# MACHINING OF POLYETHELENE-ALUMINUM COMPOSITE FROM USED BEVERAGE CARTON WASTE BY MILLING USING HIGH-SPEED CUTTING TOOLS

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## ABSTRACT

This research study the machining of Polyethylene-aluminum composite (PolyAl composite) by milling using high speed steel cutting tools. The composite plates from PolyAl were fabricated by two roll mill machine and compression machine. They are cut to size of 55 x 55 x 10 mm for machining testing by 3 axis CNC. In experiment, the factors of machining consist of feed rate, spindle speed and depth of cut. 2 types of cutting tool are studied with 2 flute high speed end mill and 4 flute high speed end mill. The experiments were designed by DOE of General full factorial. The surface roughness (Ra) was used to investigate for machining. The results, the machining by 2 flutes high speed end mill founded that Ra increase with an increase of feed rate, Ra decrease with an increase of spindle speed and Ra trends to decrease with an increase of depth of cut. The machining by 4 flutes high speed end mill founded that Ra increase with an increase of feed rate, Ra decrease with an increase of spindle speed and Ra trends to decrease with an increase of depth of cut. The optimal condition of 2 flutes high speed end mill was Ra of 1.914 um by condition of feed rate 400 mm/min, spindle speed 1500 rpm and depth of cut 1 mm, and optimal condition of 4 flutes high speed end mill was Ra of 2.385 um by condition of feed rate 1000 mm/min, spindle speed 1500 rpm and depth of cut 3 mm.

## Methodology

PolyAl composite was fabricated by two roll mill and compression process. it was cut to size of 55*55 mm, then it was machined by 3 axis CNC milling. Different cutting conditions were studied as show in Table 1. The surface roughness was investigated in this work

Table 1. Cutting conditions

| | | | |
|---|---|---|---|
| spindle speed (rpm) | 500 | 1000 | 1500 |
| Feed rate (mm/min) | 400 | 1000 | 1600 |
| depth of cut (mm) | 1 | 3 | 6 |
| cutting tools | high speed steel 2 flute, diameter of 6 mm | | |
| spindle speed (rpm) | 500 | 1000 | 1500 |
| Feed rate (mm/min) | 400 | 1000 | 1600 |
| depth of cut (mm) | 1 | 3 | 6 |
| cutting tools | high speed steel 4 flute, diameter of 6 mm | | |



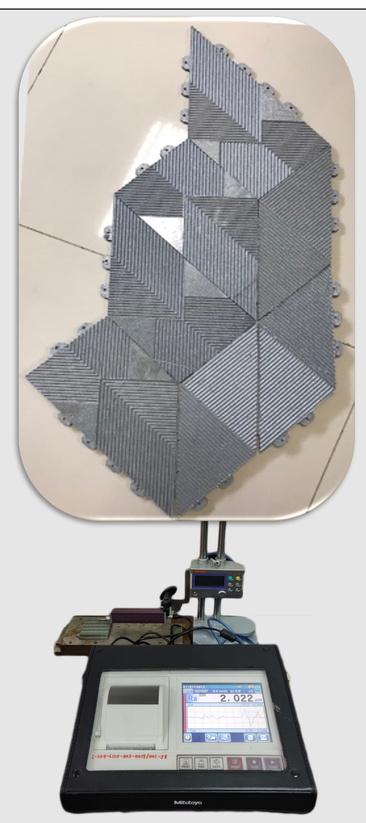
PolyAl


two roll mill


Hot compression


PolyAl composite


Machining position

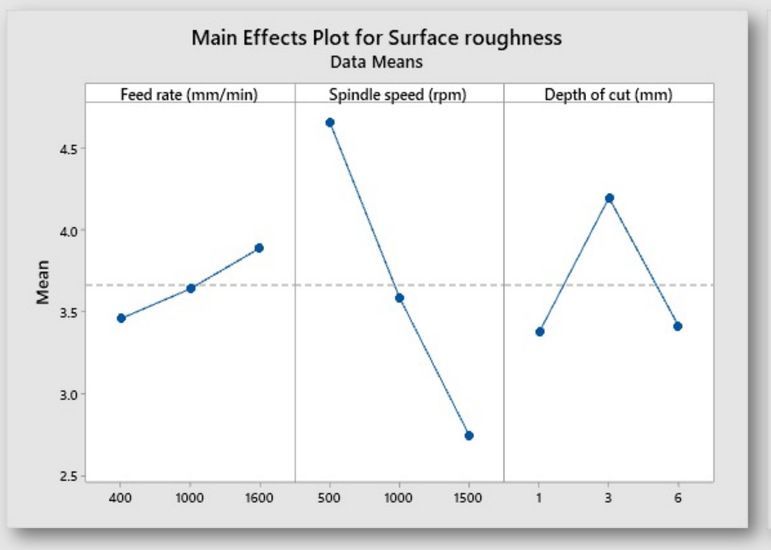

Surface roughness tester

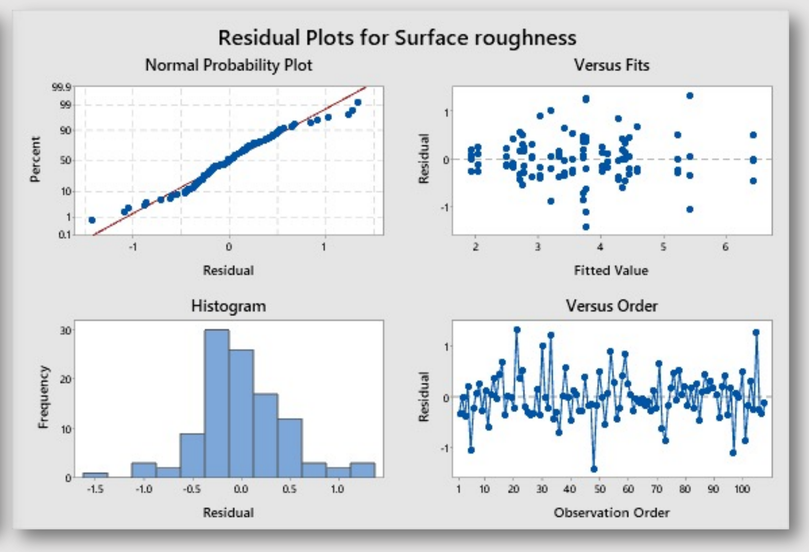
## Results ; The machining by 2 flute high speed end mill

Table 2. Analysis of variance for $R_a$

| Source | DF | Adj SS | Adj MS | F-value | P-value |
|---|---|---|---|---|---|
| Feed rate (mm/min) | 2 | 3.368 | 1.684 | 5.98 | 0.004 |
| Spindle speed (rpm) | 2 | 66.381 | 33.191 | 117.79 | 0.000 |
| Depth of cut (mm) | 2 | 15.371 | 7.686 | 27.27 | 0.000 |
| Feed rate (mm/min)* Spindle speed (rpm) | 4 | 4.832 | 1.208 | 4.29 | 0.003 |
| Feed rate (mm/min)* Depth of cut (mm) | 4 | 4.582 | 1.145 | 4.07 | 0.005 |
| Spindle speed (rpm)* Depth of cut (mm) | 4 | 4.619 | 1.154 | 4.10 | 0.004 |
| Feed rate (mm/min)* Spindle speed (rpm)* Depth of cut (mm) | 8 | 15.904 | 1.988 | 7.06 | 0.000 |
| Error | 81 | 22.824 | | | |
| Total | 107 | 137.881 | | | |

S = 0.530829 R-Sq = 83.45% R-Sq(adj) = 70.57%



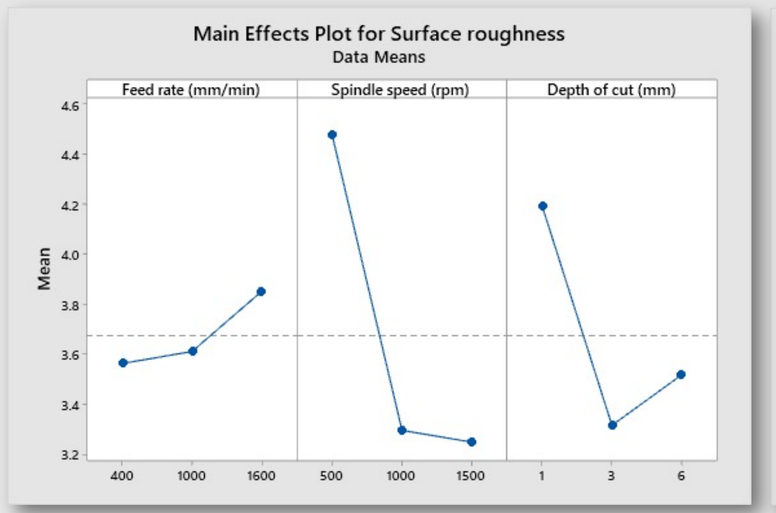



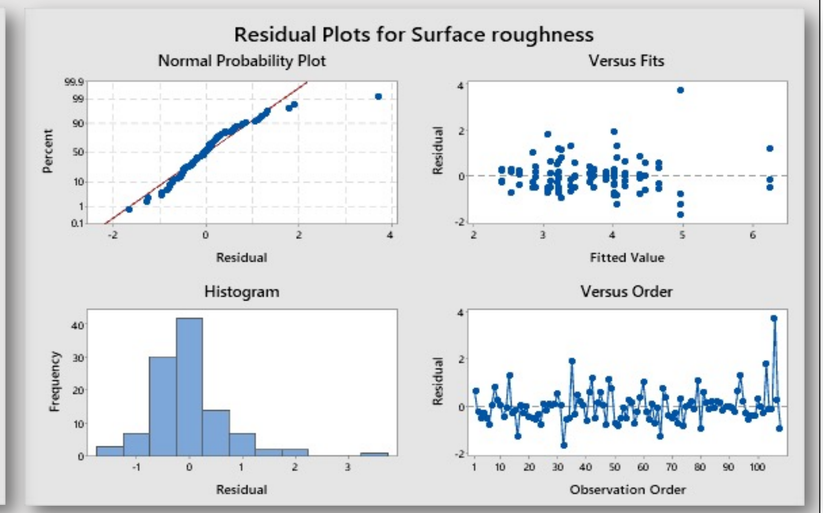

## The machining by 4 flute high speed end mill

Table 3. Analysis of variance for $R_a$

| Source | DF | Adj SS | Adj MS | F-value | P-value |
|---|---|---|---|---|---|
| Feed rate (mm/min) | 2 | 1.723 | 0.861 | 1.29 | 0.282 |
| Spindle speed (rpm) | 2 | 35.126 | 17.563 | 26.24 | 0.000 |
| Depth of cut (mm) | 2 | 15.156 | 7.578 | 11.32 | 0.000 |
| Feed rate (mm/min)* Spindle speed (rpm) | 4 | 2.048 | 0.512 | 0.77 | 0.551 |
| Feed rate (mm/min)* Depth of cut (mm) | 4 | 1.619 | 0.404 | 0.60 | 0.660 |
| Spindle speed (rpm)* Depth of cut (mm) | 4 | 6.575 | 1.644 | 2.46 | 0.052 |
| Feed rate (mm/min)* Spindle speed (rpm)* Depth of cut (mm) | 8 | 11.436 | 1.430 | 2.14 | 0.041 |
| Error | 81 | 54.207 | 0.670 | | |
| Total | 107 | 127.89 | | | |

S = 0.818 R-Sq = 57.61% R-Sq(adj) = 44.01%




## Conclusion

The results, the optimal condition of using 2 flute high speed end mill was feed rate of 400 mm/min, spindle speed of 1500 rev/min and depth of cut 1 mm which $R_a$ is 1.914. The optimal condition of using 4 flute high speed end mill was feed rate of 1000 mm/min, spindle speed of 1500 rev/min and depth of cut 3 mm which $R_a$ is 2.385