# Analysis And Optimization Of Machining Parameters Under High-Speed Machining Of Titanium Grade-5 Alloy



**Sanchit Kumar Khare[1]*, Gurpreet Singh Phull[2]**
***Corresponding Author:** Sanchit Kumar Khare
*[1]PhD Scholar, School of Mechanical Engineering, Lovely Professional University, Jalandhar-144411, Punjab, India, Email- sanchitkhare@yahoo.com, Contact No.-+91-9198911550
[2]Professor, School of Mechanical Engineering, Lovely Professional University, Jalandhar-144411, Punjab, India

**Abstract**
To scrutinize the input parameters for various responses like MRR, TWR, SR, Ti-6Al-4V become machined with HSM using different tool insert. Taguchi L9 design turned into used to carry out experiments with 4 input variables (cutting speed, feed rate, depth of cut, stepover). Received information about output response after machining and tried to optimize machining parameters using optimization techniques so that better results could be obtained. Maximum material removal rate ($mm^3$/min) was observed when the cutting velocity and with stepover of level 3 and level 2 was implemented. Once the result is received, a confirmation test is also performed so that the result can be validated with an error of 2.91%, 3.61%, and 2.67 % for MRR, SR, and TWR respectively. Appropriate results have been obtained in the use of octagonal insert.

**Keywords: -** Titanium Alloy; High-speed Machining; Metal Removal Rate; Tool Wear
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## 1. Introduction

Various methods have been adopted in the industry for better machining. One of which is the high-speed machining process. In which the cutting tool directly affects the surface finish of the product. Excess twr in machining indicates poor surface finish of the product and excess cutting force [1, 2]. In the last decay, the demand for hsm has increased, due to which higher productivity, better quality products are produced at optimum cost Due to which hsm are given importance in the category of very efficient machining [3]. The range of high-speed machining is set according to the material to be cut [4]. $V_f$ is also an effective response which affects the production. Which shows that the cutting force should not be neglected during machining. In today's time, considering the problems of the industry, special importance is being given to high-speed machining. So that by using the least cost, better results can be obtained in less time. The main objective of the industry is to achieve better finishing on the work piece surface and quality of product after machining. For which different types of technology like different cooling medium like mist cooling, flood cooling, MQL are being used. Today many materials are available in the field of materials. The machinability of the created materials has acquired significance. Titanium is a lightweight alloy. Which is being used in various industries like automotive, aerospace, biomedical etc. [1]. Due to the various characteristics, its use has increased in today's time. This paper discusses their post-machining effects on the work piece surface using octagonal type inserts. The main objective is to obtain enhance M RR, lower TWR and SR from the workpiece by using high speed machining. In this particular research, an experimental finding of cutting force and tool wear rate is carried out in the range of cutting speed 450 to 650 m/min. The effect of input variables on the level of M RR, SR and tool wear rate are evaluated. The literature review, experiment, methodology, result and discussion, conclusion section have been discussed in detail in the later parts of this paper.

## 2. Literature Review

Whatever progress has been made regarding this work in the last few years before performing this experiment. In this section, the results obtained from their experiments are discussed in detail. As far as the machining of titanium alloy is concerned, a lot of work has been done on this alloy even before today. Conditions in which the researcher did not attempt or did not pay attention to those things in the experiment. Keeping those things in mind, the parameter has been set in this work. Abele et al. observed that machining of Ti alloy shortened cutting force and enhanced performance over traditional process by incremented MRR [5]. Liao et al. proposed machining margin from 55 to 135 m/min for milling of inconal -718 [6]. The figure shows the machining range to cut various materials [5]. It has been concluded from various studies that the range of cutting speed is decided by considering the machinability and strength of the workpiece. The materials which have difficulty in cutting and whose strength is high. They require high speed to cut them at a lower portion [7].

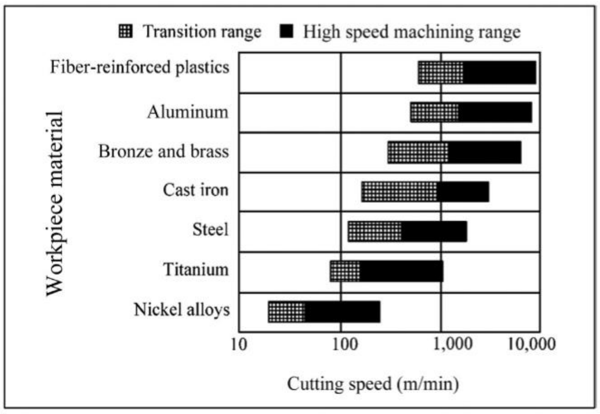
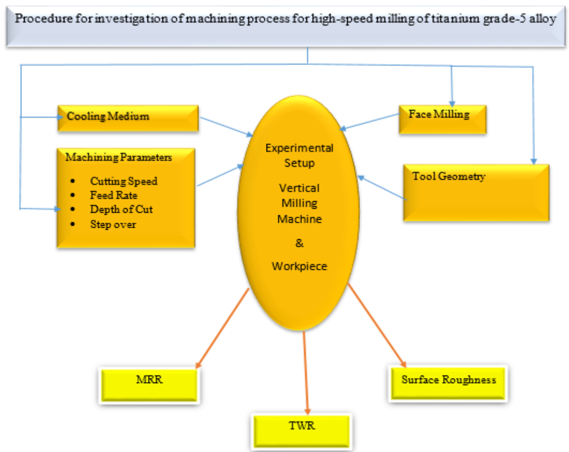



**Fig 1: -** Cutting speed range of different material [5]

In his experimental work, the researcher has observed in his experimental work by setting the cutting speed range to 49. 4 m / min to122.5 m/min. The effects on the tool chip workpiece interface are described [9].Fang analysed the $V_f$ with respect to the cutting of tool edge roundness in machining with a round edge tool [10]. Zejia Zhao has investigated $V_f$ are in better findings with the output responses at different cutting speeds within a percentage error of 3.53. In the last few years, so many optimization techniques are implemented to determine the optimum response. Among all these optimization methods, Taguchi Methods is also maintaining its world place. Singaravel et al. [13] reported that HTV (hybrid taguchi vikor) methodology was used to calculate the optimum response. Velchev et al. [14] studied the effect of insert, feed rate, depth of cut and cutting speed on minimal energy consumption. After year of accruement, the researches related to machining of titanium alloy grade -5 have generally covered most of the parameters like tool material and geometry [12,15], cutting conditions like cutting speed, feed rate, depth of cut [13] and cooling medium (MQL, flood cooling, mist cooling [14]) [16]. From the point of view of machinability, titanium alloy is a very different material, titanium alloy is not easily machined [18, 19]. In the past few years, titanium alloys have gained more importance in industrial applications than other alloys. Even after doing a lot of research on high-speed machining, even today, the high-speed machining of titanium alloy in the industry is based on suitable working conditions, operator quality and trial –and- error technique. Therefore, the objective of this work is to determine optimum machining conditions for high-speed machining of titanium alloy for optimizing output response based on Taguchi technique. Total 9 number of trials were done to observed the various and study the effect of various input variables like cutting speed, feed rate, depth of cut and stepover on MRR, SR, TWR. Statistical evaluation of the significance level of all responses was estimated by Qualitek-4 software.






Graphical abstract

## 3. Experiment

This experimental work has been done by VMC. The information of which is given in the table and the chemical composition of the workpiece material is given through the table below. To perform this experiment, machining parameters such as $v_c$, feed rate, doc, so and their three levels have been taken. The information of which is given in the table below. These were completed using L9 with the help of doe and the results obtained from them have been discussed.

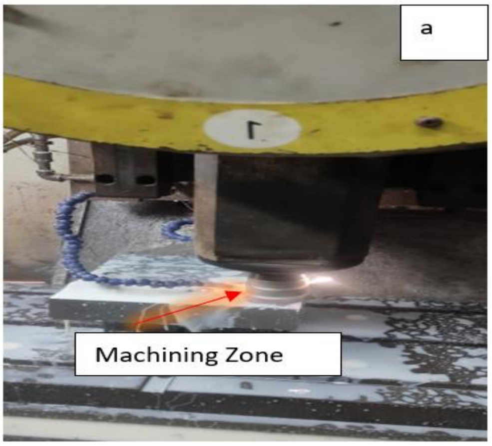



**Fig: - a)** Machining zone

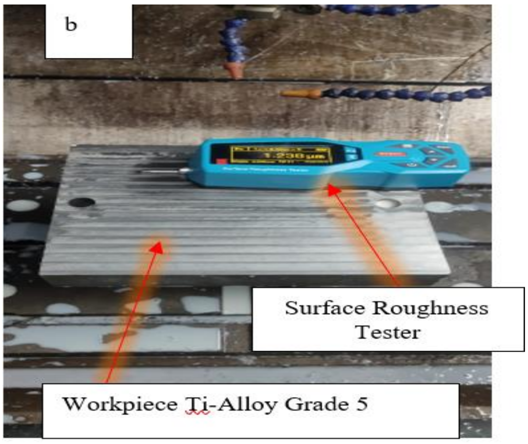



**Fig:-b)** Surface Roughness Testing

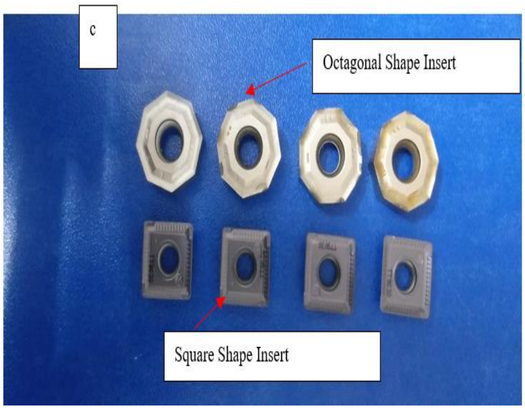



**Fig: -c)** Octagonal and Square shape insert

**Table 1 –** Elements percentage of Ti-alloy grade 5

| | | | | | | |
|---|---|---|---|---|---|---|
| Ti-88.86 % | Al-6.01 % | V-4.33 % | Fe-0.25 % | O-0.2 % | C-0.08 % | H-0.015% |

**Table 2–** Experimental machining settings

| Cutting Condition |
|---|
| Cutting speed (Vc)- 450-650 m/min |
| Feed Rate (F)- 1900-2100 mm/min |
| Depth of cut (DoC)- 0.1-0.3 mm |
| Stepover (SO)- 0.1-0.3 % |

## 3.1 DOE

The main aim of this research work are to examine the effects of cutting parameters with cooling medium on TWR, $V_f$, MRR, SR in face milling of Ti alloy. Cutting speed, feed rate, depth of cut, step over were considered as a four factors and their three-level selected for evaluation as shown in table. Keeping in mind the work done by many researchers, the levels of machining parameters have been selected in this particular work Okafor and Aramalla [8]. Better results were found after testing each factor at three levels by setting the optimum setting in the slot milling process.

## 3.2 Taguchi Method

Taguchi Technique is a tool which is used to optimize the performance characteristics of parameter design for the purpose of better designing and for better product quality [20, 21]. In this particular method, the process parameters that affect the product are mainly divided into two parts: noise and control factors. To obtain better results in the machining process, the best conditions are chosen using the control factor for the purpose of stability and the noise factor to measure the variation. According to this method, higher the better is selected in case of material removal rate and lower the better in case of surface roughness and tool wear rate.

Lower is better

$$\eta_s=-10 \log \left(\frac{1}{x}\sum_{j=1}^{x} u^2\right)$$

Higher is better

$$\eta_s=-10 \log \left(\frac{1}{x}\sum_{j=1}^{x} \frac{1}{u^2}\right)$$

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## 4. Result & Discussion

After the completion of machining, the whole results have been collected and discussed in detail. In this research work, Taguchi L9 orthogonal analysis was used in which 4 factor and 3 level were selected and the obtained results such as tool wear rate, metal removal rate and surface roughness were concluded. With the help of all these obtained results, the value of signal and noise ratio was detected using Minitab software. Using Anova, found out the important role of all the factors, which contributed significantly in improving the experimental work. Sufficient results could not be obtained due to not being able to solve the statics completely through Anova. Due to which the value of F test could not be found. There are two ways to get this value, either manually calculated or the other way is to get this value with the help of Qualitek-4 software. In the following sequence, the results of all the outcomes have been discussed in detail, which is about MRR, SR and TWR respectively.

**Table 3-** Arrangement of level, factor, and their responses

| S. No. | $V_f$ | F | DoC | So | Octagonal Shape | | | Square Shape | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | MRR | SR | TWR | MRR | SR | TWR |
| 1 | 450 | 1900 | 0.1 | 20 | 956.94 | 0.74 | 0.82 | 1269.84 | 1.428 | 2.16 |
| 2 | 450 | 2000 | 0.2 | 40 | 2666.67 | 0.77 | 2.49 | 3846.15 | 0.575 | 3.57 |
| 3 | 450 | 2100 | 0.3 | 60 | 3986.71 | 0.60 | 2.04 | 5429.86 | 0.78 | 3.23 |
| 4 | 550 | 1900 | 0.2 | 60 | 6400.56 | 0.86 | 2.13 | 5128.20 | 0.66 | 3.40 |
| 5 | 550 | 2000 | 0.3 | 20 | 10434.78 | 0.68 | 2.24 | 8391.60 | 0.91 | 3.51 |
| 6 | 550 | 2100 | 0.1 | 40 | 1739.13 | 1.35 | 3.57 | 7692.30 | 0.321 | 5.08 |
| 7 | 650 | 1900 | 0.3 | 40 | 11881.18 | 1.72 | 2.83 | 11538.46 | 1.93 | 4.01 |
| 8 | 650 | 2000 | 0.1 | 60 | 3508.77 | 1.04 | 3.36 | 2758.62 | 1.672 | 4.18 |
| 9 | 650 | 2100 | 0.2 | 20 | 6106.87 | 1.16 | 2.28 | 5128.20 | 0.98 | 3.56 |

Table number 3 has displayed the results obtained after machining is completed and the signal to noise ratio of the obtained results was detected through Minitab software that is mentioned in table no. 4 and 5.

**Table 4-** Value of S/N ratios for Octagonal shaped insert

| Trial No. | $V_c$ | f | $D_c$ | $S_o$ | MRR | S/N Ratio | SR | S/N Ratio | TWR | S/N Ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 956.9 | 59.6177 | 0.74 | 2.61537 | 0.82 | 1.7237 |
| 2 | 1 | 2 | 2 | 2 | 2666.7 | 68.5194 | 0.77 | 2.27019 | 2.49 | -7.9240 |
| 3 | 1 | 3 | 3 | 3 | 3986.7 | 72.0123 | 0.60 | 4.43697 | 2.04 | -6.1926 |
| 4 | 2 | 1 | 2 | 3 | 6400.6 | 76.1244 | 0.86 | 1.31003 | 2.13 | -6.5676 |
| 5 | 2 | 2 | 3 | 1 | 10434.8 | 80.3697 | 0.68 | 3.34982 | 2.24 | -7.0050 |
| 6 | 2 | 3 | 1 | 2 | 1739.1 | 64.8066 | 1.35 | -2.60668 | 3.57 | -11.0534 |
| 7 | 3 | 1 | 3 | 2 | 11881.2 | 81.4972 | 1.72 | -4.71057 | 2.83 | -9.0357 |
| 8 | 3 | 2 | 1 | 3 | 3508.8 | 70.9031 | 1.04 | -0.34067 | 3.36 | -10.5268 |
| 9 | 3 | 3 | 2 | 1 | 6106.9 | 75.7164 | 1.16 | -1.28916 | 2.28 | -7.1587 |

**Table 5-** Value of S/N ratio for Square shaped insert

| Trial No. | $V_c$ | f | $D_c$ | $S_o$ | MRR | S/N Ratio | SR | S/N Ratio | TWR | S/N Ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 1 | 1269.8 | 62.0750 | 1.428 | -3.09456 | 2.16 | -6.6891 |
| 2 | 1 | 2 | 2 | 2 | 3846.2 | 71.7005 | 0.575 | 4.80664 | 3.57 | -11.0534 |
| 3 | 1 | 3 | 3 | 3 | 5429.9 | 74.6958 | 0.780 | 2.15811 | 3.23 | -10.1841 |
| 4 | 2 | 1 | 2 | 3 | 5128.2 | 74.1993 | 0.660 | 3.60912 | 3.40 | -10.6296 |
| 5 | 2 | 2 | 3 | 1 | 8391.6 | 78.4769 | 0.910 | 0.81917 | 3.51 | -10.9061 |
| 6 | 2 | 3 | 1 | 2 | 7692.3 | 77.7211 | 0.321 | 9.86990 | 5.08 | -14.1173 |
| 7 | 3 | 1 | 3 | 2 | 11538.5 | 81.2430 | 1.930 | -5.71115 | 4.01 | -12.0629 |
| 8 | 3 | 2 | 1 | 3 | 2758.6 | 68.8138 | 1.672 | -4.46473 | 4.18 | -12.4235 |
| 9 | 3 | 3 | 2 | 1 | 5128.2 | 74.1993 | 0.980 | 0.17548 | 3.56 | -11.0290 |



Then the results obtained by ANOVA in the case of octagonal insert are shown in Tables 6 to 11. Table 12 to 17 shows the results obtained from the square shape insert.

### 4.1 Result of MRR, SR, TWR for Octagonal Shape Insert

Which factors contributed more to the machining through Anova, to find out the factors, the ratio should be known, which was not obtained with the help of simple way through Minitab software. F-ratio detected through Qualitek-4 software. Which is mentioned in table no. 7, 9, and 11 for MRR, SR, TWR respectively. In which it was found that in increasing the high production rate, making quality product, Depth of cut for MRR, cutting speed for SR, stepover for TWR contributed the most.

**Table 6-** Result of MRR for Octagonal shape insert

| S. No. | Factor | (f) | (s) | (V) | (F) | (S') | P (%) |
|---|---|---|---|---|---|---|---|
| 1 | Cutting Speed | 2 | 35731972.782 | 17865986.391 | ....... | 35731972.782 | 31.084 |
| 2 | Feed Rate | 2 | 9397972.057 | 4698986.028 | ....... | 9397972.057 | 8.175 |
| 3 | Depth of Cut | 2 | 67579505.58 | 33789752.79 | ....... | 67579505.58 | 58.79 |
| 4 | Stepover | 2 | 2240316.83 | 1120158.415 | ....... | 2240316.83 | 1.948 |
| Other Error | | 0 | | | | | |
| Total | | 8 | 114949767.251 | | | | 100 % |

**Table 7-** Result of MRR for Octagonal shape insert

| S. No. | Input | (f) | (s) | (V) | (F) | (S') | P (%) |
|---|---|---|---|---|---|---|---|
| 1 | Cutting Speed | 2 | 35731972.782 | 17865986.391 | 15.949 | 35731972.782 | 31.084 |
| 2 | Feed Rate | 2 | 9397972.057 | 4698986.028 | 4.194 | 9397972.057 | 8.175 |
| 3 | Depth of Cut | 2 | 67579505.58 | 33789752.79 | 30.165 | 67579505.58 | 58.79 |
| 4 | Stepover | (2) | (2240316.83) | POOLED | | | |
| Other Error | | 2 | 2240316.83 | 1120158.415 | | | 7.798 |
| Total | | 8 | 114949767.251 | | | | 100 % |

**Table 8-** Result of SR for Octagonal shape insert

| S. No. | Input | (f) | (s) | (V) | (F) | (S') | P (%) |
|---|---|---|---|---|---|---|---|
| 1 | Cutting Speed | 2 | 0.549 | 0.274 | ....... | 0.549 | 51.354 |
| 2 | Feed Rate | 2 | 0.124 | 0.062 | ....... | 0.124 | 11.603 |
| 3 | Depth of Cut | 2 | 0.019 | 0.009 | ....... | 0.019 | 1.833 |
| 4 | Stepover | 2 | 0.376 | 0.188 | ....... | 0.376 | 35.198 |
| Other Error | | 0 | | | | | |
| Total | | 8 | 1.069 | | | | 100 % |

**Table 9**- Result of SR for Octagonal shape insert

| S. No. | Input | (f) | (s) | (V) | (F) | (S') | P (%) |
|---|---|---|---|---|---|---|---|
| 1 | Cutting Speed | 2 | 0.549 | 0.274 | 28.002 | 0.529 | 49.566 |
| 2 | Feed Rate | 2 | 0.124 | 0.062 | 6.327 | 0.104 | 9.778 |
| 3 | Depth of Cut | (2) | (0.019) | POOLED | | | |
| 4 | Stepover | 2 | 0.376 | 0.188 | 19.193 | 0.356 | 33.395 |
| Other Error | | 2 | 0.018 | 0.009 | | | 7.261 |

| | | | | | |
|---|---|---|---|---|---|
| Total | 8 | 1.069 | | | 100 % |

**Table 10** -Result of TWR for Octagonal shape insert

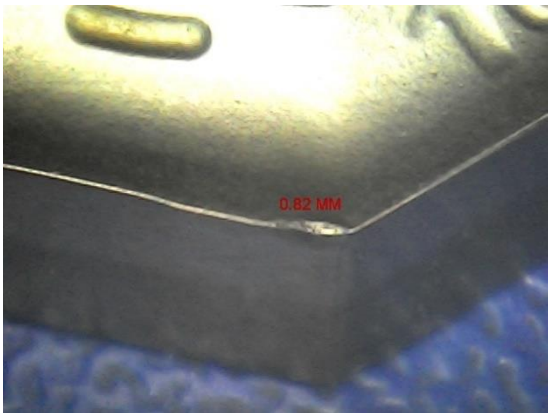
| S. No. | Input | (f) | (s) | (V) | (F) | (S') | P (%) |
|---|---|---|---|---|---|---|---|
| 1 | Cutting Speed | 2 | 1.858 | 0.929 | ....... | 1.858 | 35.599 |
| 2 | Feed Rate | 2 | 1.092 | 0.546 | ....... | 1.092 | 20.921 |
| 3 | Depth of Cut | 2 | 0.13 | 0.065 | ....... | 0.13 | 2.503 |
| 4 | Stepover | 2 | 2.138 | 1.069 | ....... | 2.138 | 40.973 |
| Other Error | | 0 | | | | | |
| Total | | 8 | 5.219 | | | | 100 % |

***Table 11****- Result of TWR for Octagonal shape insert*

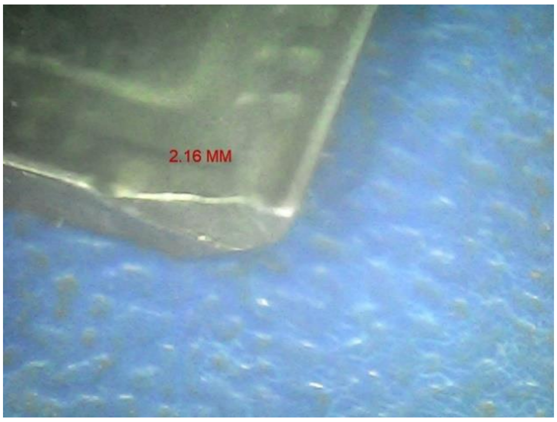
| S. No. | Input | (f) | (s) | (V) | (F) | (S') | P (%) |
|---|---|---|---|---|---|---|---|
| 1 | Cutting Speed | 2 | 1.858 | 0.929 | 14.218 | 1.727 | 33.099 |
| 2 | Feed Rate | 2 | 1.092 | 0.546 | 8.356 | 0.961 | 18.419 |
| 3 | Depth of Cut | (2) | (0.13) | POOLED | | | |
| 4 | Stepover | 2 | 2.138 | 1.069 | 16.365 | 2.008 | 38.474 |
| Other Error | | 2 | 0.13 | 0.065 | | | 10.008 |
| Total | | 8 | 5.219 | | | | 100 % |

## 4.2 Result of MRR, SR, TWR for Square Shape Insert

It was found that in increasing the high production rate, making quality product, Depth of cut for MRR, cutting speed for SR, stepover for TWR contributed the most.




**(a) Octagonal shape**




**(b) Square shape**

**Fig 2: -** Image of tool wear

Figure shows the value of lowest tool wear of both the inserts after machining. So that in the least cost and in less time, maximum and good quality product can be made. For which we have optimized the machining parameters. In the case of square shape insert, the most effective factors are depth of cut, cutting speed and stepover which mostly affect the machining response.



**Table 12-** Result of MRR for Square shape insert

| S. No. | Input | (f) | (s) | (V) | (F) | (S') | P (%) |
|---|---|---|---|---|---|---|---|
| 1 | Cutting Speed | 2 | 21756215.61 | 10878107.805 | ....... | 21756215.61 | 27.985 |
| 2 | Feed Rate | 2 | 2147928.619 | 1073964.309 | ....... | 2147928.619 | 2.762 |
| 3 | Depth of Cut | 2 | 35380842.061 | 17690421.03 | ....... | 35380842.061 | 45.51 |
| 4 | Stepover | 2 | 18456728.915 | 9228364.457 | ....... | 18456728.915 | 23.741 |
| Other Error | | 0 | | | | | |
| Total | | 8 | 77741746.103 | | | | 100 % |

**Table 13-** Result of MRR for Square shape insert

| S. No. | Input | (f) | (s) | (V) | (F) | (S') | P (%) |
|---|---|---|---|---|---|---|---|
| 1 | Cutting Speed | 2 | 21756215.61 | 10878107.805 | 10.128 | 19608286.991 | 25.222 |
| 2 | Feed Rate | (2) | (2147928.619) | POOLED | | | |
| 3 | Depth of Cut | 2 | 35380842.061 | 17690421.03 | 16.472 | 33232913.441 | 42.747 |
| 4 | Stepover | 2 | 18456728.915 | 9228364.457 | 8.592 | 16308800.296 | 20.978 |
| Other Error | | 2 | | | | | 11.053 |
| Total | | 8 | | | | | 100 % |

**Table 14-** Result of SR for Square shape insert

| S. No. | Input | (f) | (s) | (V) | (F) | (S') | P (%) |
|---|---|---|---|---|---|---|---|
| 1 | Cutting Speed | 2 | 1.252 | 0.626 | ....... | 1.252 | 54.304 |
| 2 | Feed Rate | 2 | 0.627 | 0.313 | ....... | 0.627 | 27.221 |
| 3 | Depth of Cut | 2 | 0.385 | 0.192 | ....... | 0.385 | 16.705 |
| 4 | Stepover | 2 | 0.04 | 0.02 | ....... | 0.04 | 1.764 |
| Other Error | | 0 | | | | | |
| Total | | 8 | 2.306 | | | | 100 % |

**Table 15-** Result of SR for Square shape insert

| S. No. | Input | (f) | (s) | (V) | (F) | (S') | P (%) |
|---|---|---|---|---|---|---|---|
| 1 | Cutting Speed | 2 | 1.252 | 0.626 | 30.776 | 1.211 | 52.554 |
| 2 | Feed Rate | 2 | 0.627 | 0.313 | 15.427 | 0.587 | 25.463 |
| 3 | Depth of Cut | 2 | 0.385 | 0.192 | 9.467 | 0.344 | 14.945 |
| 4 | Stepover | (2) | (0.04) | POOLED | | | |
| Other Error | | 2 | 0.04 | 0.02 | | | 7.038 |
| Total | | 8 | 2.306 | | | | 100 % |

**Table 16-** Result of TWR for Square shape insert

| S. No. | Input | (f) | (s) | (V) | (F) | (S') | P (%) |
|---|---|---|---|---|---|---|---|
| 1 | Cutting Speed | 2 | 1.891 | 0.945 | ....... | 1.891 | 38.24 |
| 2 | Feed Rate | 2 | 0.946 | 0.473 | ....... | 0.946 | 19.135 |
| 3 | Depth of Cut | 2 | 0.143 | 0.071 | ....... | 0.143 | 2.896 |
| 4 | Stepover | 2 | 1.964 | 0.982 | ....... | 1.964 | 39.725 |
| Other Error | | 0 | | | | | |
| Total | | 8 | 4.946 | | | | 100 % |

**Table 17-** Result of TWR for Square shape insert

| S. No. | Input | (f) | (s) | (V) | (F) | (S') | P (%) |
|---|---|---|---|---|---|---|---|
| 1 | Cutting Speed | 2 | 1.891 | 0.945 | 1.748 | 1.748 | 35.344 |
| 2 | Feed Rate | 2 | 0.946 | 0.473 | 6.606 | 0.803 | 16.239 |
| 3 | Depth of Cut | (2) | (0.143) | POOLED | | | |
| 4 | Stepover | 2 | 1.964 | 0.982 | 13.714 | 1.821 | 36.829 |
| Other Error | | 2 | 0.13 | 0.071 | | | 11.588 |

| | | | |
|---|---|---|---|
| Total | 8 | 5.219 | 100 % |

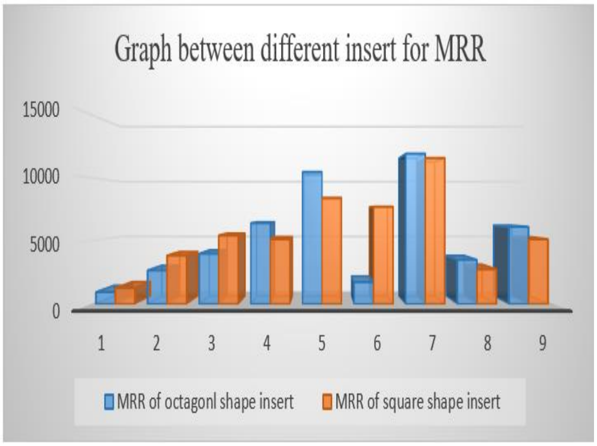



**Fig 3: -** Graph between various insert for MRR response

Both types of inserts are used in this machining. By looking at these graphs, it is known that the insert of octagonal shape has given better results than the insert of square shape. Trial number 4, 5, 7, 8, 9 have given better results.

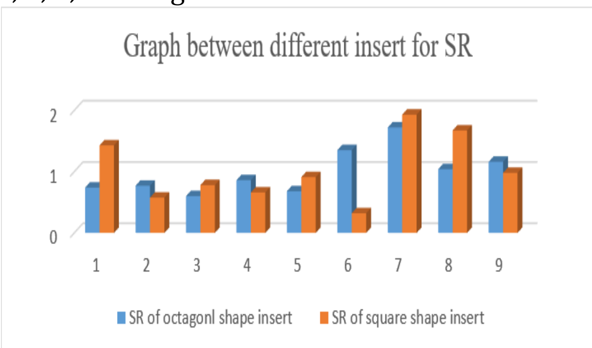



**Fig 4: -** Graph between various insert for output result

Trial no. 1, 3, 5, 7, 8, 9 results are better than octagonal shape. So from the point of view of surface roughness, the octagonal shape insert is a better option than other inserts. In the case of high-speed machining of titanium alloys.

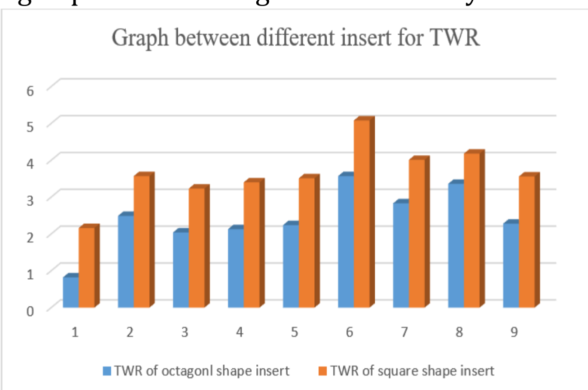



**Fig 5: -** Graph between various insert for output response

Trial no. The response of 1 to 9 was found to be better for the octagonal shape insert. So octagonal shape insert from TWR point of view is preferred to get better response.

### 4.3 Confirmation Test

After the completion of the machining, the data obtained was taken together and again the confirmation test was done. The obtained results were compared with the experimental data. The last advance in machining using Taguchi's methodology is to know the optimize value and measure the enhancement of the performance characteristics with the select input parameters.



**Table 18-** Confirmation Result

| Optimal Machining Value | | | | | | |
|---|---|---|---|---|---|---|
| | MRR | | SR | | TWR | |
| | Predicted | Experiment | Predicted | Experiment | Predicted | Experiment |
| Level | Vc3F2DoC3SO3 | Vc3F2DoC3SO3 | Vc1F2DoC3SO3 | Vc1F2DoC3SO3 | Vc1F1DoC1SO1 | Vc1F1DoC1SO1 |
| S/N Ratio | 83.7537 | 8.3201 | 6.01638 | 5.6548 | 1.72372 | 1.4568 |

The results for MRR, SR and TWR showed an error of 2.91%, 3.61% and 2.67 % for s/n respectively.

## 5. Conclusion

The results that came out after experimenting with high-speed machining on titanium alloys are the conclusions that can be drawn from them. They are explained here in detail.

- The use of octagonal inserts has yielded better results in high-speed machining of titanium alloys than square shaped inserts.
- In the case of tool wear, the tool life of the octagonal insert after machining was found to be better as compared to the square shape insert.
- When comparing surface roughness values, better surface finish was found using octagonal inserts.
- In the initial experiment trail, 1, 2 square shape inserts yielded better results, but overall trail observation found that the use of octagonal inserts improved the metal removal rate.
- Completed the confirmation test using octagonal insert, which appears to calculate the predicted and experiment values between them using the Taguchi method, 2.91%, 3.61%, 2.67% error was found for MRR, SR,TWR respectively.
- The optimum value of machining condition for MRR, SR and TWR obtained from improved repositories with the help of Taguchi technique is 3233, 1233, 1111 respectively.

The Taguchi method proved to be very effective in achieving better results of machining. By adjusting the setting of this machining parameter in the future, the researcher can proceed further with different cooling conditions also.

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