VOL. 13, NO. 7, APRIL 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

MILLING TOOL CONDITION MONITORING USING ACOUSTIC EMISSION

Chockalingam P.[1], Ervina Efzan M. N.[1] and Natarajan C.[2]
[1]Faculty of Engineering and Technology, Multimedia University, Melaka, Malaysia
[2]Department of Mechanical Engineering, Hindustan Institute of Technology, Coimbatore, India
E-Mail: palanisamy.chockalingam@mmu.edu.my

ABSTRACT

Milling of T6-6061 aluminium alloy material is a complex and challenging process due to the difficulties in finding the optimum milling process parameters for achieving the desirable properties such as surface roughness and optimum tool life. The parameters selection is generally based on the skill and knowledge of the technicians involved and number of time consuming trial and error runs. The experiment presented involved measuring the acoustic emission during the milling experiment with different spindle speeds and feed rates. It has been found that spindle speeds and feed rates have the highest effect on the cutting of the aluminium alloy thus also influencing the tool wear.

Keywords: milling, tool, aluminium, acoustic.

INTRODUCTION

In the modern world, the process of milling is among the most commonly used form of machining. Milling is preferred due to its precision in cutting and the high tolerance and surface finishes it offers. Cutting tool wear and life are directly affected by wear; many studies have been dedicated to unravelling and understanding the phenomena. The monitoring of wear in cutting tool would further enhance the efficiency of the process in having the ability to estimate the tool condition. In recent development, the use of acoustic emission as a monitoring means during machining process has been seen as a breakthrough progress. Acoustic emission is defined as the transient elastic wave that is caused by the release of material's internal stress energy within its structure. This is useful for the monitoring process as the process of milling causes plastic deformation of a material and the emission could be analyzed to reflect the condition of the cutting tool during the cutting process.

The AL 6061-T6 is largely favoured in the fabrication of aeroplane parts and also vehicle, having high endurance to relative temperature coupled with the key of high specific forces [1]. This compound has numerous advantage and remarkable mechanical properties, thus allowing AL 6061-T6 to be machined expeditiously and moderately [2,3,4]. The flaws in stressed components emit energy as it experiences stress. The energy travels in the form of high-frequency stress waves. Sensors such as transducers enable the energy to be converted and collected as voltage and then further processed as AE signal data. Some of the data can be measured in decibels (dB) which is used to describe sound intensity. The spindle speed, feed and depth of cut are selected parameters and high speed steel (HSS) milling cutter fused in this study.

A research study by Olufayo and Abou [5] concluded that the cutting speed has more influence on the wear states of cutting tool than other parameters based on the findings. Another conclusion is that when cutting using low feeds, sudden chipping took place due to the impact of the tool edge directed at the workpiece during tool entry. Another study done by Aditya Dhulubulu (2015)[6] said that the results of tool wear were monitored using forces and acoustic signals which indicated a rise in signal level with increase in tool wear. And further said that tool wear were monitored using forces and acoustic signals indicated a rise in signal level with increase in tool wear. According to Slavko *et al.* (2001) [7] oxidation, abrasion, and adhesive process can cause extensive wear to the cutting tool.

The aim of tool wear monitoring is to predict its lifespan or impending machine failure as the state of the cutting tool is essential in ensuring good surface finish. While there are a few approaches to monitor tool wear such as using signals or vibration analysis, acoustic emission could be monitored either using equipment or the sensory hearing of a skilled operator. From previous studies, tool wear in end milling are most affected by factors such as spindles speed and feed rate. The settings of spindle speed and feed rate depends unequivocally on the machining requirement and operators experience to achieve optimum effect with minimum tool wear and good surface finish. Furthermore, parameters in milling plays an essential part in the execution of the process such as the material used, depth of cut, and diameter of the cutter used. The role these parameters played are minor compared to spindle speed and feed rate and should be kept constant.

MATERIALS AND METHODS

The Aluminum 6061-T6 has a modulus of elasticity of 70GPa and density of 2.70Kg/cm. Due to this material properties, it is often utilized in architectural and structural parts. Acoustic emission occurs due to stress when a material undergoes permanent or plastic changes in its internal structure. AE can provide complex information on the origination of a flaw in stressed component and also give information of its developments over continuous process. The milling was performed using universal milling machine. The machining was done with high speed steel end mill of 10 mm diameter. The milling was carried out on 100 mm x 100mm x 10 mm material.

Therefore, 18 different milling was cut for a length of 5 cm. All machining were done in dry conditions. The acoustic emissions of each cut were recorded using Science Journal. The Science Journal is an application that measures intensity, or loudness in decibels (dB). The frequency of a sound wave is equivalent to its rate of vibration.

RESULTS AND DISCUSSIONS

Table-1 showed the milling parameter and output data. From this set of experiment, it can be observed that the maximum sound intensity logged occurred during cutting using the highest spindle speed available which is 1750 min-1 for each combination. The maximum sound intensity recorded is 79, 78 and 77 dB. The V_{ave} could also be seen slightly increasing as the feed rate and spindle speed is increased.

Table-1. Result of sound intensity with new tool.

No.	Feed rate (mm/min)	Speed (rpm)	Tool 1	Tool 2
			Sound, V (dB)	Sound, V (dB)
1	100	580	66	68
2		875	70	73
3		1750	76	72
4	285	580	70	69
5		875	72	71
6		1750	75	75
7	470	580	70	70
8		875	73	71
9		1750	76	76

The of acoustic emission observed generated from cutting of the workpiece with minor multiple sources such as the noise from the moving parts inside the milling machine and also collision noise of the chips resulting from cutting of the workpiece. Cutting passes monitored with random short intense sound emission from surrounding were scrapped and restarted. From the microscope analysis of the cutting tool, we can see signs of abrasive wear on the cutting tool. Due to high temperature, some parts of the workpiece melted and stuck onto the surface of the cutting tool.

The same pattern can be observed from the tool 2 experiments. Although in the second experiment the tool used has been moderately worn out from continuous use prior to the experiment. The effects could be seen from the Vave of each cut which is slightly lower than the Vave of a fresh cutting tool in mint condition. The cutting tool showed signs of wear caused by the friction during cutting process. Although the cutting tool is much harder than the workpiece, the high temperature during the cutting process increases the wear rate on the cutting tool. The increase in temperature of the cutting tool drastically increase the plastic deformation for certain material. The cutting speed also intensify the wear rate and reduces tool life.

Signs of abrasive wear could be seen on the surface of the cutting tool as shown in Figure-1. Other evidence of wear on the tool could be seen on the surface of the cutting tool such as the plastic deformation seen on the surface. Crater wear could also be seen along the edge of the cutter could be due to the chemical effect on the cutting tool and together with increasing cutting speed.

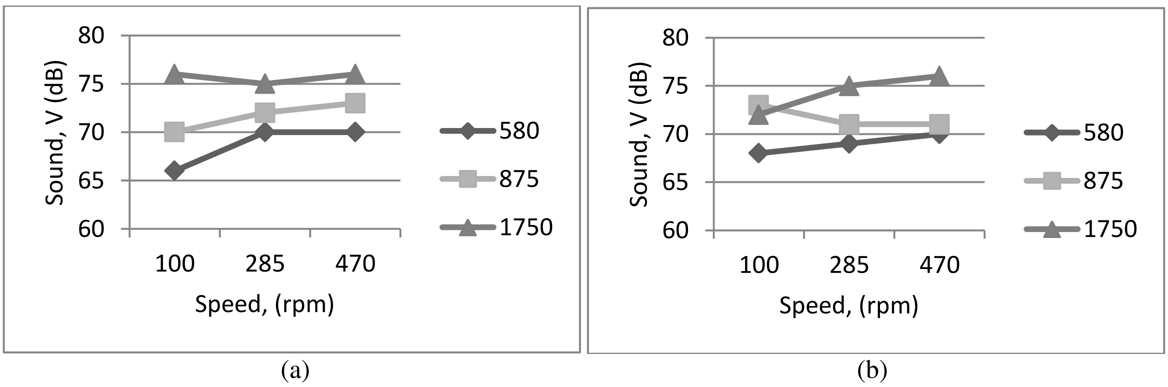

Figure-1. Relationship between cutting speed with sound (a) Tool 1 (b) Tool 2.

CONCLUSIONS

The post-processing method is analyzed. The factors that affect the milling of aluminium 6061-T6 are chosen and evaluated. Increasing the feed rate increases acoustic emission of the machining process, whereas the higher spindle speed also increases the acoustic emission of the machining process. Tool life monitored using acoustic emission could be done with the selection of machining parameters.

The findings have been compared with previous studies where they showed compatibility towards each other. This monitoring technique is relevant to the studies of the machining of metals such as the many types of milling, turning and drilling where the machining process generates substantial amount of acoustic emission.

REFERENCES

[1] Najiha1 M.S., Rahman M.M. and Kadirgama K. 2015. Maching performance of Aluminium alloy 6061-T6 on surface finish using MQL. International Journal of Automotive and Mechanical Engineering. 11: 2699-2712.

[2] Chockalingam P, Jasdeep Singh A.S., Natarajan C. 2017. Development of Response Surface Model to Predict the Surface Roughness During Milling of Aluminium Alloy. International Journal of Science, Engineering and Technology Research. 6(11): 1456-1460.

[3] Chattopadhyay A.K, Roy P, Ghosh A, Sarangi SK. 2009. Wettability and machinability study of pure aluminium towards uncoated and coated carbide cutting tool inserts. Surface and Coatings Technology. Vol. 203, pp.941-51.

[4] Sreejith P.S. 2008. Machining of 6061 aluminium alloy with MQL, dry and flooded lubricant conditions. Materials Letters. 62: 276-278.

[5] Olufayo O. & Abou-El-Hossein K. 2015. Tool life estimation based on acoustic emission monitoring in end-milling of H13 mould-steel. The International Journal of Advanced Manufacturing Technology. 39-51.

[6] Dhulubulu A. 2015. Acoustic emission (AE) monitoring of the milling process with coated metal carbide inserts using TRIM C270 cutting fluid.

[7] Dolinšek, S., Šuštaršič, B., & Kopač J. 2001. Wear mechanisms of cutting tools in high-speed cutting processes. Wear. 250(1): 349-356.