Study of High Feed Cutting Efficiency of Aluminum Alloy AW – Alzn5,5mgcu

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***Abstract* – Presented article is focused on the study of high feed cutting of EN AW - AlZn5,5MgCu material. Experimental part describes the study of the efficiency of high feed milling of the specified material and its subsequent comparison with conventional methods and standard tools. This part describes the realization of five milling options, 4 of which are realized by the HFC method and the last alternative is realized by conventional milling. The conclusion is focused on complex assessment of the efficiency of machining of the specified aluminium alloy from economic and technical point of view and the comparison of individual HFC alternatives with the conventional milling method.**

***Keywords* – high feed cutting, efficiency, aluminium alloy.**

1. Introduction

Competition on the global market in chip machining is nowadays increasing from hour to hour. Technologies, methods and way of approach are innovated on daily base to increase efficiency of production process. Decreasing of production time and lowering of production costs are crucial factors for every production company. High feed machining is nowadays one of the trends in the field of chip machining [1][2][3].

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2. Experimental set up

Presented research is focused on efficiency study of high feed milling of aluminum alloy EN AW-AlZn5,5MgCu. Experiments were performed using technological system machine – tool – workpiece. The machine used for the experimental study was HAAS VF – 2, 3-axial vertical machining centre from the producer Haas Automation, Inc. Experimental tools were used for milling with high feed and with conventional way of approach. The experimental material was selected aluminum alloy AlZn5,5MgCu. The properties of the selected experimental material are listed in tables below (Table 1., Table 2. and Table 3.). [4][5][6]

The experiments were realized in 5 alternatives from which 4 were high feed machining and 1 was conventional milling. The experiment was evaluated based on time and economic efficiency. [7][8]

Table 1. Physical properties of EN AW ALZn5,5MgCu

Physical properties	Values
Density [kg. m^3]	2.8
Elasticity modulus [GPa]	71
Electric conductivity [m.Ω^{-1}.mm^{-2}]	19-23
Coefficient of thermal expansion [K^{-1}.10^{-6}]	23.4
Thermal conductivity [W/m.K]	130-160
Specific heat capacity [J.kg^{-1}.K^{-1}]	862

Table 2. Mechanical properties of EN AW ALZn5,5MgCu

Mechanical properties [Unit]	Values
Yield strength Rp0,2[MPa]	220-460
Tensile strength Rm[MPa]	360-540
Elongation A50[%]	1-6

Table 3. Chemical composition of alloy EN AW ALZn5,5MgCu

Alloy	Alloying element – mass ratio [%]								
	Fe	Si	Cu	Mg	Mn	Cr	Ti	Zn	other
EN AW ALZn5,5MgCu T651	0.50	0.40	1.20 2.00	2.10 2.90	0.30	0.18 0.28	0.20	5.10 6.10	0.15

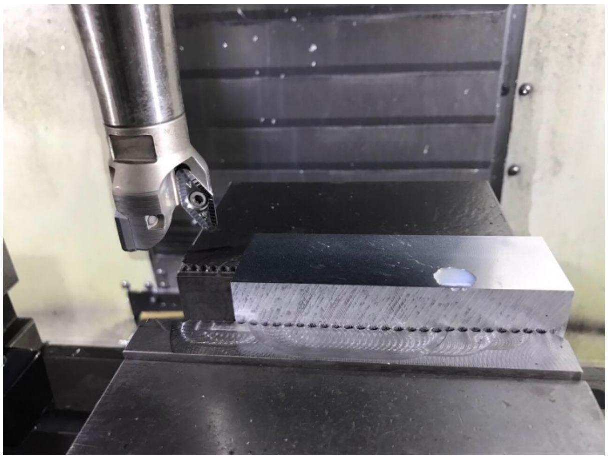

Figure 1. Experimental workpiece

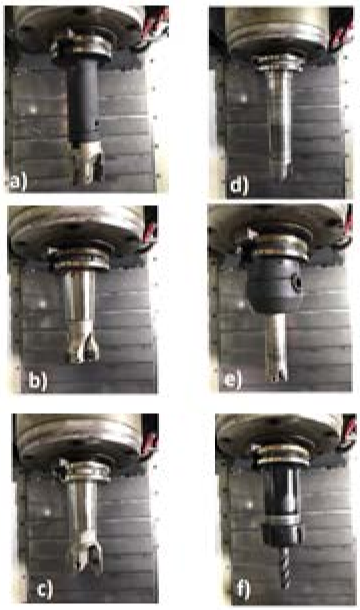

Figure 2. Experimental tools

Legend to Figure 2.:
a) Milling head
b) Face cutter
c) Plunge-cutting Φ42
d) Plunge-cutting Φ32
e) High feed milling cutter
f) Monolith cutter

Technological conditions of each experimental machining are listed in the tables below.

1st Experiment – tool DELTATec 90P – Boehlerit with diameter Φ40

Table 4. Cutting conditions – 1st experiment

mill diameter [mm]	40
number of teeth	4
cutting speed [m.min^{-1}]	200
feed rate [mm.min^{-1}]	3200
depth of cut [mm]	1
RPM [min^{-1}]	4000
feed on tooth [mm]	0.2
total depth [mm]	15

Experiment No. 1 was performed with cutting speed 200 m.min^{-1} and the total depth of machining was 15 mm. The first test is classified as high feed machining due to feed rate over 2000 mm.min^{-1} and depth of cut lower than 2 mm (Tab. 4.).

2nd Experiment - tool 90° MTC Φ42 – Hoffmann

Table 5. Cutting conditions – 2nd Experiment

mill diameter [mm]	42
number of teeth	3
cutting speed [m.min^{-1}]	550
feed rate [mm.min^{-1}]	10600
depth of cut [mm]	2
RPM [min^{-1}]	4100
feed on tooth [mm]	0.85
total depth [mm]	15

The second alternative was performed with cutting conditions listed in Table 5. and according to these conditions it is classified as high feed machining.

3rd Experiment – tool Φ32 – Hoffmann

The third alternative was performed using conditions cutting speed 500 m.min^{-1}, depth of cut 2 mm and 0.85 mm feed on tooth. According to Table 6., they are fulfilled conditions for high feed cutting.

Table 6. Cutting conditions – 3rd Experiment

mill diameter [mm]	32
number of teeth	3
cutting speed [m.min^{-1}]	500
feed rate [mm.min^{-1}]	2160
depth of cut [mm]	2
RPM [min^{-1}]	6000
feed on tooth [mm]	0.12
total depth [mm]	15

4th Experiment – tool Feedking Φ20

The fourth experiment (last of HFC) was performed according to the cutting conditions listed in Table 7.

Table 7. Cutting conditions – 4th Experiment

mill diameter [mm]	20
number of teeth	4
cutting speed [m.min^{-1}]	250
feed rate [mm.min^{-1}]	2400
depth of cut [mm]	0,7
RPM [min^{-1}]	4000
feed on tooth [mm]	0,15
total depth [mm]	15

5th Experiment – conventional tool Φ40

The fifth experiment was performed using conventional mill with cutting conditions for conventional milling (Tab. 8.).

Table 8. Cutting conditions – 5th Experiment

mill diameter [mm]	Mill ISO 90P
number of teeth	4
cutting speed [m.min^{-1}]	120
feed rate [mm.min^{-1}]	230
depth of cut [mm]	1.5
RPM [min^{-1}]	1000
feed on tooth [mm]	0.08

Complex assessment of time efficiency consists of assessment of total production time for one component and for production batch. The total production time is sum of machining time and secondary (side) time of production. Machining time was calculated based on technological conditions and tool paths. Secondary time was measured using digital stopwatches and was equal for all experiments 1.5 minute (90 seconds). It consists of change of tool, clamping and unclamping of workpiece and non-machining feed time.

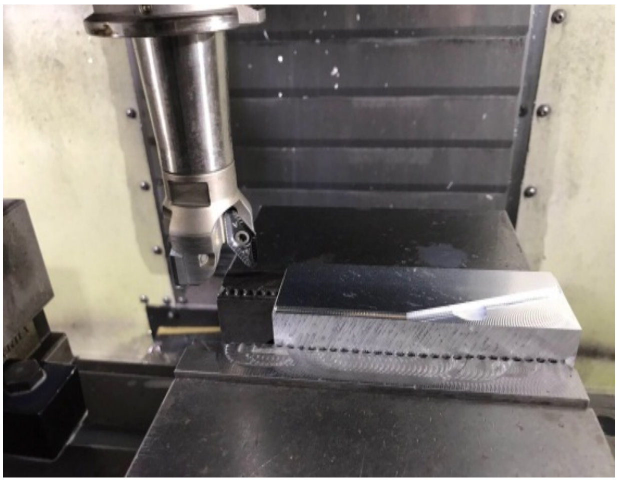

Figure 3. Experimental realization – milling of contour

The following table shows the overview of machining times for each alternative (Tab. 9.).

Table 9.

Alternative	Total time [min]
1st Experiment	4.97
2nd Experiment	3.01
3rd Experiment	3.04
4th Experiment	5.74
5th Experiment	12.21

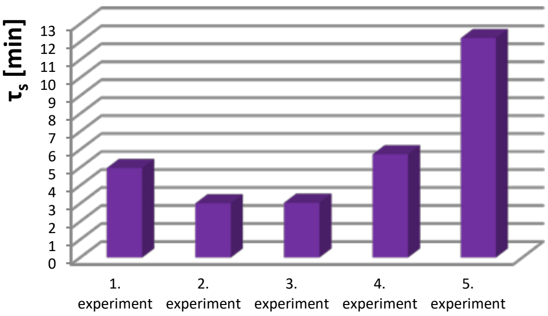

Figure 4. Graphical interpretation of manufacturing times for each experiment

3. Conclusion

Based on the experimental results shown in Table 9. and Figure 4., it can be stated that the lowest machining times were obtained in the second alternative with time 3.01 s. Comparable time 3.04 s was obtained using the third alternative. As can be seen from the graph using conventional milling, it was obtained 400% time compared to the alternative No. 2.

Acknowledgements

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