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The Effect of Drill Reamer Tool on Cutting Force and Temperature when Machining with Different Parameters and Cutting Condition

H Rachmat[2], NH Rafai[1*], EA Rahim[1], K Kamdani[1], MAS Adzman[1], CK Wong[3], Y L Chong[3]

[1]Faculty of Mechanical and Manufacturing Engineering,
University Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

[2]Fakultas Rekayasa Industri, Telkom University, Bandung, 40257, INDONESIA

[3]HPMT Industries Sdn Bhd, Tmn Perindustrian Berjaya, Shah Alam, 40460, MALAYSIA

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Abstract: Normally in manufacturing process, drilling and reaming are separate processes. However a new tool is developed which combined both processes. In this study, the performance of a new drill reamer is studied in terms of cutting force and temperature under internal cooling, external cooling and minimum quantity lubricant (MQL) condition. Three types of tools are used to machine aluminum; 140° twist drill, 140° and 180° drill reamer. Various values of feed were involved while cutting speed and depth of cut are kept constant. From the result it showed that 140° twist drill has produced low cutting (thrust) force and temperature. In addition, low value of cutting force and temperature were also generated when applying low feed and internal cooling condition for all tools.

Keywords: cutting force, temperature, internal and external cooling, MQL

1. Introduction

In traditional machining process, in order to produce hole with better surface finish, there are two processes that need to be considered; drilling and reaming. Drilling is process when a drill bit enters the workpiece axially and cuts a blind hole or through hole with a diameter equal to the tool while reaming removes a minimal amount of material and is often performed after drilling to obtain more accurate diameter and smoother the hole's internal finish. Normally, drilling and reaming process are done separately which led to time consuming. Thus, by combining both drill bit and reamer as one tool, it could increase the production rate and reduce the production cost. The main problem in material removal process is the variation of workpiece hardness and strength which can affect the cutting force and temperature and head to tool failure and damaged the workpiece. Cutting force is a force produced on a cutting tool and work piece when machining operation takes place while cutting temperature is the temperature occurred cause by friction at the contact area between the cutting tool and the work piece. Cutting force and temperature is widely regarded as being the one of the most valuable information for tool condition and performance monitoring such as machining accuracy, surface quality, machine tool vibration, power requirements, and tool life. The effect of cutting force and temperature can be controlled by applying certain cutting condition (internal, external or minimum quantity lubricant (MQL)) and cutting parameter such as cutting speed, feedrate, depth of cut and tool geometry.

In internal cooling, the cooling liquid flow inside the cutting tool whereas in external cooling and MQL the cooling liquid was flow or spray outside the tool. Minimum quantity lubricant was developed in order to minimize wasted cooling liquid that used in internal and external cooling. In addition, minimum quantity lubricant is eco-friendly coolant and low cost compared to the cooling liquid use in the internal and external cooling [1]. By using internal cooling, it

*Corresponding author: nhakim@uthm.edu.my

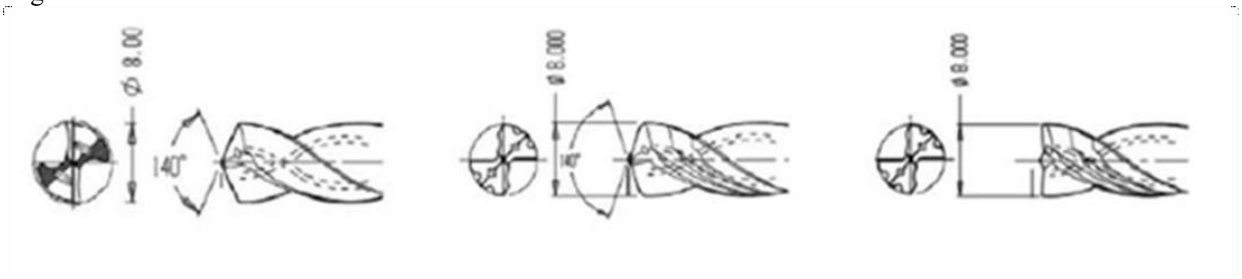
reduces the cutting force more and prolongs the tool life more compared to MQL [2]. Feed values have shown significant effect on the cutting force, cutting temperature and formation of built up edge [3, 4]. Low feed value will reduce the cutting force and temperature. Therefore, this study is conducted to define the effect of new development of drill reamer tool on the cutting force and temperature when machining in different cutting parameter in internal cooling condition.

Table 1 - Design of experiment

Tool Type	Tool Diameter	Cutting Condition	Feed (mm/rev)
140° Twist Drill	8 mm	Internal Cooling External Cooling MQL	0.15
140° Drill Reamer			0.30
180° Drill Reamer			0.45

2. Experimental Set Up

Aluminium grade 7075 workpiece is drilled and reamed by using MAZAK Vertical Center Nexus 410A-II machine with three different types of carbide cutting tool which is 140° point angle twist drill, 140° point angle drill reamer and 180° point angle drill reamer (Fig. 1). The parameter selected to be manipulate in this study is feed while cutting speed and depth of cut are keep constant. The cutting process is conducted by applying internal cooling (Fig. 2), external cooling and minimum quantity lubricant. The designs of experiments for this study are shown in Table 1 where cutting speed and depth of cut remain constant at 80 mm/min and 15 mm. Before machining process start, thermocouple was inserting to the workpiece (Fig.3) and mount to the piezoelectric dynamometer that has already mount to the machine worktable. When machining is start, the cutting force and cutting temperature is measure and record during a machining. The machining is repeated until all input parameters is used. Data from cutting force, cutting temperature will be analyzed to study the performance of the cutting tool. The whole experimental setup shows in Fig. 4.



140° twist drill 140° drill reamer 180° drill reamer

Fig. 1 - Dimension of the cutting tools

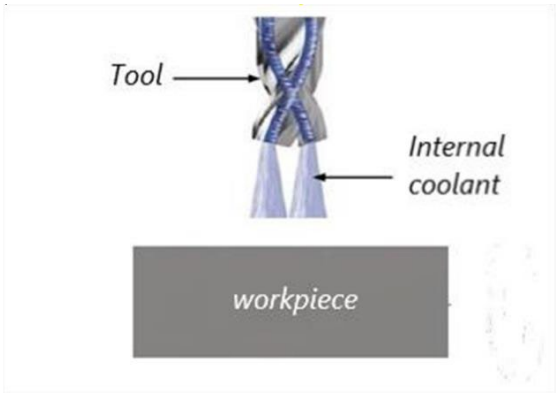


Fig. 2 - Internal cooling

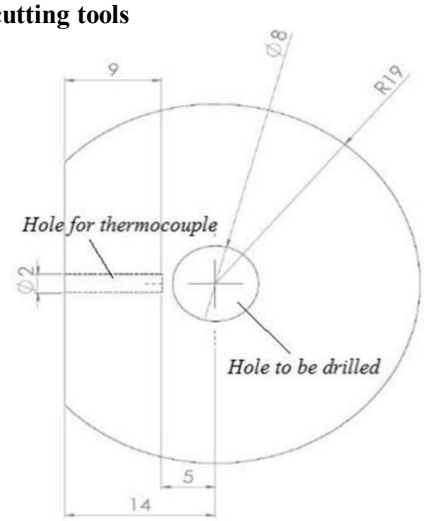


Fig. 3 - Top view of the aluminum workpiece

3. Result

3.1 Thrust Force

Fig. 5 – (a)(b)(c) indicated that on all types of cutting tool, the feed significantly effect the thrust force. The thrust force seems to be decreased when the feed decreased. Types of the cutting tool also effect the thrust force. The 140°

point angle twist drill recorded the lowest value of thrust force in all feed value followed by 140° point angle drill reamer and lastly 180° point angle drill reamer. In all value of feed and all types of cutting tool, machining condition also had an effect to the thrust force. From the experiments result, thrust force seems lowest in the internal cooling condition. While thrust force, was observed had highest value in MQL condition. Thrust force was lower in internal cooling machining condition because the coolant enters properly into the cutting zone to form a boundary lubricant layer which reduces the friction compared to the external cooling and MQL condition [6]. Furthermore, minimum quantity lubricant machining condition had higher value of thrust force because the lubricant could only flow at the upper zone of the cutting area. When the drill and drill reamer cut deeper, the lubricant might be not enter the cutting zone especially at the lower cutting zone. This led to the high friction and follow by the high thrust force.

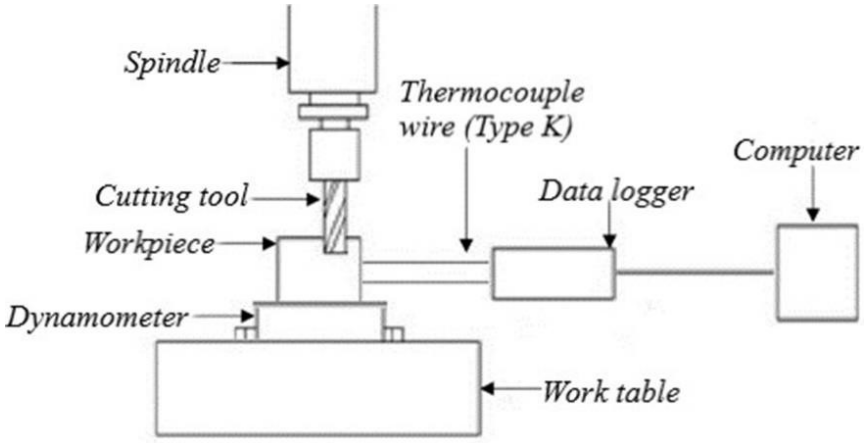


Fig. 4 - Experimental set up [5]

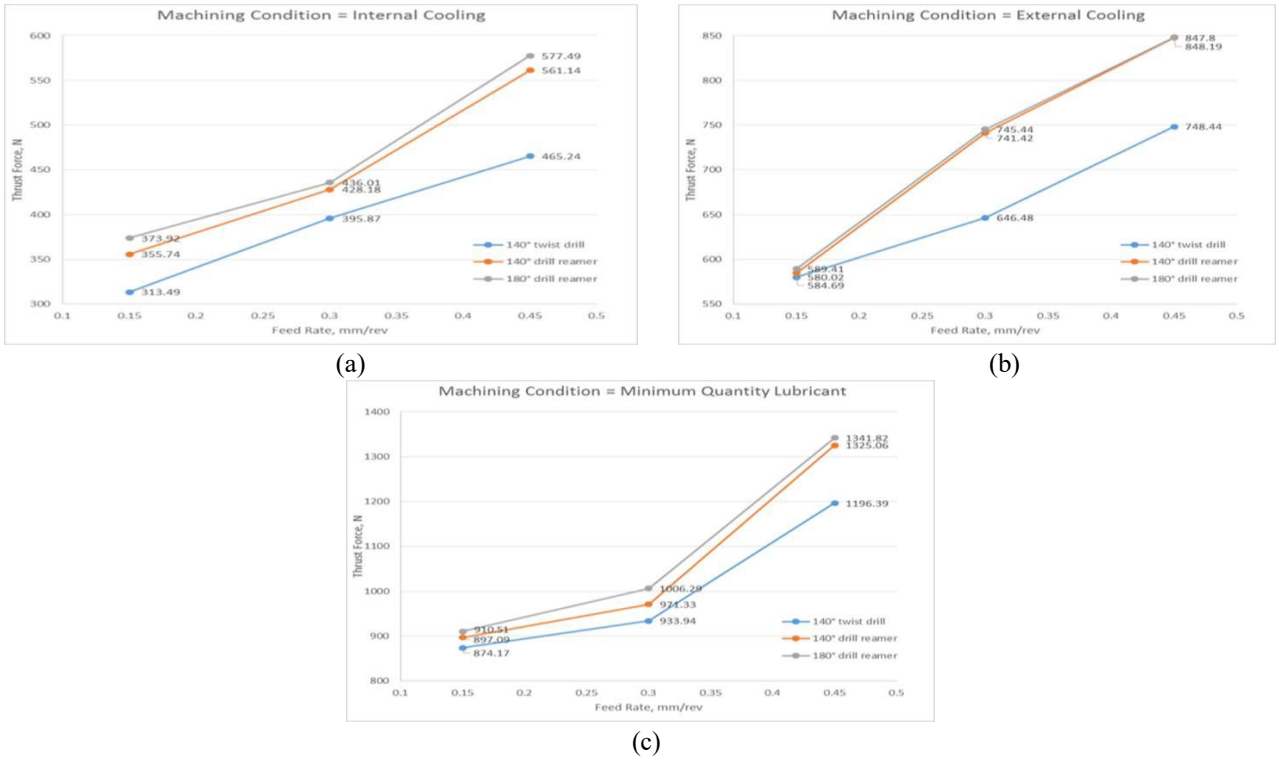
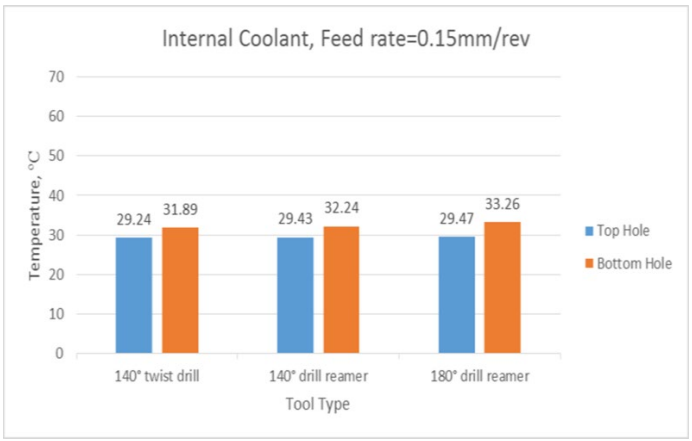


Fig. 5 - Graph of thrust force against feed in (a) internal cooling; (b) external cooling; (c) MQL condition

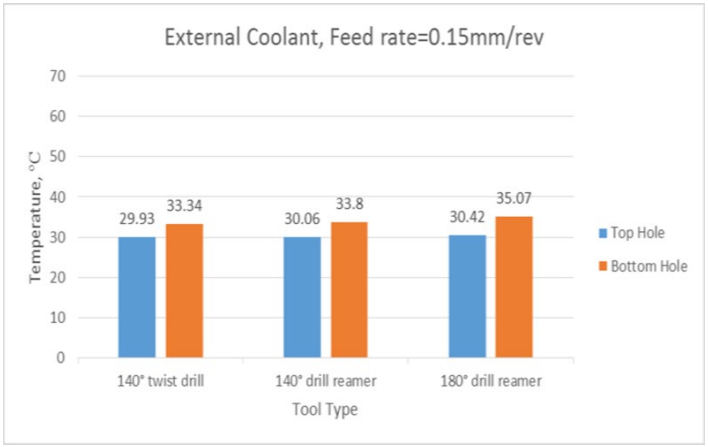
3.2 Cutting Temperature

For cutting temperature, Fig. 6 – (a)(b)(c), the general trend is that cutting temperature values seem to be lowest at lower feed. Cutting temperature is higher at the bottom of the hole. With the increase in feed rate, section of chip increases and consequently friction increase, thus will generate more heat. 140° point angle twist drill recorded the lowest value of cutting temperature follow by 140° point angle drill reamer and lastly 180° point angle drill reamer at 0.15 mm/rev of feed. From all the graph, 140° point angle twist drill recorded the lowest value of cutting temperature while 180° point angle drill reamer recorded the highest value. 180° point angle drill reamer had highest value of

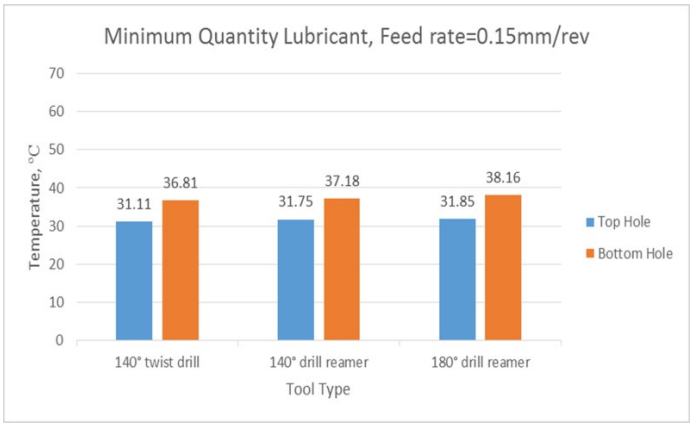
cutting temperature compared to the other because it had the larger tool-chip interference. Large tool-chip interference led to the high friction. High friction will increase the cutting temperature. Although 140° twist drill and 140° drill reamer had a same point angle, 140° drill reamer recorded higher value of the cutting temperature compared to 140° twist drill due to drill reamer tool performed two processes at the same time; drilling and reaming. The reaming process added extra friction to the tool and led to the high cutting temperature. Machining condition seems to have significantly affect the cutting temperature. Internal cooling machining condition recorded the lowest value of cutting temperature for all type of tools. MQL recorded the highest value of cutting temperature for all type of tools. The result is due to similar factors that which influence the cutting force in this experiment.



(a)



(b)



(c)

Fig. 6 - Graph of temperature against tool type in (a) internal cooling; (b) external cooling; (c) MQL condition

4. Conclusions

The effect of a twist drill and drill reamer tool (different angle point) on thrust force and cutting temperature when machining aluminum grade 7075 in different cutting condition have been investigate experimentally. From the experiment conducted, the conclusions that can be drawn are:

1. as the feed rate increase, the cutting (thrust) force and cutting temperature increase,
2. internal coolant condition gave the best performance in term of thrust force and cutting temperature,
3. performance of 140°-point angle twist drill was better than other tools in term of cutting force and cutting temperature at all feed values and machining conditions,
4. the 140°-point angle drill reamer show a better performance than 180°-point angle drill reamer in term of cutting force and cutting temperature at all feed values and machining conditions,
5. the combination of the low feed and internal cooling machining condition was the best parameter to achieve low value of cutting temperature and cutting force for all type of the cutting tool.

Acknowledgement

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References

[1] Zheng, X., Liu, Z. and Chen, Min. (2013). Experimental study on micro-milling of Ti6Al4V with minimum quantity lubrication. Int. J. Nano manufacturing, 9, 5-6.

[2] Chengliang, Z., Song, Z., Yan, X. and Qing, Z. (2016). Effects of internal cooling channel structures on cutting forces and tool life in side milling of H13 steel under cryogenic minimum quantity lubrication condition. International Journal of Advanced Manufacturing Technology, 83(5-8), 975- 984.

[3] Ibrahim, M. R, Rahim, E. A, Ghazali. M.I, Chai, M. H, Goh, Z. O. (2014). Experimental analysis on ultrasonicassisted turning (UAT) based on innovated tool holder in the scope of dry & wet machining. Aplied Mechanics and Materials, 660, 104-108.

[4] Ibrahim, R. Rafai, N. H. Rahim, E.A, Cheng, K. Ding, H. (2016). A performance of 2 dimesional ultrasonic vibration assisted milling in cutting force reduction on aliminium AL6061. ARPN Journal of Engineering and Applied Sciences, 11, 11124–11128.

[5] Satoshi, E. M. A. (2012). Effects of Twist Drill Point Geometry on Torque and Thrust. Sci. Rep. Edu, 36, 165-174.

[6] Hong, S.Y., Ding, Y. and Jeong, W.C. (2001). Friction and cutting forces in cryogenic machining of Ti-6Al-4V. International Journal of Machine tools and Manufacture, 41, 2271- 2285.