

Study on cutting temperature and surface roughness during the milling process of aluminium alloys

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Abstract. In this paper some experimental determinations on the temperature and surface roughness during the milling process of aluminium alloys (5083, 6082 and 7075) was conducted, using different cutting parameters (depth of cut, feed and rotational speed). The results are presented as graphical dependencies of temperature and surface roughness as function of cutting parameters also as a screen capture of the values obtained using an adequate technique for temperature of the milling process of aluminium alloys.

1. Introduction

Aluminium alloys are some of most used materials in technique due to low weight and appropriate physico-mechanical properties.

The study of the cutting temperature during the milling process is very important due to the high thermal conductivity of aluminium alloys, and, as a consequence, a large amount of the heat is absorbed by the work piece. On this way, the workpiece temperature increases, and can affect the nominal dimensional, tolerance, and sometimes the surface damage occurs.

In [1] the authors predict the temperature during milling process of aluminium alloy 7050-T745 using an infrared thermal image system and finite element method, and show that the highest cutting temperature increase with an increase in the flank wear.

Using the infrared thermography, in [2] the influence of cutting parameters (spindle speed, axial and radial depth, and feed per tooth) on the average cutting temperature is evaluated. The authors remark the difficulty of measuring the temperature of the materials due to the emissivity and their strong reflexion power.

The temperature analyze using different cutting conditions (flood cooling, near dry machining and dry cutting) is performed in [3], and to perform these analyze a non contact infrared thermometers was used. The temperatures were simultaneous measured for object (cutting area) temperature, internal temperature, and the external one. The maximum temperature was obtained for dry cooling conditions.

Taking in account for milling the thin-walled components of the airplanes, in [4], the influence on stability and heat generation is analyzed, using experimental conditions and also simulation. The authors perform the experiments with a chamfered cutting edges and different process parameters. They conclude that the increasing of feed per tooth, the maximum temperature in workpiece can be reduced.

In [5], studying the dry end milling operation on 6083, aluminium alloys, show that the rise in the temperature of the work piece, which may lead to dimensional inaccuracies, surface damage and deformation of the workpiece and try to optimize the milling parameters, and they identify the depth of cut as the most relevant factor affecting the workpiece temperature.

In order to measure the temperature during milling process, different methods are used. So, the authors, studying the temperature during milling magnesium alloys, show that the optical pyrometry



is suitable only for monitoring surface temperature of the workpiece, thermocouples is not suitable for temperature measurement in the cutting area, but infrared camera proves to be most suitable in terms of recorder temperature values, [6].

From point of view of the surface roughness during milling of aluminium alloys, using minimum quantity lubricant and different cutting parameters, in [7], the authors conclude that Surfaces roughness is better using minimum quantity lubricant techniques rather than using coolant by wet techniques.

In [8], the authors analyze the influence of the feed on surface roughness for 6061 aluminium alloy and give some practical recommendations to improve the surface quality.

This paper is focused on on the measurement and analysis of work piece temperature and surface roughness for three types of aluminium alloys.

2. Experimental setup

2.1 Materials and cutting tool

Materials used in this study are three types of aluminium alloys, 5083, 6082 and 7075, with composition and mechanical properties presented in table 1 and table 2.

The probes was prepared for the experiments are prepared as in figure 1(b), and the shape and dimensions of the probes are shown in figure 1(b).

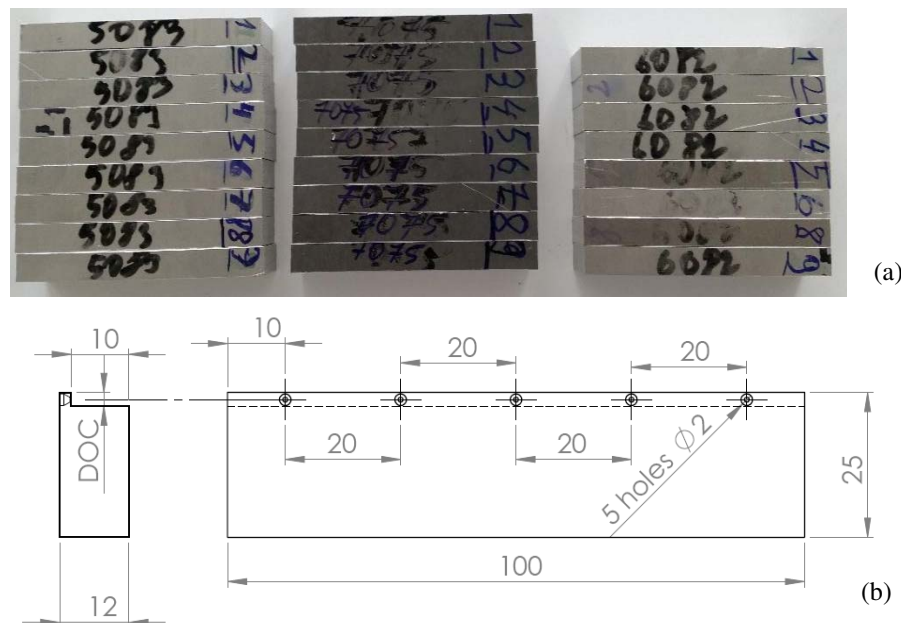


Figure 1. Materials used for temperature study in milling process and shape and dimensions of the probe

Table 1. Mechanical properties and composition of 7075 and 5083 aluminium alloys

Material	Mechanical properties				Chemical composition								
	Rp0,2, MPa	Rm, MPa	A5 %	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Others each	Others total
EN AW-7075 EN 485	532	594	10	0,1080	0,1630	1,6460	0,1090	2,6960	0,2020	5,8810	0,0282	0,0112	0,0430

EN AW-5083 EN 485-	302	176	20	0,26	0,39	0,07	0,60	4,80	0,10	0,08	0,03	0,02	0,05			
Table 2. Mechanical properties and composition of 6082 aluminium alloy																
Material	Mechanical properties				Chemical composition, %											
	Rm, MPa	Rp0,2 MPa	Elong. % 50 mm	HB	Si	Fe	Cu	Mn	Mg	Cr	Ni	Zn	Ti	Ga	V	Al
EN AW-6082 EN 485-	295	240	8	89	1,1	0,42	0,1	0,7	0,85	0,17	0,013	0,095	0,016	0,009	0,2	REM

The cutting tool, carbide end mill, with $\phi 10$ mm diameter and 4 flutes, is presented in figure 2.



Figure 2. Carbide end mill, with $\phi 10$ mm diameter and 4 flutes

2.2 Experimental assembly for temperature measuring

In order to measuring the cutting temperature, in figure 3, an adequate experimental assembly was realized.

The experimental assembly consists in: Portable infrared thermometer, Compact Connect type [9], with the measuring temperature range ($-32^{\circ}\text{C} - 760^{\circ}\text{C}$), emissivity adjustable between (0.1-1.00), precision $\pm 1\%$ and ratio distance/spot size 20/1, coupled with K-type thermocouple.

2.3 Cutting conditions

Rotational speed, $n = 360$ rpm, $v_f = 100$ mm/min) and depth of cut: $a_p = \text{variable}$ ($a_p = 2$ mm, $a_p = 1.5$ mm $a_p = 1$ mm) for all experiments on aluminium alloys.

2.4. Measuring of the surface roughness

In order to measuring the surface roughness a Portable Surface Roughness Tester - TR200, [10], as it is shown in figure 4.

3. Results

3.1 Temperature results

The data were collected using the cutting conditions, portable infrared thermometer above described. The measured data was obtained using a Compact Connect software, and figure 5 presents a capture of the Compact Connect display.

For all data collected, using the ".dat" files, the graphical dependencies of the temperature as function of time, for $n = 360$ rpm, $v_f = 100$ mm/min, and a_p - variable are represented, as it shown in figure 6, figure 7 and figure 8.

In the all three graphical dependencies the data was represented using the values of the temperature registered for each material and determination (5083, 6022 and 7075, and also $a_p = 2$ mm, $a_p = 1.5$ mm and $a_p = 1$ mm, respectively).

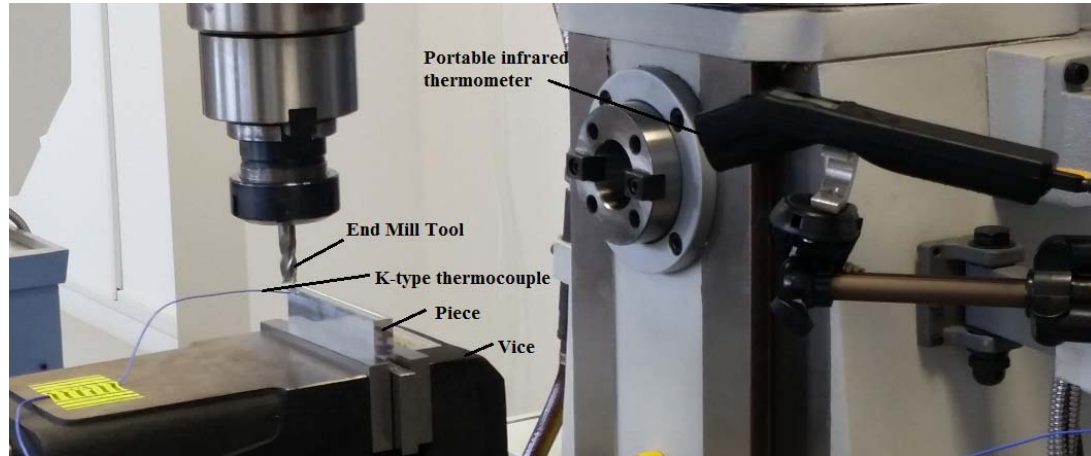


Figure 3. Experimental assembly



Figure 4. Portable surface roughness and workpiece

3.2 The surface roughness results

For each piece (see figure 4), using the roughness tester TR 200, the roughness parameters was measuring, and the results are presented in figure 9, figure 10, and figure 11.

Using the data collected for milling process, in figure 12 is graphically represented the values of the surface roughness as function of the machined material (aluminium alloys 5083, 6082 and 7075) using the same conditions: $n = 360$ rpm, $v_f = 100$ mm/min; $a_p =$ variable).

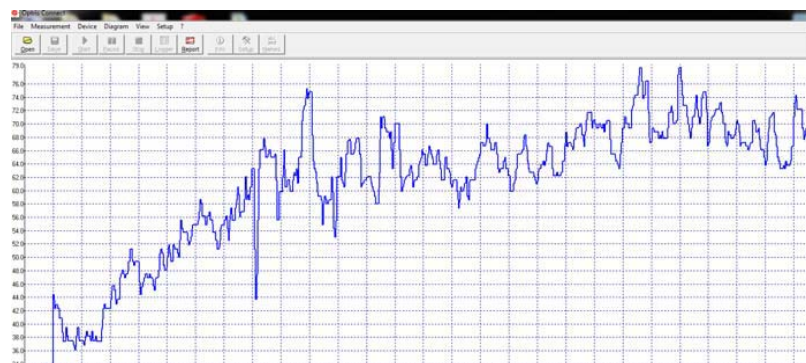


Figure 5. Temperature registered during milling process of aluminium alloys with Portable infrared thermometer

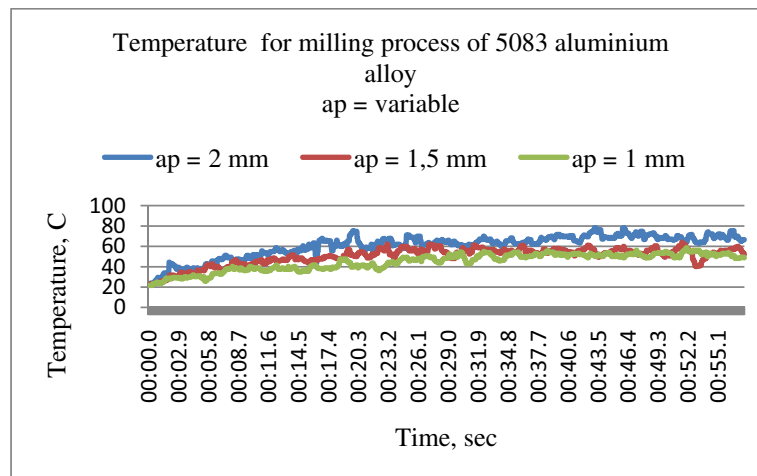


Figure 6. Temperature for milling process of aluminium alloy 5083,
 $n = 360$ rpm, $v_f = 100$ mm/min; a_p = variable

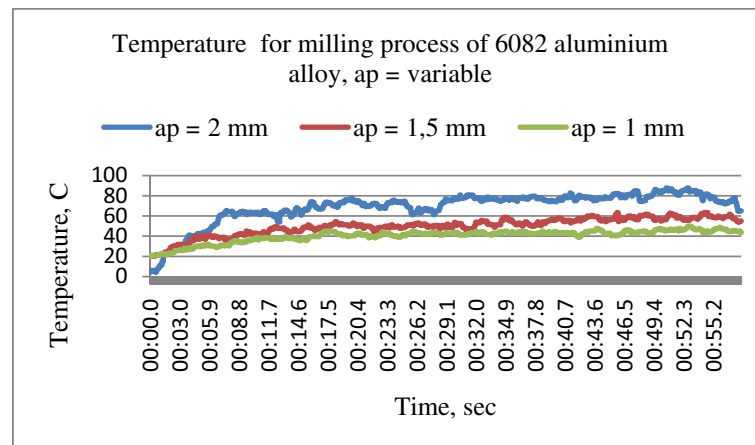


Figure 7. Temperature for milling process of aluminium alloy, 6082,
 $n = 360$ rpm, $v_f = 100$ mm/min, a_p = variable

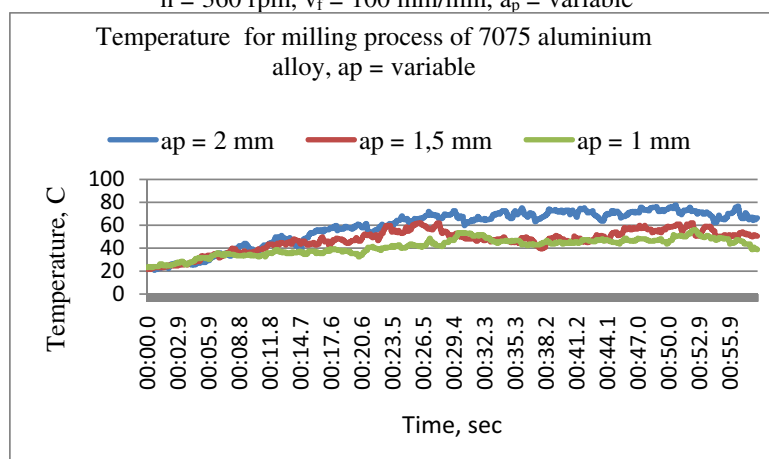


Figure 8. Temperature for milling process of aluminium alloy, 7075,
 $n = 360$ rpm, $v_f = 100$ mm/min, a_p = variable

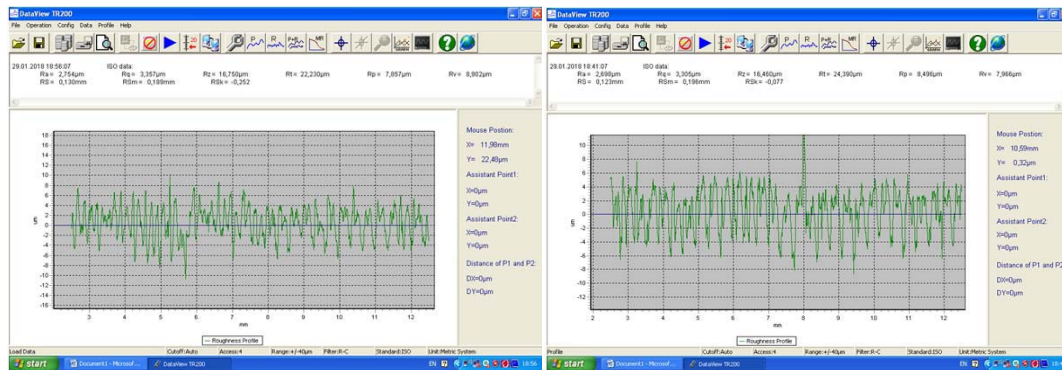


Figure 9. The Surface roughness for 5083, aluminium alloys
($n = 360$ rpm, $v_f = 100$ mm/min, $a_p = 1$ mm)

Figure 10. The Surface roughness for 6082 aluminium alloy
($n = 360$ rpm, $v_f = 100$ mm/min, $a_p = 1$ mm)

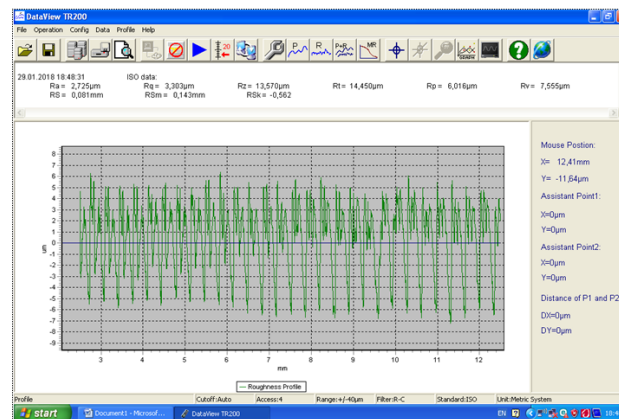


Figure 11. The Surface roughness for 7075 aluminium alloy
($n = 360$ rpm, $v_f = 100$ mm/min, $a_p = 1$ mm)

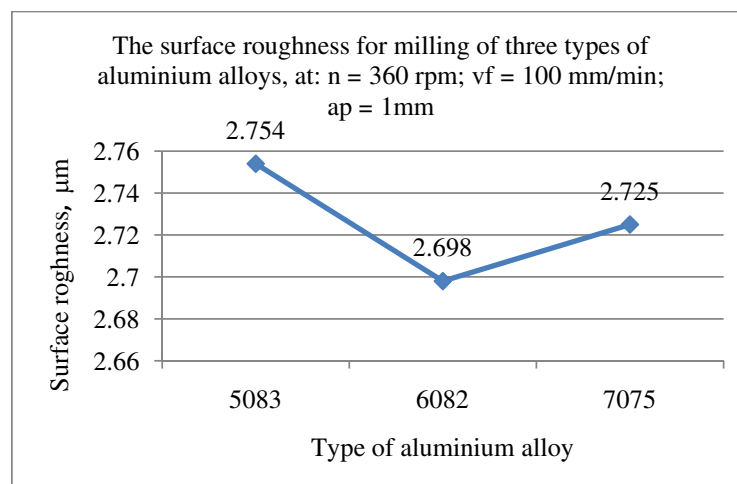


Figure 12. Surface roughness for milling of aluminium alloys 5083, 6082 and 7075, for
 $n = 360$ rpm; $v_f = 100$ mm/min; $a_p = 1$ mm

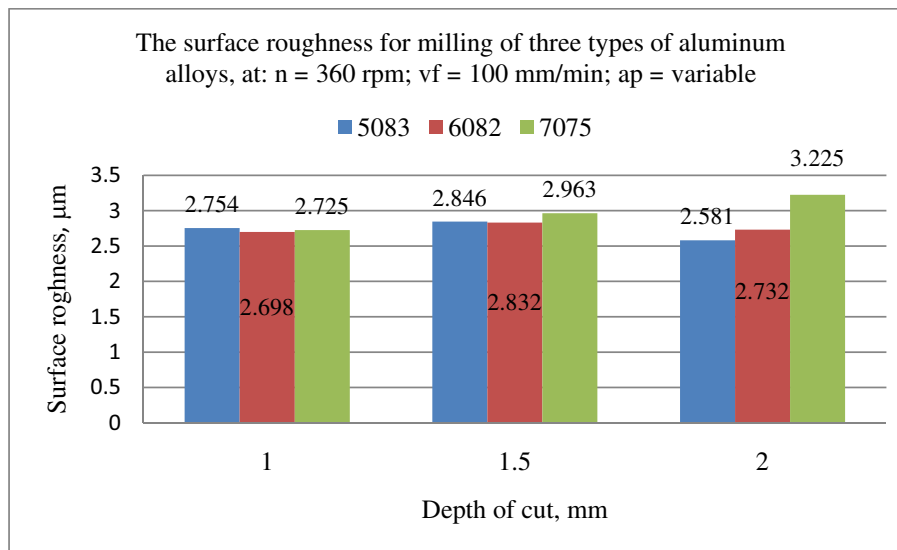


Figure 13. Surface roughness for milling of aluminium alloys 5083, 6082 and 7075 for different depth of cut

4. Conclusions

From point of view of temperature as function of depth of cut, the maximum value (figures 6, 7 and 8), for all aluminium alloys, was measured at depth of cut, $a_p = 2$ mm. If is consider the type of aluminium alloy, the maximum value of temperature was 84.7°C , for 6082, greater than 5083 (77.2°C) and 7075 (75.6°C).

For the surface roughness maximum value measured, for $a_p = 2$ mm and 7075 aluminium alloy was $R_a = 3.225 \mu\text{m}$. Also for $a_p = 1.5$ mm and 7075 aluminium alloy, was $R_a = 2.963 \mu\text{m}$, but no for $a_p = 1$ mm, where the maximum value was $R_a = 2.754 \mu\text{m}$, for 5083, aluminium alloy (figure 13), while the minimum value for the surface roughness was $R_a = 2.581 \mu\text{m}$, for milling of 7075 aluminium alloy.

But, due to the difficulties of cutting process of aluminium alloy, especially built-up-edge phenomena, both the temperature and the surface roughness are negatively influenced.

5. References

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