • • • •			1 - 1 - 1 - 1
Source DF Seq SS Adj SS Adj MS F P C (%) SPD 1 6.496 6.496 6.496 0.85 0.410 1.38 Ton 2 321.754 321.754 320.774 321.754 320.757 6.54 Total 17.469.040 17.469.040 17.469.040 17.469.04 17.469.04 17.469.04 17.469.04 17.673 6.54		pa	aram	eters	on S/	'N		Fig.	3. E	ffect of	input	paran	neters	on S/N
$\frac{\text{SPD}}{\text{Ton}} = \frac{1}{2} \frac{6.496}{2.321.754} \frac{6.496}{2.1754} \frac{6.496}{10.85} \frac{6.496}{0.85} \frac{0.410}{0.931} \frac{1.38}{0.667} \frac{1.38}{3.03} \frac{1.38}{0.951} \frac{1.213}{0.991} \frac{1.4219}{1.4219} \frac{1.4219}{7.109} \frac{1.09}{0.93} \frac{0.467}{0.425} \frac{3.03}{3.03} \frac{1.07}{0.425} \frac{0.425}{3.49} \frac{1.07}{0.425} \frac{1.06}{0.425} \frac{1.07}{0.425} \frac{1.09}{0.425} \frac{1.07}{0.425} \frac{1.09}{0.425} \frac{1.09}{0.45} \frac{1.09}{0.45} \frac{1.09}{0.45} \frac{1.09}{0.45} \frac{1.09}{0.45$				Sourc	e	DF	Sea S	S Ad	j SS	Adj MS	F	P	C (%)	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				SPD		1	6.4	96 6	.496	6.496	0.85	0.410	1.38	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$				Ton		2	321.7	54 321	.754	160.877	20.97	0.008	68.55	
SV 2 9.822 9.822 4.911 0.64 0.574 2.09 WF 2 56.405 8.203 1.07 0.425 3.49 VM 2 51.01 56.310 58.310 0.89 0.478 2.92 Rsidual Error 4 30.692 30.692 7.673 6.54 Total 17 469.404 7.673 6.54 Table 4. Analysis of Variance of input parameters on S/N Neme-390.01 Memory of MRR Memory of MRR <	11			Toff		2	14.2	19 14	.219	7.109	0.93	0.467	3.03	
$\frac{WF}{VM} = 2 \ 16.405 \ 16.405 \ 8.203 \ 1.07 \ 0.425 \ 3.49 \\ VM = 2 \ 56.310 \ 56.310 \ 28.155 \ 3.67 \ 0.124 \ 12.00 \\ R = 2 \ 13.706 \ 13.706 \ 6.853 \ 0.89 \ 0.478 \ 2.92 \\ Residual Error = 4 \ 30.692 \ 30.692 \ 7.673 \ 6.54 \\ Table 4 - $				SV		2	9.8	22 9	.822	4.911	0.64	0.574	2.09	
VM 2 56.310 56.310 28.155 3.67 0.124 12.00 R 2 13.706 13.706 6.853 0.89 0.478 2.92 Residual Error 4 30.692 30.692 7.673 6.54 Table 4. Analysis of Variance of input parameters on S/N Normal-1996 Cl Memory - 100 MR Memory - 100				WF		2	16.40	05 16	.405	8.203	1.07	0.425	3.49	
R 2 13.706 13.706 6.853 0.89 0.478 2.92 Residual Error 4 30.692 30.692 7.673 6.54 Total 17 469.404 Table 4. Analysis of Variance of input parameters on S/N Nermal 936 Cl Mermal 936				VM		2	56.3	10 56	.310	28.155	3.67	0.124	12.00	
Residual Error 4 30.692 30.692 7.673 6.54 Total 17 469.404 Table 4. Analysis of Varfance of input parameters on S/N Probability Plot of MRR Normal - 596.01 Were - 596			1	R		2	13.70	06 13	.706	6.853	0.89	0.478	2.92	
		115	1	Residu	al Error	r 4	30.69	92 30	.692	7.673			6.54	
Table 4. Analysis of Variance of input parameters on S/N			1	Total		17	469.40	04						
Probability Plot of MRR Normal +SSK CI			Tat	ole 4.	Analy	sis o	f Vari	ance	of in	nput pa	ramet	ers on	S/N	
HARE ASS ASS ASS ASS ASS ASS ASS ASS ASS ASS			3				Probabi	lity Plot	of MRI	2				
How as a state of the state of				99					1	11	Mea	n 8.252		
Around 30 House				25					1.	//	SIDE	v 3.869 18		
HUND D D D D D D D D D D D D D D D D D D				90				1	1	/	AD P-Va	0.311 ive 0.315		
Honore and the second s				80				11						
MARK 10 15 20				70 12 60				1.1	1					
1 3 0 5 MAR				& S			1	1/						
20 1 3 0 5 MRR 15 20 10 15 20				30			(1)	/						
1 0 5 10 10 20 MARK 0 12 20				20		1	11							
1 5 0 5 19 15 20 MRR					1	1	/							
11 5 0 5 10 15 20 MRR					/	11	6							
MRR				1.5		0	5	10	1	5 20				
Else E Dashahillés salaé aé MDD							N	IRR						

Conclusions

The present work introduces the calculation of optimum WEDM parameters when arc cutting SKD11 steel. In this work, seven input process parameters including the cutting voltage, the pulse on time, the pulse off time, the serve voltage, the wire feed, the cutting speed, the arc radious were investigated. The impacts of the input factors on the MRR were explored. It was noted that T_{on} has the greatest influence on MRR (68.55%) and after that is VM (12.00%). The other input factors have a lower influence on MRR: WF (3.49%), T_{off} (3.03%), R (2.92%), SV (2.09%) and SPD (1.38%). In additon, the following optimum input factors was suggested: VM=12; $T_{on} = 12$; $T_{off} = 8$; SV=24; WF=12; and SPD=4. It is also found that the proposed model is proper to use in practice.