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EXPERIMENTAL PARAMETRIC STUDIES ON MONEL USING ABRASIVE WATER JET MACHINING

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Abstract – Abrasive water Jet Machining, for the most part, embraced by aeronautic trade for machining high-quality materials and different composites. The primary extent of work is to examine the impact of information process parameters, for example, Transverse speed, Abrasive stream rate and standoff separation for accomplishing ideal Processes reactions, for example, Metal Removal Rate(MRR), Surface harshness (Ra), and Kerf width at the same time machining on the nickel-chromium based super mix HASTELLOY C 276. A movement of preliminaries is directed to find the ideal parameters. Improvement of systems parameters is foreseen by using dim social assessment. A compliance test is directed to approve the ideal level of Processes parameters expectation.

1. INTRODUCTION

Water planes were locate its new applications in machining of hardest materials [1-3]. It is genuinely a flexible, profitable, cold cutting process[4]. In AWJM Water is siphoned at a high weight around 2000-4000 bar utilizing intensifier. At the point when water at such weight is given through the hole of about 0.2 – 0.4 mm distance across, changes over the potential vitality of water into dynamic vitality, coming about a high speed fly of 1000 m/s. This high speed of water stream when it leaves the spout cuts the materials of the necessary size and a shape is appeared in Fig. 1.

Fig 1. Abrasive Water Jet Machining of Inconel-825

A lot of contributions have been made on the optimization of procedure parameters of various materials by utilizing Abrasive water fly machining and been audited. Some of them are examined below.mild Steel (MS-A36) (pliable in nature) with full factorial DOE is introduced here. Further, the impact of warm treatment (during cutting) on surface morphology of the material machined has been read for investigating the adequacy of the proposed philosophy. Due to TEM, an expansion in material expulsion rate, decrease in control utilization machining time is seen by John A. Webster [6] AWJM is high compelling machining process used to expel materials from aeronautical artistic materials. As of late research is carrying on earthenware production and composites to expel materials utilizing AWJM process.

B.Satyanarayana, G.Srikar [7] observed AWJM is versatile machining process for remove material by using optimize parameters. On Inconel utilizing grey grade multi response technique.

From above Literature overview it is clear that work has been accounted for on Experimental Investigation on Inconel-825(Nickel,Iron and Chromium based amalgam) material which is utilized for Aeronautical, Creogenics and Chemical handling applications. Plan of Experiments (DOE) is set up in Mini-Tab Software by utilizing Taguchi for streamlining Processes parameters chose are Transverse speed, Abrasive stream rate and Stand-off Distance. These procedures parameters will be improved dependent on Maximum MRR, Minimum Surface Roughness and Minimum Kerf Width in the wake of Machining is finished by leading ANOVA and Gray Taguchi Technique.

2. EXPERIMENTAL SETUP

Material Properties

The material picked is MONELis a super composite which is precipitation solidified material and significant level of destructive obstruction. It is a ickel-Molybdenum-Chromium amalgam with increases of copper and Titanium. It has great yield quality and mechanical properties even at cryogenic temperatures to respectably high temperatures. It is exceptionally impervious to profoundly destructive acids like sulphuric corrosive and phosphoric acids.

TABLE 1. CHEMICAL COMPOSITION OF BASE MATERIAL (WT%)

Ni	Mo	Cr	Fe	W	Co	Mn
Remainder	17	16.5	7.0	4.5	2.5	1.0
C	V	P	S	Si		
0.35	0.04	0.03	0.08			

Fig.2. Workpiece After and Before Machining

Experimental Setup

The work piece was of strategy parameters of different materials by using Abrasive water fly machining and been evaluated. Some of them are analyzed below.mild Steel (MS-A36) (malleable in nature) with full factorial DOE is presented here. Further, the effect of warm treatment (during cutting) on surface morphology of the material machined has been perused for exploring the ampleness of the proposed way of thinking. Due to TEM, a development in material ejection rate, decline in charge use machining time is seen by John A. Webster [6] AWJM is high convincing machining process used to oust materials from aeronautical masterful materials. Starting late look into is carrying on pottery creation and composites to remove materials using AWJM process.

Fig.3. Excel Abrasive water Jet Machine Set up

Design of Experiments

The Design of experiments is performed to find number of experiments has to conduct with process parameters and their levels for robust design. With in moderate time and minimum cost.

DOF= (1+Number of Parameters) X (Number of levels-1)

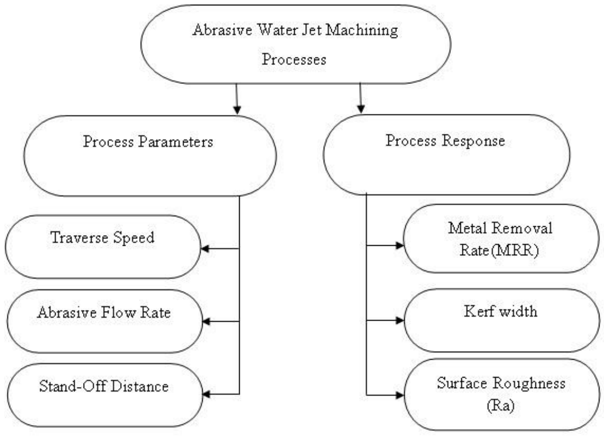

Fig.4. Process parameters and Process levels flow chart

I. RESULTS AND DISCUSSION

Metal Removal Rate and Surface Roughness are most significant criteria's, which assist us with deciding how harsh a work piece material is machined. By breaking down the exploratory information of the chose material, it has been discovered that ideal choice of the three fundamental parameters, i.e, Transverse speed, grating mass stream rate and spout standoff separation are significant on controlling the procedures yields, for example, Metal Removal Rate (MRR), Surface Roughness (Ra) and Kerf width. The impact of these parameters are examined while keeping different parameters considered in this investigation as consistent.

TABLE 2. TAGUCHI L_{25} OA WITH PARAMETERS AND RESPONSES

S. No	*Transverse speed (mm/min)*	*Abrasive flow rate (gm/min)*	*Stand off Distance (mm)*	*Kerf width-mm*	*MRR-gm/sec*	*Surface roughness (Ra) µm*
1	40	50	1	0.66	0.044	3.016
2	40	100	2	0.56	0.057	2.805
3	40	150	3	0.5	0.037	3.021
4	40	200	4	1.01	0.068	3.237
5	40	250	5	1	0.089	3.300
6	50	50	2	0.96	0.068	3.902
7	50	100	3	0.57	0.035	5.300
8	50	150	4	1.02	0.076	3.676
9	50	200	5	0.94	0.061	2.257
10	50	250	1	0.82	0.055	2.589
11	60	50	3	1	0.089	2.106
12	60	100	4	0.91	0.060	2.500
13	60	150	5	0.96	0.075	3.536
14	60	200	1	0.55	0.037	2.740
15	60	250	2	0.93	0.060	2.551
16	70	50	4	0.44	0.031	2.756
17	70	100	5	0.78	0.067	3.928
18	70	150	1	0.49	0.057	3.410
19	70	200	2	0.68	0.056	2.791
20	70	250	3	0.44	0.037	2.742
21	80	50	5	0.67	0.054	2.857
22	80	100	1	0.34	0.039	3.984
23	80	150	2	1.01	0.071	4.116
24	80	200	3	0.99	0.085	2.712
25	80	250	4	0.57	0.043	2.606

Grey Taguchi Technique

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So as to research the essentialness of the procedure parameters on Metal Removal Rate, Kerf Width, Surface Roughness. ANOVA was performed. ANOVA table for the Gray social evaluation are appeared in Table 2. From these it is shows that Transverse Speed has most affecting parameter which is about 15.88% it shows a lot of commitment on dim social evaluation and following with Abrasive Flow Rate and Stand-off Distance has impact on dark social evaluation with commitment of 13.01% and 13.48%.

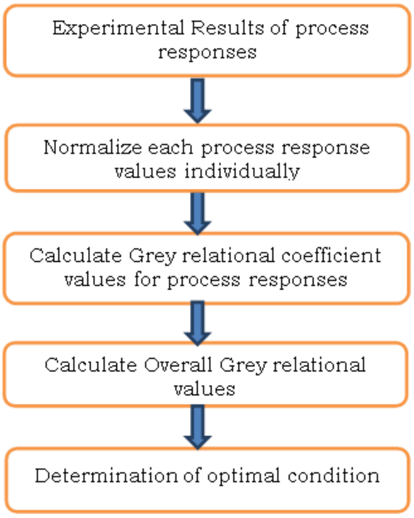

Fig.5. Grey Taguchi Technique Flowchart

Normalization of Experimental Results

The initial phase in Gray-Taguchi investigation is to standardize the exploratory aftereffects of Metal Removal Rate, Kerf Width, Surface Roughness. Every reaction esteem is standardized in the scope of 0 to 1. For normalizing Metal Removal Rate 'Higher-the-better' is to choose speak to in (equ.1) in machining of work pieces makers will target Maximum Metal Removal Rate in brief time of time, Kerf Width, Surface Roughness 'Lower-the-better' is to be chosen with the end goal that workpieces will cut precise and great surface completion will be obtained (equ.2) rule is utilized.

$$X_j(v) = \frac{y_j(v) - \min y_j(v)}{\max y_j(v) - \min y_j(v)} \text{ ------------1.}$$

$$X_j(v) = \frac{\max y_j(v) - y_j(v)}{\max y_j(v) - \min y_j(v)} \text{ ------------2}$$

Where, $X_j(v)$= value after normalizing data/Grey relations generation value,

Min $y_j(v)$=smallest value of $y_j(v)$

Max $y_j(v)$=Largest value of $y_j(v)$

Grey Relational Coefficient

In the wake of normalizing the consequences of Metal Removal Rate, Kerf Width, Surface Roughness, the following stage is computation of dark social coefficient esteems for Metal Removal Rate, Kerf Width, Surface Roughness. The dim social coefficient j (v) can be determined by utilizing equ.3 this dim social coefficient esteem is utilized to get dim request.

$$\varepsilon_j(v) = \frac{\Delta_{\min} + \phi\Delta_{\max}}{\Delta_{oj}(v) + \phi\Delta_{\max}} \text{ --------3}$$

Grey Relational Grade and Order

Dim social grade for each test run is the normal of dark social coefficient esteem for a specific test run. Dim social evaluation can be determined by utilizing equ.4. Higher estimation of dim social grade demonstrates the best esteem, so most elevated evaluation esteem gives the higher request. The dim social evaluation and their request is given in Table3.

$$\gamma_j = \frac{1}{n}\sum_{v=1}^{n} \varepsilon j(k) \text{ ----------------4}$$

Where, n = number of process responses

$\varepsilon_j(v)$ = Grey relational coefficient

TABLE 3. GREY RELATIONAL GRADE AND ORDER

EXP. No.	*Grey Relational Grade*	*Order*
1	0.514686587	19
2	0.592703395	8
3	0.557924366	12
4	0.500681407	21
5	0.637398782	3
6	0.468280529	24
7	0.426407384	2
8	0.509357411	20
9	0.594696539	7
10	0.547580023	16
11	0.780000000	1
12	0.558578622	13
13	0.518723446	18
14	0.564009670	11
15	0.549222598	15
16	0.605595339	6
17	0.490540176	22
18	0.573262405	10
19	0.555855550	14
20	0.615311111	4
21	0.546913670	17
22	0.608885651	5
23	0.465468383	23
24	0.649047595	2
25	0.581574011	9

TABLE 4. ANALYSIS OF VARIANCE

Source	*DF*	*Seq. SS*	*Seq. MS*	*F-Value*	*% Contribution*
A	4	0.01955	0.004888	0.83	15.88
B	4	0.01609	0.004022	0.68	13.01
C	4	0.01656	0.004141	0.70	13.48
Error	12	0.07090	0.005908	--	57.59

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Total	24	0.12310	--	--	100

Prediction of Response Values for Optimum Levels as per Grey Taguchi Technique

From means of each level of process parameters we will construct a response table. For grey-relational grade. The response table for grey-relational grade is given in Table.5.

TABLE 5. RESPONSE TABLE FOR MEANS OF GREY RELATIONSL GRADE

Level	*Transvers Speed (A)*	*Abrasive Flow Rate (B)*	*Stand Off Distance (C)*
1	0.5607	0.5831	0.5617
2	0.5093	0.5354	0.5263
3	0.5941*	0.5249	0.6057*
4	0.5681	0.5729	0.5512
5	0.5704	0.5862*	0.5577
Delta	0.0848	0.0613	0.0794
Rank	1	3	2

From above Table 5 the ideal forms Parameters request Transverse speed shows its impact significantly on Processes reaction in light of the fact that MRR,Surface Roughness and Kerf width is legitimately relative to its Transverse speed.Such that Transverse speed An is significant esteem 0.5941.

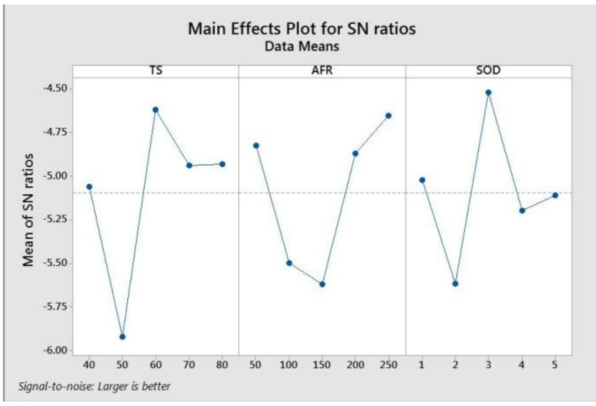

Fig.6. Main Effective plot S/N Ratio for Grey Relational Grade

From the underneath Response table the ideal condition for expanding Metal Removal Rate, least Kerf Width and Surface unpleasantness at the same time in Abrasive Water Jet Machining (AWJM) process, is seen as A3 B5 C3 for example Transverse speed is 60 mm/min, Abrasive Flow Rate is 250 gm/min and Stand Off Distance is 3 mm. For this ideal setting A3 B5 C3 led experimentation for approving outcomes to get best procedures reactions.

Regression Equation

Relapse condition is find from MiniTab-17 Software ideal procedures reactions are gotten by substituting ideal procedures parameters which are acquired from relapse investigation in relapse conditions 5,6&7.

lN(MRR) = -2.87 - 0.106 lN(TS) + 0.053 lN(AFR) + 0.161lLN(SOD)-------------5

lN(KW) = 0.36 - 0.305 lN(TS) + 0.069 lN(AFR) + 0.217 lN(SOD)----------------6

lN(SR) = 1.458 - 0.019 lN(TS) - 0.0492 lN(AFR) – 0.0208 lN(SOD)---------------7

TABLE 6. OPTIMAL PARAMETER CONTROL LEVEL

S.No	*Process response*	*Optimal setting*	*Actual Value*	*Experimental Value*	*% of Error*
1	Metal Removal Rate	$A_3\,B_5\,C_3$	0.05877	0.0573	2.5
2	Kerf width		0.7638	0.7643	-0.06
3	Surface Roughness		2.9615	2.9610	0.016

$$\text{Experimental Error}= \frac{Actual - Experimental}{Actual} * 100 \text{--------8}$$

From the confirmation experiments, the error percentage of process responses from the predicted responses is less than ±5% is acceptable.

II.CONCLUSION

In this paper conclusions are drawn dependent on trial outcomes, investigation of fluctuation (ANOVA), and dim taguchi procedure as pursues:

1. Traverse Speed (TS) is the most significant factor on MRR during AWJM. Meanwhile Abrasive Flow Rate and Standoff distance is sub significant in influencing on MRR and kerf width.
2. Lowest surface roughness is obtained at TS 60mm/min, AFR 50 gm/min and SOD is 3mm.
3. Kerf width is minimum at TS 80mm/min, AFR 100 gm/min and SOD is 1mm.
4. The optimal condition for maximizing Metal Removal Rate,
minimum Kerf Width and Surface roughness simultaneously in AWJM is. Transverse speed is 60 mm/min, Abrasive Flow Rate is 250 gm/min and Stand Off Distance is 3 mm.

REFERENCES

1. Experimental Investigation of Abrasive Water Jet achining Processes Parameters and Its Effects on Processes Responses Using Gray Taguchi Streamlining Technique" Journal of Production Engineering JPE(2016) Vol.19 (2), 10 October 2016 ISSN:1821-493
2. N. Tamannaee, J.K. Spelt, M. Papini," Abrasive slurry stream miniaturized scale machining of edges, planar territories and transitional inclines in a powder filled co-polymer", Accuracy Engineering ,Department of Mechanical and Industrial Engineering, University of Toronto, Department of Mechanical and Industrial Engineering, Ryerson University, Toronto, Canada , Issue 24, June 2015..
2. Fritz Klocke, Sein Leung Soo ,Bernhard Karpuschewski, John A. Webster, Donka Novovic, Amr Elfizy, Dragos A.Axinte, Stefan Tönissen,"Abrasive machining of cutting edge aviation combinations and composites",CIRP Annals – Manufacturing Technology, Volume 64,Issue 2, May 2015.
3. Fang-Jung Shiou, Assefa Asmare,"Parameters streamlining on Surface unpleasantness improvement of Zerodur optical glass utilizing an Innovative rotating rough liquid multi-stream cleaning process", Precision Engineering, Department of Mechanical Engineering, National Taiwan University of Science and Technology, Taiwan,Issue 17, April 2015.
4. Derzija Begic-Hajdarevic, Ahmet Cekic, Muhamed Mehmedovic, Almina Djelmic"Experimental Study on Surface Roughness in Abrasive WaterJetCutting" 25th DAAAM International Symposium On Intelligent Manufacturing and Automation, ISSN: 1877-7058, 2015.
5. B. Satyanarayana, G. Srikar," Optimization of rough water fly machining process parameters utilizing Taguchi Gray RelationalAnalysis(TGRA)",

Proceedings of thirteenth IRF International Meeting, Pune , India, ISBN: 978-93-84209-37-7, Issue 20,July 2014.

6. Debasish ghosh, probal k. das, b.doloi "parametric investigations of grating water stream cutting onsurface unpleasantness of silicon nitride materials" all india fabricating innovation, plan and research meeting (aimtdr), december twelfth fourteenth, 2014.

7. Vijay kumar buddy, s.k.choudhury utilization of grating water stream machining infabricating small scale instruments for edm for delivering exhibit of square openings" all india fabricating innovation, structure and research gathering (aimtdr), december twelfth fourteenth, 2014.

8. A REVIEW ON ABRASIVE WATER JET CUTTING International Journal of Recent progresses in Mechanical Engineering (IJMECH), Vol.3, No.3, August 2014.

9. M.Uthayakumar,v.arumugaprabu, m.kathiresan "trial examination of the procedure parameters in grating waterjet cutting of redmud strengthened banana/polyester cross breed composites"all india fabricating innovation, structure and research gathering (aimtdr), december twelfth fourteenth, 2014.
10. S. R. Patel, Dr. A. A. Shaikh ,"Control and estimation of grating stream rate in an Abrasive Waterjet Machine",International diary of inventive Research in Science, Engineering and Technology, ISSN: 2319-8753 ,Volume 2,Issue 12,December 2013.
11. Cristian Birtu, Valeriu Avramescu," Abrasive water fly cutting-Technique, Equipment,Performances", Nonconventional Innovations Review,Romania, Issue March ,2012.
12. Veselko Mutavgjic,Zoran Jurkovic, Marina Franulovic, Milenko Sekulic,"Experimental examination of surface harshness acquired by Rough Water stream machining", fifteenth International Research/Expert Conference ,"Trends in the Development of Machinery and Associated Technology", Prague, Czech Republic , Issue 12,September 2011.
13. M. Chithirai pon selvan and n. Mohana sundara raju"assessment of procedure parameters inabrasive waterjet cutting ofstainless steel" global diary of advances in building and innovation (ijaet), issn: 2231-1963, july 2011.
14. B. Venkateswar Rao, Praveen Kumar Kancherla, Sunita Panda "Multiband opened Elliptical printed Antenna Design and Analysis" Journal Of Mechanics Of Continua And Mathematical Sciences (JMCMS), Vol.- 14, No.- 4, July-August (2019) pp 378-386.
15. Kumaraswami Gajula, Amulya Boyina, K. Praveen Kumar "Dynamic Quad band Antenna Design for Wireless Medical and Satellite Communication Applications" Journal Of Mechanics Of Continua And Mathematical Sciences (JMCMS), Vol.- 14, No.- 4, July-August (2019) pp 239-252.
16. Amulya Boyina, K. Praveen Kumar "Dynamic Coplanar Wave manage Fed Switchable Multimode Antenna Design and Analysis" Journal Of Mechanics Of Continua And Mathematical Sciences (JMCMS), Vol.- 14, No.- 4, July-August (2019) pp 188-196.