iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL
FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: VII Month of publication: July 2023

DOI: https://doi.org/10.22214/ijraset.2023.54596

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VII Jul 2023- Available at www.ijraset.com

Response Optimization of Machining Parameters using MCDA-Vikor Method for Acrylic Glass with AHAJM

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Abstract: Abrasive Hot Air Jet Machining (AHJM) is becoming one of the most prominent machining techniques forPolymethyl Methacrylate (PMMA) and other brittle materials. In this attempt has been made to combine abrasive and hot air to form an abrasive hot air jet. Abrasive hot air jet machining can be connected to different tasks, for example, boring, surface scratching, scoring and small scale completing on the glass and its composites. The impact of air temperature onthe material expulsion rate connected to the procedure of glass carving and scoring is talked about in this article. The unpleasantness of the machined surface is additionally investigated. It is discovered that the material removal rate (MRR) increments as the temperature of transporter media (air) is expanded. In the present work to be attempt to investigate machining characteristics of PMMA material on hot air abrasive jet machining. In hot air abrasive jet machining(HAJM) abrasive particles stay on abrasive particle stay molten by compacted air in a closed chamber and are intensive over the objective surface over a nozzle the stream of particles coming out of the nozzle through very high velocity's (175-300m/s) impacts the objective surface and eliminates the material by destruction.

The investigation has to be carried on to study the effect of process parameters as material removal rate(MRR) as surface roughness(SR) with different input parameters like Air Pressure, , Size Of Abrasives , Stand-Off Distance ,Temperature Of Carrier Gas. In this experimental process Tungstencarbide coated nozzles were to be used flow of silicon carbide(sic) particles will be used.The Poly(methyl methacrylate) (PMMA), furthermore saw as acrylic glass, acrylic material, or plexiglass as suitably as by using the change names Plexiglas, Crylux, Lucite, Acrylate.

PMMA it is an unquestionable thermoplastic .the creation formula of PMMA is (C5O2H8)n it has incredible properties to, for instance, lightweight, 92% Transparent observable light effect inside 3mm of thick material, extraordinary solidarity to consider another polystyrene. it's for the most part important in these zones, for instance, Because of its direct properties, lightweight and preferable quality took a gander at over glass, It was broadly usedto make aircraft windshields, shades and weapon turrets. After this couple of different business applications were made for PMMA, for instance, glass material, façade arrangement, publicizing, vehicle headlamps, etc.,

Keywords: Abrasive Hot Air Jet Machining-AHAJM,ACRYLIC GLASS , Taguchi analysis, ANOVA, MCDA- VIKORmethod .

I. INTRODUCTION

Abrasive Hot Air Jet Machining (AHAJM) is a handling non-conventional machine which works materialswithout creating stun and heat. AHJM is applied for some, reasons like boring, cutting, cleaning, and drawing activity. In Abrasive stream machining, rough particles aremade to encroach on the work material at high speed. A stream of rough particles is conveyed via bearer gas or air. The high-speed stream of abrasives is created by changing over the weight vitality of bearer gas or air to its Kinetic vitality and henceforth the high-speed flight.

Spouts direct grating plane in a controlled way onto work material. The high-speed grating particles expel the material by smaller-scale cutting activity just as fragile break of the work material. Machining, Drilling, Surface Finishing are the Major Processes that can be performed productively.

The procedure parameters are utilized like factors which impactmetal evacuation. They are bearer gas, rough, and speed ofgrating, work material, and spout tip separation (NTD).

Rough stream cutting is utilized in the cutting of materials as different as Titanium, Brass, Aluminium, Stone, Any Steel, Glass, Composites and so on.

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II. PRINCIPLE OF WORKING

The grinding media can be passed on by a versatile hose to land at the inside, difficult to-land at zones. Second, AHAJM has restricted power and less warmth age than standard machining structures. Unpleasant fly machining (AJM) is seen as one of the most engaging systems that can engraving accurate dimples outwardly of hard and frail materials some judicious employments of AJM have recently shown its high potential as a littler scale machining methodology, for instance, improvement and completing of window glass. At the point when all is said in done, AHAJM is requested as effect wrapping up. The machining framework is perceived from ordinary shot affecting in that it incorporates a precision fly spout of under 1 mm in separation over, through which a controlled mass of fine, hard unpleasant particles is diligently gone for the workpiece surface. Thus, AHAJM can meet the essential for planning of significantly controlled little scale dimples onto the outside of difficult to-machine materials. From another viewpoint, AHAJM is a machining procedure that uses the ordinarily malevolent lead of breaking down, where fine, hard particles ambush the workpiece unremittingly, in a positive way. Material clearing in the AHAJM method is developed by the usage of a consistent fly, which is made by mixing unpleasant particles in with a rapid air stream, which last presents vitality to the grinding particles, enlivening them going before their impingement on the workpiece. The grinding particles serve fundamentally as the harsh medium, giving a different social event of little scale machining instruments supporting material ejection. Extraordinarily boundmachining forces and low significance of made warmth aretwo Additional central purposes of AHAJM. Basically it might be portrayed as the material ejection process where the material is ousted or machined by the impact breaking down of the rapid stream of air or gas and unpleasant mix, which is revolved around to the workpiece. In Abrasive Hot Air Jet Machining (AHAJM), grinding particles are made to infringe on the work material at a fast. The fly of harsh particles is passed on by means of transporter gas or air. The rapid stream of harsh is delivered by changing over the weight imperativeness of the transporter gas or air to its engine essentialness and subsequently fast fly. The spout arranges the unpleasant stream in a controlled manner onto the work material, with the objective that the partition between the spout and the workpiece and the impingement edge can be set alluringly. The fast unpleasant particles oust the material by scaled downscale cutting action similarly as the delicate break of the work material. Fig. 1 underneath schematically shows the material removal process.

Figure 1:schematically shows the material removal process

Table 1 : Nomenclature of machining unit and theirspecification for PMMA

Nomenclature	Specification
Sample Material	PMMA
Thickness Of Material	3mm
Nozzle Material	Tungsten Carbide
Size Of Work Piece	30x30mm
Nozzle Diameter	3
Abrasive type	Silicon carbide
Abrasive size in microns	60,80,100
Pressure in bar	5,6,7
SOD in mm	5,6,8
Temperature Of Air^{o}c	35,45,55
No Of Experiment	9
Chemical formula	$(C_5O_2H_8)_n$

Table 2 : Estimations Of Process Parameters For DifferentLevels

S.No	Factors	Units of factors	levels		
			Level1	Level2	Level3
A	Pressure of air	bar	5	6	7
B	SOD	MM	8	6	5
C	Abrasive size	microns	60	80	100
D	Air Temperature	Degree Celsius	35	55	45

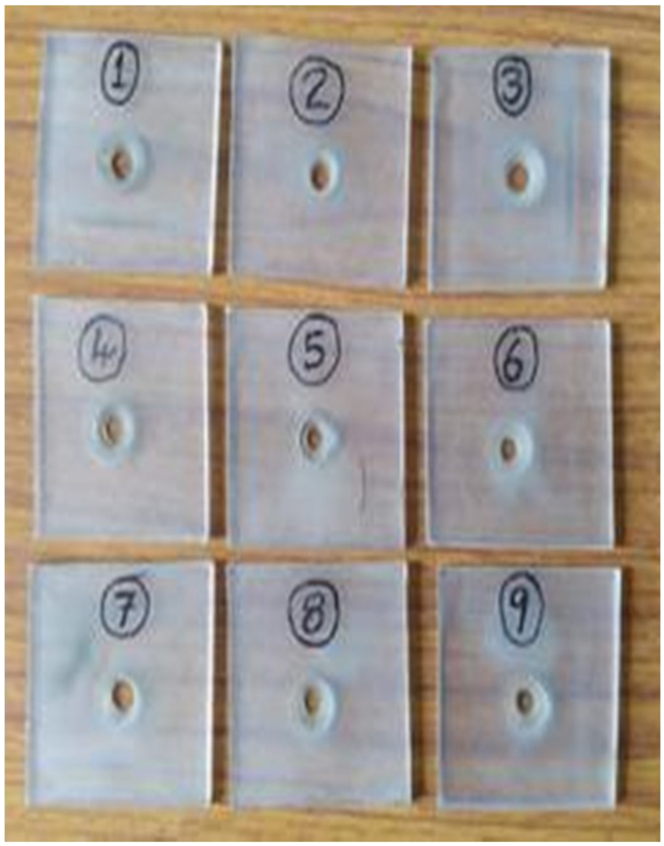

Figure 2; PMMA specimen after HAJM

A. ANOVA

The measurable programming minitab19 with a scientific instrument of ANOVA is utilized to figure out which parameter essentially influences the exhibition qualities .the consequences of ANOVA for the single- reaction S/N proportion MRR and SR appear in table3 and table 4

Table 3: General Linear Model: MRR versus Air pressure,SOD, Ab size, Temperature

Results of ANOVA for MRR

Source DF Seq SS Contribution Adj SS Adj

MSpressure 2 0.019909 32.14% 0.019909

0.009954 SOD 2 0.003950 6.38% 0.003950

0.001975Ab Size 2 0.029699 47.94% 0.029699

0.014849 Air Temp 2 0.008395 13.55% 0.008395

0.004197

Total 8 0.061952 100.00%

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Table 4: General Linear Model: SR versus Air pressure, SOD, Ab size, Temperature

Results of ANOVA for SRAnalysis of Variance

Source	DF	Seq SS	Contribution	Adj SS	Adj MS
pressure	2	4.47017	66.97%	4.47017	2.23509
SOD	2	1.36224	20.41%	1.36224	0.68112
Ab Size	2	0.77603	11.63%	0.77603	0.38801
Air Temp	2	0.06602	0.99%	0.06602	0.03301
Total	8	6.67446	100.00%		

It tends to be seen the least demanding commitment is abrasive size has been done of 47.94% forMRR and pressure has been done 66.97% for SR. The unwinding of the parameters has less responsibilities. It is obvious that Air Pressure is one of the gigantic variables that have more effect than some different components on MRR and Ra regards.

B. Multiple-Criteria Decision Analysis (MCDA)

Procedure streamlining is the control of changing a procedure in order to advance (make the best or best utilization of) some predetermined arrangement of parameters without abusing some requirement. The most well-known objectives are limiting expense and augmenting throughput or potentially effectiveness. This isone of the major quantitative apparatuses in the mechanical making. When enhancing a procedure, the objective is to expand at least one of the procedure details, while keeping all others inside their limitations. This should be possible by utilizing a procedure mining apparatus, finding the basic exercises and bottlenecks, and acting just on them.

The closer to embraced me the plan of down to earth test through the MCDA-VIKOR comparability approach technique extremely valuable getting so greatanswer for advancement issues underway procedure. Various criteria basic leadership (MCDA) alludes to settling on choices within the sight of numerous, generally clashing, criteria. MCDA issues are normal in regular day to day existence. In close to the home setting, a house or a vehicle one purchases might be portrayed regarding value, size, style, security, comfort, and so forth. In the business setting, MCDA issues are increasingly confounded andmore often than not of enormous scale. For instance, numerous organizations in Europe are directing hierarchical self-evaluation utilizing several criteria andsub-criteria set in the EFQM (European Foundation for Quality Management) business greatness model. Acquiring branches of huge organizations regularly need to assess their providers utilizing a scope of criteria in an alternate territory, for example, after-deal administration, quality administration, monetary strength, and so forth.

Despite the fact that MCDA issues are across the board constantly, MCDA as control just has a generally short history of around 30 years.

The improvement of the MCDA control is firmly identified with the headway of PC innovation. In one hand, the quick improvement of PC innovation as of late has made it conceivable to lead an orderly investigation of complex MCDA issues. Then again, the far-reaching utilization of PCs and data innovation hasproduced a tremendous measure of data, which makes MCDA progressively significant and helpful in supporting business basic leadership.

III. METHODOLOGY

The multiple-criteria decision analysis (MCDA) strategy is well-known procedure broadly applied for deciding the best arrangement among a few choices havingdifferent properties or choices. An MCDA issue can be spoken to by a choice network (D) as pursues. The techniques for assessing the best answer for an MCDA issue incorporate registering the utilities of options and positioning these other options. The elective arrangement with the most noteworthy utility is viewed as the ideal arrangement. The accompanying advances are associated with VIKOR strategies.

The VIKOR system has the accompanying advances:

1) *Stage 1:* Decide the best Xi^+ and the most noticeably awful Xi^-estimations of all basis capacities, I = 1,2,...,n;

$Xi^+ = \max (X_{ij}, j=1,...,J)$, $Xi^- = \min (X_{ij}, j=1,...,J)$, if the I^{th} capacity is advantage; $Xi^+ = \min (X_{ij}, j=1,...,J)$,

$Xi^- = \max (f_{ij}, j=1,...,J)$, if the I^{-th} capacity is cost.

2) *Stage 2:* compute the qualities S_i and R_i, j=1,2,...,J, by therelations:

$$S_i = \sum_{j=1}^{m} \left(w_j \times \frac{x_i^+ - x_{ij}}{x_i^+ - x_i^-}\right)$$

Where

S_i=unitymeasure,

w_j = weigⓘtage of eacⓘ criteria ,

x_i^+ = best value of perticularcriteria, x_i^- = worst value of perticular riteria, x_{ij} = value of tⓘe perticular sell,

Then calculate individual regradevalue(maximum value of each row)

$$R_i = \max_i \left(w_j \times \frac{x_i^+ - x_{ij}}{x_i^+ - x_i^-}\right),$$

3) *Stage 3:* calculate the qualities Q_i, j=1,2,...,J, by theconnection

$$Q_i = v \times \frac{s_i - s^+}{s^- - s^+} + (1 - v) \times \frac{R_i - R^+}{R^- - R^+}$$

where

$S^+ = \min S_i$, $R^+ = \min R_i$, $S^- = \max S_i$, $R^+ = \max R_i$

Here $\mathbf{S^+}$= Best (or) minimum value of S_i, $\mathbf{R^+}$= Best (or) minimum value of R_i , and
$\mathbf{S^-}$= Worst (or) maximum value of Si, $\mathbf{R^-}$ =Worst (or) maximum value of R_i

4) *Stage 4:*The based on alternative Q_i values the ranking ofthe alternative can be given
The rank 1 will be given to the alternative ofminimum of Q_i value, The next rank is the next minimum value of Q_i. Etc.,. and The rank 9 will be given to the alternative of maximum value of $Q_i$value.

5) *Stage 5:* Propose as a trade-off arrangement the option A(1) which is the best positioned by the measure Q (least) if the accompanying two conditions are fulfilled:

C_1= acceptable advantages , C_2 = Acceptablestability in decision making ,
For

$$C_1 = Q(A^2) - Q(A^1) \geq DQ,$$

where
$Q(A_1)$ =Q_i value of the first ranked alternative
Value and
$Q(A_2)$ = Q_i value of the second ranked alternative
value
If one of the conditions is not satisfied , then a set of compromise solutions is proposed , which consists of

a) Alternative (A1) and (A2) if only conditions C2 is not satisfied , (or)
b) Alternative $a^1, a^2, \ldots\ldots a^m$ if conditions C1 is not satisfied ; a^m is determined by the relation

$Q(a^m)-Q(a^1)<DQ$ for maximum M " (theposition of these alternative are in closeness)".
$Q(A^2)-Q(A^1)$= J≤ DQ satisfied second condition
$Q(A^3)-Q(A^1)$= J ≥ DQ satisfied firstcondition
The acquired trade-off arrangement could be acknowledged by the leaders since it gives a most extreme utility of the lion's share (spoke to by min S), and a base individual lament of the adversary (spoke to by min R). The measures S and R are incorporated into Q for a trade- off arrangement, the base for an understanding built up by shared concessions

IV. SURFACE ROUGHNESS PARAMETERS

Even the best polished metal surface , when examined under a micro scope giving high magnification is seen to be more or less rough, having peaks and valleys of different heights and depth asshown in fig this is knowshas surface roughness . the height peaks as are called as “asperities” when two flat surfaces are placed over one another ,the asperities of the upper surface rest on those of the lower surface, thus the surface makes contact at these points only while over most contact at these points only while over most of the area they are separated. Thus the real area of contact is very much smaller than the apparent area of contact.

1) *Ra* – arithmetical mean roughness value: The arithmetical mean of the absolute values of the profile deviations (Zi) from the mean line of the roughness profile (Figure 3).

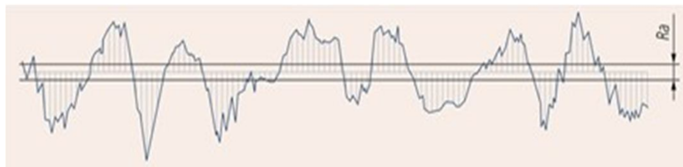

Figure 3 : Arithmetical mean roughness value Ra

2) *Rmr(c)* – material component of the profile: The fraction of a line, which, in section a profile, cuts through the material at a stipulated height c abovethe mean line (in µm). Stated as a percentage.
3) *RSM* – mean peak width: Mean value of the width of the profile elements Xsi (previously S m); horizontal and vertical counting thresholdsare stipulated for this evaluation (Figure 4).

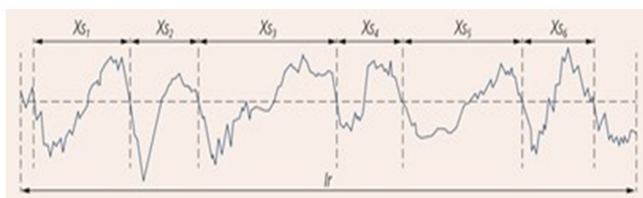

Figure 4: The mean groove spacing RSm is the meanvalue of the spacing Xsi of the profile element

4) *Rt* – total height of the roughness profile: Difference between height Zp of the highest peak and depth Zv of the deepest valley within theevaluation length ln (Figure 5).

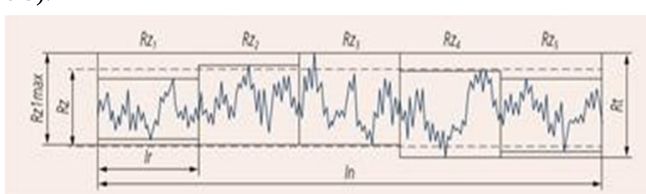

Figure 5: Total height of the roughness profile Rt, meanroughness depth Rz and maximum roughness depth Rz1 max

5) *Rzi* – greatest height of the roughness profile: Sum of the height of the highest-profile peak and the depth of the deepest profile valley, relative to the mean line, within a sampling length.

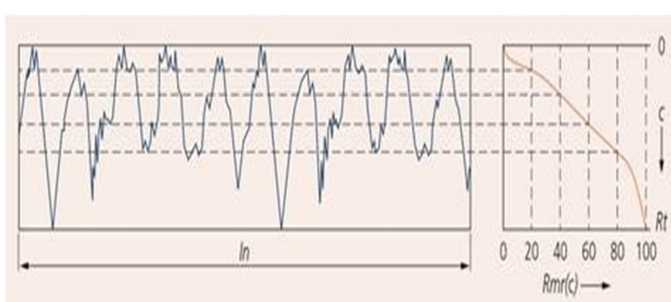

Figure 6 : The material component curve of the profile depicts the material component Rmr (c) of the profile as afunction of the section height c (Abbott-Firestone curve)

6) *Rz1 max* – maximum roughness depth: Largest of the five Rzi values from the five samplinglengths lri within the evaluation length ln. (vii) Rz– mean roughness depth: Mean value of the five Rzi values from the five sampling lengths lri.

V. RESULTS DISCUSSION

The end HAJM limits ,pressure, SOD ,Abrasive size ,and air temperature is determined by ANOVA four emphasis for ever of two councils were done of variable spout breadth consequently as to amount MRR, Ra and signal to noise ratio is assessed by the Minitab programming.

A. Main Effects Plot for Means

Figure 7:Main Effects Plot for Means For MRR

B. Main Effects Plot for SN ratios

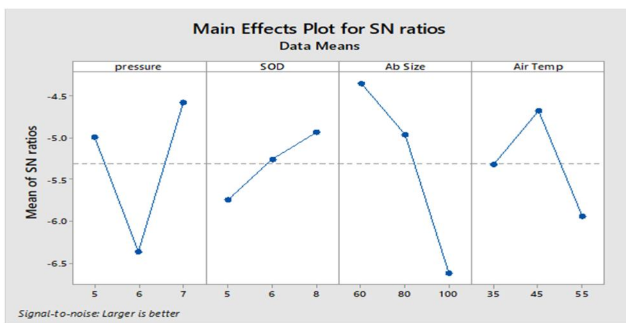

Figure8: Main Effects Plot for SN ratios for MRR

In figure 7&8 is demonstrates primary impact plot for SN proportions and means, the chart is plotted among mean Of MRR and a few parameters these two diagrams are shown impact of a few factors on mean of S/N proportions and mean of materials end rate plotted to exploitation the machining impact acquired.it is seen from the plot show comparative pattern as uncovered by plot of mean of MRR. This helper approves the impact and result of parameters.

Taguchi Analysis: SR versus pressure, SOD, Absize, Air temp

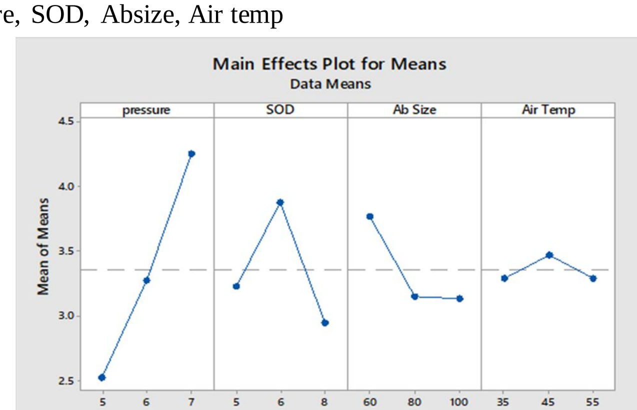

Figure:9 Main Effects Plot for Means for SR

Main Effects Plot for SN ratios

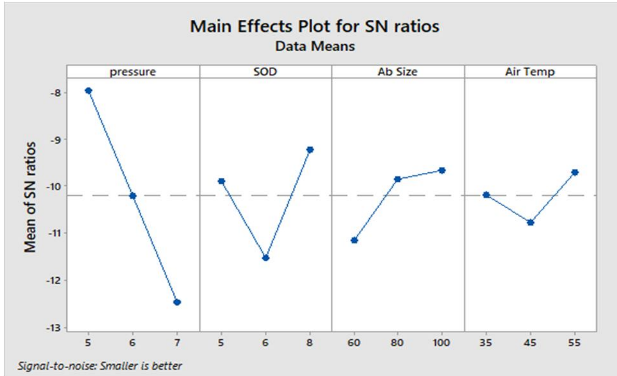

Figure:10 Main Effects Plot for SN ratios for Ra

Table 5 : Results after HAJM at Various Responses

Expno.	MRR	SR	LOOKS	S_i forMRR	S_i forSR	S_i forlooks	Total S_i	R_i	Q_i	Rank
1	0.656	2.672	5	0	0.03	0	0.03	0.03	0.112	2
2	0.635	2.973	4	0.057	0.085	0.033	0.175	0.085	0.1	1
3	0.428	3.129	2	0.615	0.115	0.1	0.83	0.615	0.813	9
4	0.486	2.510	3	0.459	0	0.66	1.119	0.66	0.726	7
5	0.415	3.510	2	0.65	0.188	0.1	0.938	0.65	0.645	5
6	0.550	3.689	2	0.286	0.228	0.1	0.614	0.286	0.158	3
7	0.571	3.744	2	0.23	0.482	0.1	0.812	0.482	0.433	4
8	0.618	5.127	3	0.103	0.25	0.666	1.019	0.666	0.679	6
9	0.525	3.867	3	0.324	0.218	0.666	1.208	0.666	0.785	8

VI. CONCLUSIONS

In the present examination, MCDA-VIKOR is utilized to decide the ideal procedure parameters by utilizing multi-target work for accomplishing better yield reactions. The variety between the VIKOR results and Taguchi results are watched the advancing procedure parameters in AHAJM for better machining reactions indicated Table 5

The impact of the framework parameters viz. pressure, Abrasive size, Standoff segment and air temperature on the work material (PMMA) are examined for their impact on MRR a non-straight condition is being gotten and is indicated graphically and from the condition and the frameworks got two or three terminations are attracted which are as indicated by the going withas follow.

It can likewise be reasoned that grating plane machining with silicon carbide rough is appropriate for hard and weak materials like glass, acrylic and fiberglass.It can likewise be reasoned that informs where material expulsion is of prime significance there standoff separationought to be kept ideal, grating of coarser size ought to be utilized and high weight ought to be utilized. While in situations where surface completion is of prime significance low standoff separation high weight and bettergrating ought to be utilized.

The parameters Pressure, SOD, Ab Size and Air Temperature and their collaborations, influence the deburring procedure. At lower MRR, the deburring time increments with the showdown separation. On account of higher MRR, the deburring time at first diminishes and on arriving at an ideal worth it increments with the SOD.

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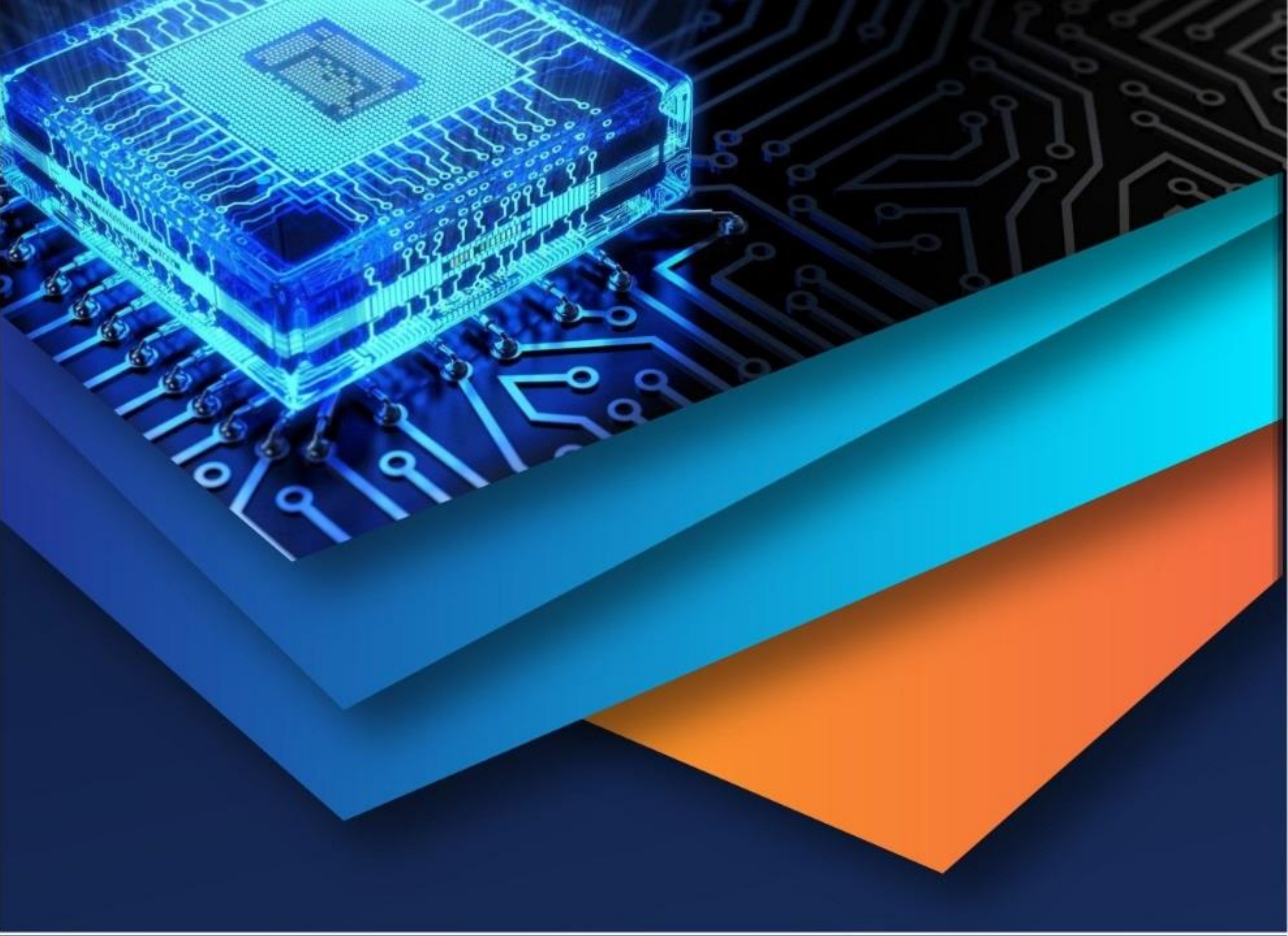

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