TEST Engineering & Management

*March – April 2020*
*ISSN: 0193-4120 Page No. 9548 - 9553*

# Optimization of Machining Parameters in Turning Agricultural Waste based Aluminium Hybrid Composite

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***Article Info***
***Volume 83***
***Page Number: 9548 - 9553***
***Publication Issue:***
***March - April 2020***

***Article History***
***ArticleReceived****: 24 July 2019*
***Revised****: 12 September 2019*
***Accepted****: 15 February 2020*
***Publication****: 11 April 2020*

***Abstract:***
The purpose of the present research is to identify the suitable turning parameters for rice husk ash and molybdenum disulfide reinforced aluminium composite. The parameters that are taken in to consideration for the study is rice husk ash (RHA) percentage, speed and feed while turning in which the objective function is surface roughness. The turning operation with three parameter consideration is designed through Taguchi method and the L9 array is selected. The turning operation is performed in high speed computer numerical controlled lathe and roughness is measured through SJ201 mitutoyo tester. The results confirmed that the machinability of the aluminium is greatly affected by the reinforcement incorporation. Further, the feed rate and speed also influences the surface roughness in significant amount.

***Keywords****: Aluminium; Composite; Turning; Taguchi; roughness*

## 1. INTRODUCTION

Attention of investigators is growing in the recent past over the aluminium based composite materials as a result of their ever demanding requirement in automobile, aero and mineral processing industries [1,2]. The ever demanding requirement for aluminium matrix composites (AMC) is because of their potential properties such as superior strength/weight ratio and heat conductivity. Generally these advanced materials are manufactured by reinforcing hard ceramic particles such as silicon carbide, alumina, boron nitride and titanium carbide etc in various forms such as particulates, fibers or whiskers [3]. Some other researchers are also tried some agro and industrial wastes like rock dust, fly ash cenosphere and etc instead of hard high cost synthetic ceramic reinforcements [4-6].

Thestrength, stiffness, resistance to wear, corrosionand fatigue and elevated temperature characteristics of the aluminium gets elevated when these reinforcement particles are distributed consistently. But, the other problem arising with these composites are their poor machinability which hinders their popularity among the materials community. Presence of the reinforcements in the matrix not only elevates the properties of the aluminium, it also diminishes its machinability. Higher tool wear is observed while machining these AMCs as because the hard ceramic particles presence which is very difficult to cut [7]. It was reported in the earlier reseerches that the machinability of the aluminium is greatly affected by the reinforcement presence and its particle size[8]. This difficulty in AMC machining is because of the hard nature of reinforcements which plays like a small cutting edge while machining that affects the tool cutting edge. This wear occurring in the tool tip also affects the tools performance while machining that result in poor surface finish of work.

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So it is highly necessary to analyze the newly developed material for its machining behaviour and also it is necessary to find the appropriate input parameter values to get better machined part in order to successfully commercialize the material.

## 2. EXPERIMENTATION

Al6061 grade aluminium is chosen as base material to develop aluminium composite with rice husk ash and molybdenum disulfide as reinforcements. The secondary reinforcement $MoS_2$ is directly purchased from the market whereas the RHA primary reinforcement is obtained by firing dried rice husk in a controlled atmosphere container. Then the ash is collected and sieved to get the particles of uniform size (40micron). The technique chosen to fabricate these advanced material is compo casting in which the reinforcement is added in multiple steps at multiple temperatures. The setup utilized for fabricating the composite materials is shown in figure 1.

**Figure 1. Experimental setup for MMC processing**

At first, the base aluminium alloy is kept in the furnace at 610°C which makes the material semi solid. On the other hand, a measured amount of rice husk ash and $MoS_2$ particles were preheated separately in a muffle furnace at 250°C in the view of eliminating the moisture and other volatile matters and also to increase the wettability with base molten alloy. Once the base material reaches the molten state the reinforcements namely rice husk ash and $MoS_2$ particles were added and stirred with mechanical stirrer. Then the mixture is poured into the die after removing slag and allowed to cool in the air. The procedure is repeated for fabricating composites with 5, 10 and 15% rice husk ash reinforcements whereas the addition of $MoS_2$ is kept as constant as 3% in weight.

The fabricated AMC of the size given in table 1 is used to perform turning operations in the machine shown in figure 2. The details of the machine and machining condition along with roughness testing instrument data are given in table 1. The parameters and their respective levels followed in the study are given in table 2. The data in table 2 is utilized to design the turning experiment through Taguchi method and the array is given in table 3. The roughness of the surface is measured in three different places of the machined surface and average is taken for further analysis.

**Figure 2.** Experimental setup for machining

**Table1**. Machining conditions

| Conditions | Details |
|---|---|
| Work piece Dimensions | Dia.-25 mm & length-100 mm |
| Machine tool | LMW smart junior CNC Lathe |
| Insert | Uncoated carbide |
| Surface roughness tester | Mitutoyo SJ-210 |


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| | |
|---|---|
| Machining Condition | Dry |

**Table 2.** Machining parameters with levels

| Parameter | Unit | Level 1 | Level 2 | Level 3 |
|---|---|---|---|---|
| RHA % | Wt.% | 5 | 10 | 15 |
| Speed | rpm | 2750 | 3250 | 3750 |
| Feed | mm/rev | 0.05 | 0.1 | 0.15 |

## 3. RESULTS AND DISCUSSION

### 3.1. Influence of input parameters on surface roughness

The turning experiments were performed based on the designed orthogonal array and the measured surface roughness values are given in table 3. The results were analyzed through Taguchi method in which the results were initially converted into signal to noise (SN) ratio and then analyzed for which three categories are generally followed 1. Larger is better, 2. Smaller is better and 3. Nominal is better. As the current study aims to decrease the surface roughness i.e. to improve the finish the smaller the better category is followed to convert the measured roughness values into SN ratio. Based on the SN ratio values, the mean table and main effect plot were plotted and the same is given as table 4 and figure 3.

**Table 3.** L9 experimental design with surface roughness

| Sl. No | RHA % | Speed | Feed | Surface Roughness |
|---|---|---|---|---|
| | 5 | 2750 | 0.05 | 1.15 |
| | 5 | 3250 | 0.1 | 1.69 |
| | 5 | 3750 | 0.15 | 1.82 |
| | 10 | 2750 | 0.1 | 1.74 |
| | 10 | 3250 | 0.15 | 2.12 |
| | 10 | 3750 | 0.05 | 1.61 |
| | 15 | 2750 | 0.15 | 2.12 |
| | 15 | 3250 | 0.05 | 1.98 |
| | 15 | 3750 | 0.1 | 2.35 |

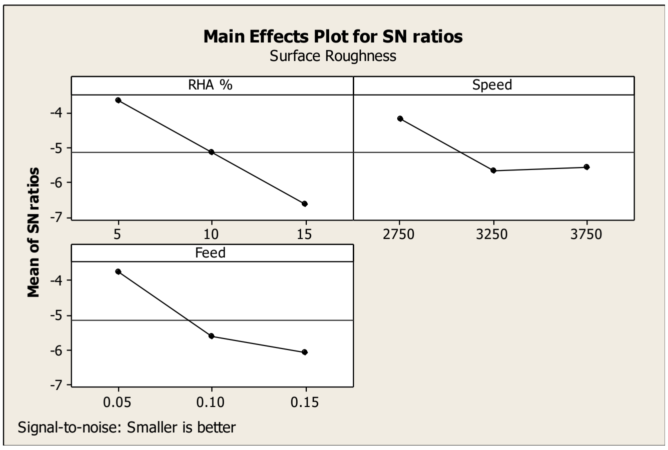


**Figure 3.** Influence of parameters on surface roughness

The main effect plot given in figure 3 and mean values in table 4 clearly shows the effect of considered parameters on surface roughness while turning Al/RHA/$MoS_2$ composites. The negative effect of rice husk ash on surface roughness is clearly visible in the figure 3 i.e. the surface roughness greatly increases with every addition of RHA particles. This phenomenon is owing to the fact that the harder reinforcement particles are hard to cut and so are ploughed out instead of cutting. This removed particle makes irregularity in the machined surface which results in higher surface roughness. So the surface roughness gets increased with every increase in rice husk ash particles quantity. Initially the roughness of the surface increases when the speed is increased but it starts to decline with further increase in speed. This decrease in roughness may be attributed to the formation of uniform oxide layer over the machined surface due to the heat generated at higher speed. This formed oxide layer covers the irregularities in the surface that ends in good surface finish. On the other hand, the roughness greatly increases with feed as a result of increased load on the tool which has to cut more material in same time when high feed is given. When the feed

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rate is high, the feed marks are clearly visible in the machined surface that ends up in poor surface finish. So, it is better to keep minimal feed rate while turning if good surface finish is needed. The delta values in the table 4 indicated the order of influence of the considered parameters i.e. RHA %, feed and followed by speed.

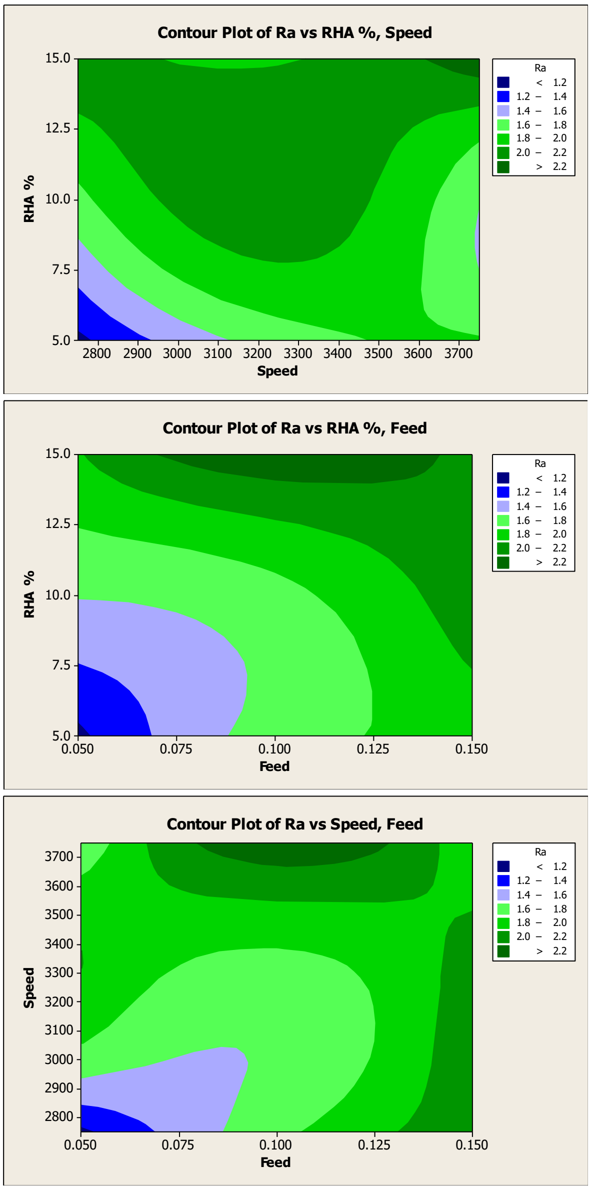


**Figure 4.** Contour plot for Ra Vs input parameters

Contour plot for various input parameters against surface roughness is given in figure 4. The plot clearly demonstrates that the surface roughness is minimal when both the RHA% and speed is minimal which is very high when the 15% RHA composite is machined at 3250rpm speed. It is also clear that the roughness is minimal when RHA% and feed rate is minimal. Further, the minimal speed and feed yield better surface finish while machining RHA and $MoS_2$ reinforced Al composite.

**Table 4.**Response Table for surface roughness

| Level | RHA % | Speed | Feed |
|---|---|---|---|
| 1 | -3.658 | -4.184 | -3.761 |
| 2 | -5.158 | -5.673 | -5.597 |
| 3 | -6.627 | -5.586 | -6.085 |
| Delta | 2.969 | 1.489 | 2.324 |
| Rank | 1 | 3 | 2 |

### 3.2. ANOVA

Analysis of variance is performed for identifying the significance of RHA%, speed and feed over the surface roughness while turning and the results are given in table 5. The p value in the table clearly indicates the significance of all the considered parameters over the surface roughness as because p value is less than 0.05. The % contribution of each parameter over Ra is calculated based in the seq SS values and is given in table 5 and plotted as graph in figure 5. The RHA % influences the Ra most among the considered parameters followed by feed and speed.

**Table 5.**Analysis of Variance for Ra

| Source | DF | Seq SS | Adj SS | Adj MS | F | P | Contribution % |
|---|---|---|---|---|---|---|---|
| **RHA %** | 2 | 0.53562 | 0.53562 | 0.26781 | 79.29 | 0.012 | 53.65 |
| **Speed** | 2 | 0.13349 | 0.13349 | 0.06674 | 19.76 | 0.048 | 13.37 |
| **Feed** | 2 | 0.32249 | 0.32249 | 0.16124 | 47.74 | 0.021 | 32.30 |
| **Error** | 2 | 0.00676 | 0.00676 | 0.00338 | | | 0.68 |



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| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Total** | 8 | 0.99836 | | | | | 100.00 |
| R-Sq = 99.32% R-Sq(adj) = 97.29% | | | | | | | |

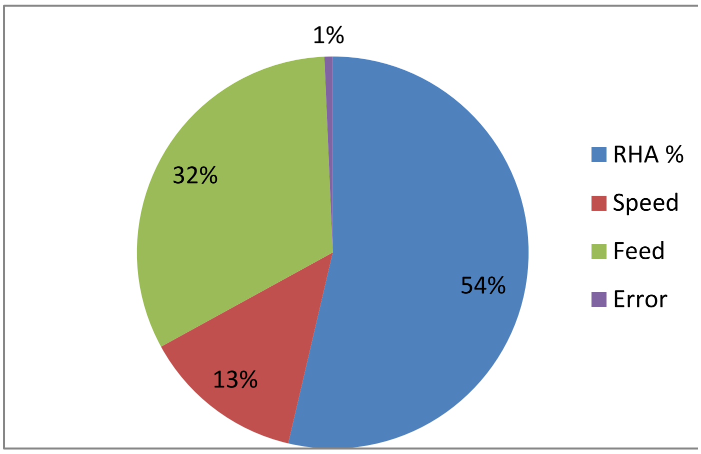


**Figure 5.** Contribution % of input parameters for Ra

## 4. CONCLUSION

Aluminium 6061 alloy is successfully reinforced with agricultural waste product namely rice husk ash and molybdenum disulfide through compo casting. The developed composite is analyzed for its machinability in turning operation and the following conclusions were drawn

- Addition of RHA reinforcement in Al 6061 decreases the machinability i.e. surface roughness increases.
- Feed has more effect over Ra and high feed results in poor surface finish.
- Speed has least effect when compared to reinforcement percentage and feed while turning Al MMC.

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*ISSN: 0193-4120 Page No. 9548 - 9553*

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