Thrust Force Analysis in Drilling Wood and Natural Fibre Reinforced Composite

Anggit Murdani[a], RN Akhsanu Takwim and Muhammad Fakhruddin[b]
Department of Mechanical Engineering, State Polytechnic of Malang, Jl. Sukarno Hatta No. 9, Malang 65141, Indonesia

Keywords: Plywood, Natural Fibre, Polyester, Auger, Spur, Twist, Drilling.

Abstract: The objective of this research is presenting the method for analysing the behaviour of drill bit during cutting process by means the measurement of thrust force. The behaviour of the drill bit during cutting process is very useful for developing cutting tool such as drill bit for composite and wood. Thrust force is measured by using modified loadcell connected to data acquisition system. In this research, three types of drill bits are used for drilling plywood and natural fibre reinforced polyester composite. The drill bits used are twist drill, spur bit, and auger bit. The value of measured force demonstrates the behaviour of the drill bit during cutting process. This value of the thrust force can be used for analysing the influence of machining parameters, optimizing the tool and its process.

1 INTRODUCTION

Assembly process requires good quality of machined part such as hole (Caggiano et al, 2018). In recent years, many researchers develop cutting tool to be more efficient and produce higher quality of products (Ismail et al, 2017; Karpat et al, 2015; Ramesh et al, 2015; Rakesh, 2012). One of fast-growing topics in machining is drilling wood base materials (Bajpai et al, 2013; Boccarusso et al, 2020; Maleki et al, 2019; Nasir et al, 2019). In conventional machining, especially in practical work, problem is still occurred in drilling wood base materials such as wooden products and natural fibre reinforced composite.

Drilling wood and natural fibre reinforced composite persists problem in delamination of the layers or plies (Khashaba, 2012; Kilickap, 2010; Prakash et al, 2018; Saoudi et al, 2018). Several methods were developed to reduce the delamination in drilling wood and natural fibre reinforced composite. Drill bits innovation and machining attachment are most common method (Khashaba, 2012).

In this study, the behaviour of the drill bit during cutting process is observed by means of analysing thrust force. The next goal of this study is to develop drill bit that is more effective to cut the material, i.e., reducing delamination of layer on the hole exit.

2 RESEARCH METHOD

The materials used in this study are plywood and composite. The materials are three plies type of plywood with 10mm thickness and jute fibre reinforced polyester composite. Three kinds of drill bit are used to make hole on the specimens, i.e., Twist drill bit, Brad point drill bit, and Auger drill bit. The diameter of the drill bits is 8 mm.

Four axis CNC machine is used with constant feed rate of 0.3 mm/rev. The spindle speed is 1400 rpm. Modified loadcell is used for sensing the thrust force during cutting process. The loadcell is connected to dynamic strain amplifier and data acquisition system that able to capture data in the rate of 1000 Hz.

3 RESULT AND DISCUSSION

Figure 1 and 2 show the recorded thrust force during drilling hole using twist drill on plywood and fibre reinforced composite. Figure 3 and 4 show the

[a] https://orcid.org/ 0000-0003-4212-9403
[b] https://orcid.org/ 0000-0002-3526-3842

Murdani, A., Takwim, R. and Fakhruddin, M.
Thrust Force Analysis in Drilling Wood and Natural Fibre Reinforced Composite.
DOI: 10.5220/0010945600003260
In *Proceedings of the 4th International Conference on Applied Science and Technology on Engineering Science (iCAST-ES 2021)*, pages 354-357
ISBN: 978-989-758-615-6; ISSN: 2975-8246

recorded thrust force during drilling hole using Brad point drill bit on plywood and fibre reinforced composite. Figure 5 and 6 show the recorded thrust force during drilling hole using Auger drill bit on plywood and fibre reinforced composite.

All figures and its illustration are not subjected to a scale. Drill bit picture is located at an approximate position when the observed thrust force is considered important. The workpiece is fitted to the length of thrust force curve, started from the point when the drill bit the entrance surface of the workpiece and ended at the point when the exit hole is completely drilled.

Figure 1-6 compares the three types of drill bits in drilling two different materials. As shown in Figure 1 and 2, twist drill demonstrates a basic behaviour of thrust force generated during drilling process on plywood and composite, respectively.

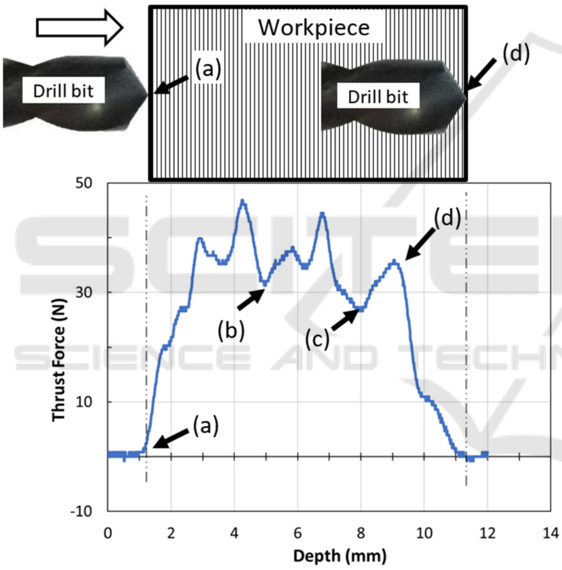

Figure 1: Thrust force during drilling hole using twist drill on plywood.

The maximum thrust force is higher in drilling composite, since the composite is considered harder than the plywood. Therefore, the gradual increase of thrust force can be observed in drilling plywood (arrow (a)). In Figure 1, pointed by arrow (b) and (c), represent the thrust force when the drill point reaching the interface between the plies of the plywood. The arrow (d) pointing the thrust force level when the exit hole started to form. On the other hand, in Figure 2, in drilling jute fibre reinforced polyester composite with twist drill showing steeper slope than in drilling plywood when the drill point started to swipe the workpiece, as shown by arrow (a), and when the drill point starts to open the exit hole, as shown by arrow (b). The drilling on composite material shows the higher thrust force in overall process.

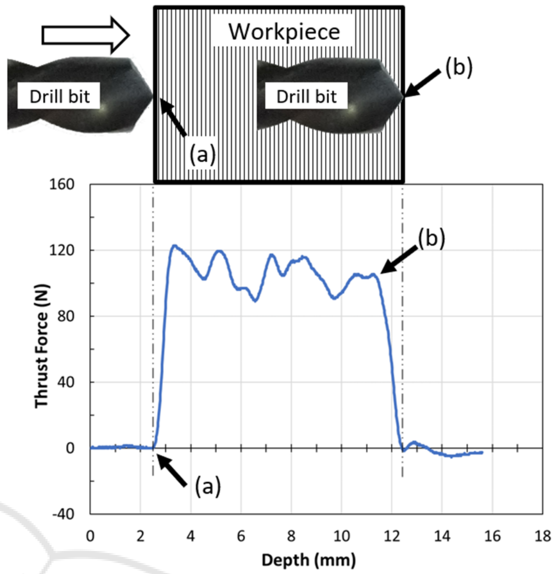

Figure 2: Thrust force during drilling hole using twist drill on composite.

Figure 3 and 4 show the behaviour of thrust force generated during drilling workpieces with Brad-point drill bit. The effect of the drill point is clearly shown on the recorded thrust force which is different from the twist drill.

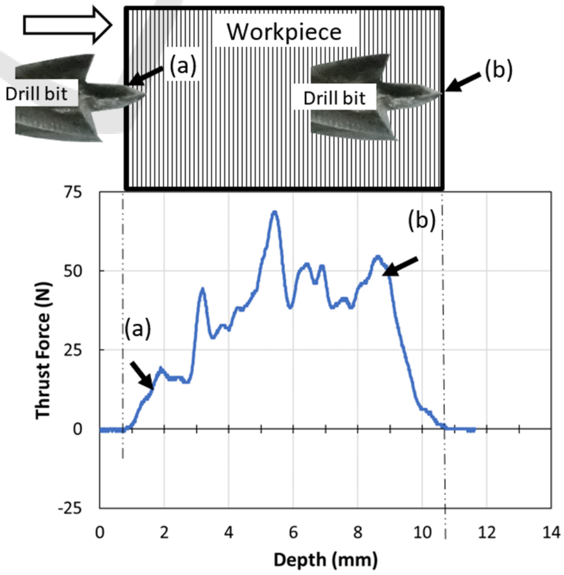

Figure 3: Thrust force during drilling hole using Brad point drill on plywood.

In Figure 3, as shown by the arrow (a), the thrust force gradually increases in the first step when the drill point starts to deep the hole. The similar result is presented by Boccarusso et al, (2020). The thrust force continues to increase after the cutting edge start to swipe the workpiece and finally decrease when the sharp point starts to open the exit hole (arrow (b)). Figure 4 shows the effect of the drill point of Brad-point drill bit on the generated thrust force in drilling jute fibre reinforced polyester composite is similar to the Figure 2, however, the beginning slope of Figure 4 is less steep than that of Figure 2. When the sharp point starts to open the hole, the thrust force steeply increase and the slope slightly change less steep at the point indicated by arrow (a). Finally, the thrust force decreases when the sharp point starts to open the exit hole (arrow (b)). The overall thrust force is approximately equal between Figure 2 and 4.

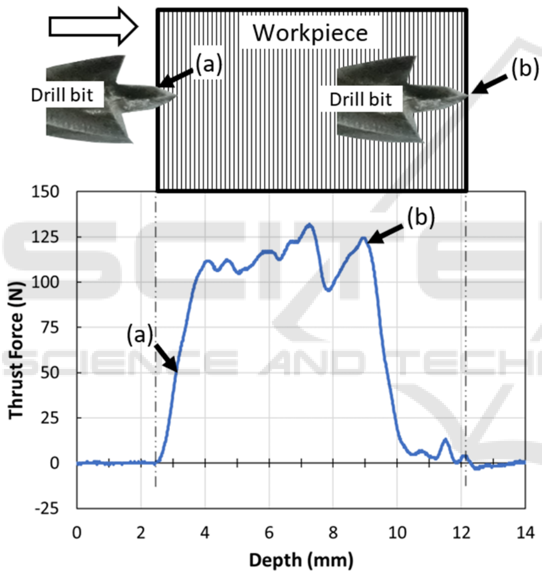

Figure 4: Thrust force during drilling hole using Brad point drill on composite.

Figure 5 and 6 show an interesting behaviour of the thrust force during drilling plywood and jute fibre reinforced composite using Auger bit. In both materials, the recorded thrust force shows the traction exerted by the thread of the drill point.

In Figure 5 and 6, the starting thrust force are increase due to the first touch of the drill point. However, the level of the thrust force is different between the plywood and the composite. The initial thrust force of jute fibre reinforced polyester composite is much higher than that of plywood, since the plywood is much softer than the composite. After the initial thrust force, as the drill point continue to cut the material, the thrust force gradually decreases (arrow (a)) and exerts traction on the workpiece. This traction can be seen as the negative value of the thrust force from location pointed by arrow (a) until location pointed by arrow (b). The thrust force increases (arrow (c)) when the cutting edge starts to swipe the workpiece surface and finally decrease when the drill point opens the exit hole (arrow (d)). The effect of materials on the thrust force behaviour is different in the term of traction.

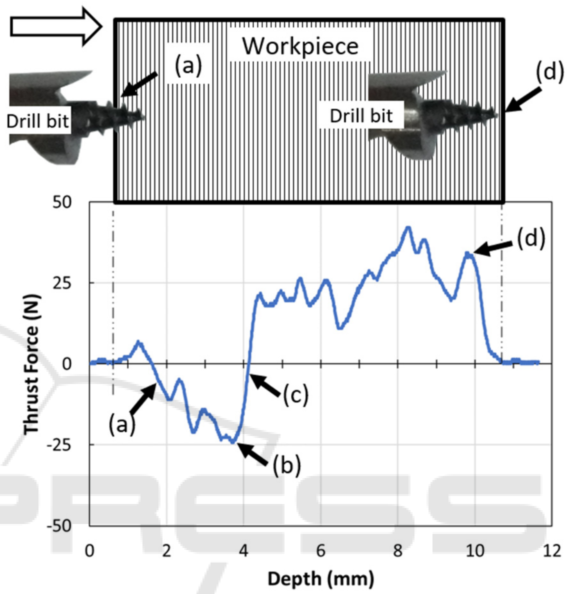

Figure 5: Thrust force during drilling hole using Auger bit on plywood.

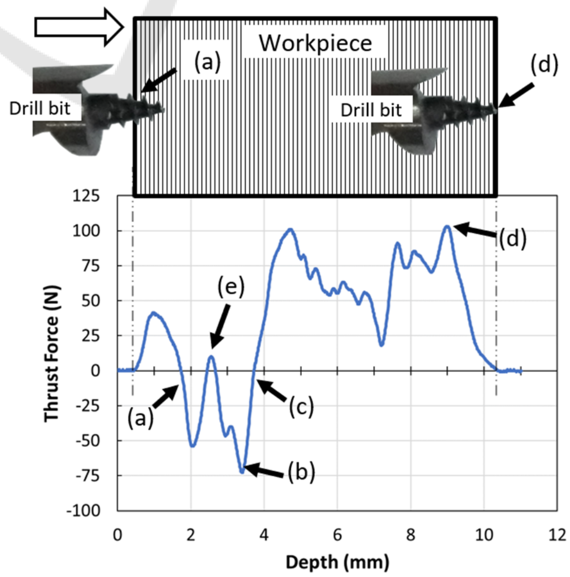

Figure 6: Thrust force during drilling hole using Auger bit on composite.

The traction exerted by threaded point of the drill bit on plywood is lower than that of jute fibre reinforced polyester composite. This is caused by the weaker contact between thread and the plywood during drilling. On the other hand, although the composite has stronger contact between the thread and the composite, in a certain stage, the contact between the thread and the composite is loosen, causing the traction decrease, i.e., the thrust force increases as shown in Figure 6 pointed by arrow (e). After that, the contact between the thread and the composite re-established and the traction increases. When the cutting edge start to swipe the workpiece, the thrust force increases gradually as shown by arrow (c).

4 CONCLUSIONS

The behaviour of the drill bit during drilling process that is shown by the thrust force, represent the mechanism of cutting process based on its tool tips geometry. The twist drill shows the high average thrust force and the delamination persist. The Brad point drill bit and Auger bit shows lower thrust force. While the Auger bit give the best result in the lowest effect on the delamination.

ACKNOWLEDGEMENTS

This project is funded by Research Grant in Applied Research Scheme of Politeknik Negeri Malang fiscal year 2021.

REFERENCES

Bajpai, PK and Singh, I. (2013). *Drilling behavior of sisal fiber-reinforced polypropylene composite laminates*. Journal of Reinforced Plastics and Composites.

Boccarusso, L, D'Addona, DM, Durante, M, De Fazio, D, Minutolo, FMC, Langella, A. (2020). *A study on the drilling process of hemp/epoxy composites by using different tools*. Procedia CIRP.

Caggiano, A, Nele, L, and Teti, R. (2018). *Drilling of Fiber-Reinforced Composite Materials for Aeronautical Assembly Processes in Characterizations of Some Composite*, Intechopen, London.

Durao, LMP, Gonc, DJS¸ Alves, Manuel, J, Tavares, RS, de Albuquerque, VHC, and Marques, AT. (2011). *Comparative analysis of drills for composite laminates*. Journal of Composite Materials.

Ismail, SO, Dhakal, HN, Dimla, E, and Popov, I. (2017). *Recent advances in twist drill design for composite machining: A critical review*. Proc IMechE Part B: J Engineering Manufacture.

Karpat, Y and Bahtiyar, O. (2015). *Comparative Analysis of PCD Drill Designs During Drilling of CFRP Laminates*. Procedia CIRP.

Khashaba, UA. (2012). *Drilling of polymer matrix composites: A review*. Journal of Composite Materials.

Kilickap, E. (2010). *Investigation into the effect of drilling parameters on delamination in drilling GFRP*. Journal of Reinforced Plastics and Composites.

Maleki, HR, Hamedi, M, Kubouchi, M, and Arao, Y. (2019). *Experimental study on drilling of jute fiber reinforced polymer composites*. Journal of Composite Materials.

Nasir, AAA, Azmi, AI, Lih, TC, Mohd. Khalil, AN, and Kim, NK. (2019). *Tensile behaviour of open hole flax/epoxy composites: Influence of fibre lay-up and drilling parameters*. Journal of Composite Materials.

Prakash, M, and Dhar, PVSDA. (2018). *Investigation on the effect of drilling parameters on the tool wear and delamination of glass fibre-reinforced polymer composite using vibration signal analysis*. Journal of Composite Materials.

Rakesh, PK, Singh, I and Kumar, D. (2012). *Drilling of composite laminates with solid and hollow drill point geometries*. Journal of Composite Materials.

Ramesh, B, Elayaperumal, A, Satishkumar, S, Kumar, A, and Jayakumar, T. (2015). *Effect of drill point geometry on quality characteristics and multiple performance optimization in drilling of nonlaminated composites*. Proc IMechE Part L: J Materials: Design and Applications.

Saoudi, J, Zitoune, R, Gururaja, S, Salem, M, and Mezleni, S. (2018). *Analytical and experimental investigation of the delamination during drilling of composite structures with core drill made of diamond grits: X-ray tomography analysis*. Journal of Composite Materials.