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A Review on Chip Formation Characteristics Under Dry and Flood Cutting

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Abstract: In this new globalization era, machine manufacturing has been developed too much. The purpose of this study is to review the chip formation in order to get desirable chip whether in dry cutting or flood cutting by using AISI 1045. Following the objective which to review the relation between machining parameters and chip pattern and to clarify the tool wear pattern with the reason of wear in dry and flood cutting. From the literature study that has been conducted by using repositories database, chip formation in each cutting style has been analysed. More than fifty articles were used in the analysis process. The parameter that has been set for this review is the cutting speed, cutting depths and rake angle. All the parameter result in this study has been recorded in two cutting style which is dry cutting and flood cutting. All the tool wear and tool wear reason in between two cutting styles has been recorded. Therefore, this research can be done to fulfil all the industries requirement in each product such as good surface finish, good accuracy and saving cost.

Keywords: Dry Cutting,Flood Cutting, Chip Formation, Turning Process

1. Introduction

Turning process is defined as the process in which a material removed by using a tool which is used to create rotational parts by cutting away unwanted material. The turning process requires a turning machine, work piece and cutting tool. The material removed by the machine called chips[1]. The shape of chips produced can give a lot of information and we can straight analyse based on the cutting process. The introduction should describe general information on the subject matter area of study. It is usually arranged in such a manner to gradually bring to focus the specific motivations of the current study, the research questions, the problem statements, the hypotheses, the objectives, as well as the expected outcome.

In the process of chip formation, the cutting tool engages the workpiece, the material directly contact ahead of the tool is sheared and deformed under high pressure[2]. The deformed material is then wanted to relieve its stressed condition by fracturing and flowing into the space above the tool in the form of chip. The chip is highly deformed and the workpiece material took plastic deformation. Most of the mechanical energy used to form the chip becomes heat which generates high temperature in the cutting region. Theoretically, higher temperature will result to higher tool wear[3]. In machining

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process, reducing the temperature at the cutting region is essential by applying lubricant to reduce the friction wear but it can give bad effect to the environment[4]. Many machining industries are trying to achieve high quality of product, great dimensional accuracy and cost saving product. By using the flood cutting, high amount of fluids is needed and that can cause the increasing in cost of production not be taken seriously. The fluid may harm the soil and water resources when disposal process It also have a high potential to give effect to machine operators such as skin disease and give breathing problem. Therefore, handling and disposal of the cutting fluid must be done by following proper procedure and rules for environmental protection. Due to the technological innovation, dry cutting is the most suitable but there is important role in each process depend on some situation. However, it is really important to do the process without effecting tool life and workpiece quality.

In dry cutting, the friction is higher comparably with flood cutting and the chip produced will be highly adhesive which can cause high temperature in the cutting region and shorter tool lifetime. Therefore, dry cutting process is quite not suitable for all process and all materials especially hard materials. So, in this experiment, the observation of the relation between machining parameters and chip pattern will be taken to clarify the tool wear pattern and reason of wear.

It is important to manufacture products using the sustainable methods in the uses of dry cutting in machining operations. In addition, it is essential to determine the optimal machining parameters, while maintaining long tool life, acceptable surface finish and good part accuracy for the products. Machined surface quality is a very important output parameter to be controlled within the permissible value. Surface roughness and subsurface microstructure changes are some of the items to be controlled to avoid crack propagation of fracture. Surface finish also affects the production quality and give huge effect of first impression. To get the best machining quality, the machining process need to be done the best machining. It is well known that machining parameters play a significant role in determining the surface quality of a product and affects the product functional characteristic.

The product quality depends very much on surface finishing affected from the machining parameter. Lacking of surface roughness quality also leads to decrease of product quality[5]. In field of manufacture, especially in engineering, the surface finish quality can be a considerable importance that can affects the functioning of a component, and possibly its cost. Surface finishing has been receiving attention for many years in the machining industries. It is an important design feature in many situations, such as parts subject to fatigue loads, precision fits, and fastener holes and so on. In terms of tolerances, surface finishing imposes one of the most crucial constraints for the machines and cutting parameters selection in process planning.

In this study, the machining characteristics of steel AISI 1045 workpiece are evaluated through the reading or literatures, focusing on dry and flood cutting. From literatures, studies were conducted under various machining parameters including cutting angle, cutting speed, feed rate and depth of cut.

2. Methodology

The review of the about chip formation characteristic in orthogonal cutting process under dry and flood technique was get from previous study. The uses of any search engine and electronic database have led to gather all the information and being analysed to do review study. A method to conduct systematic review, eligibility and exclusion criteria has been used by using Scopus. The data was obtained with free of charge by using internet, but there is also that we need to pay to the data collector as they need to recover all the expenses of the data collection. A limitation of articles, journal and thesis from 10 years ago has been decided to prevent from any changing of information or new invention.

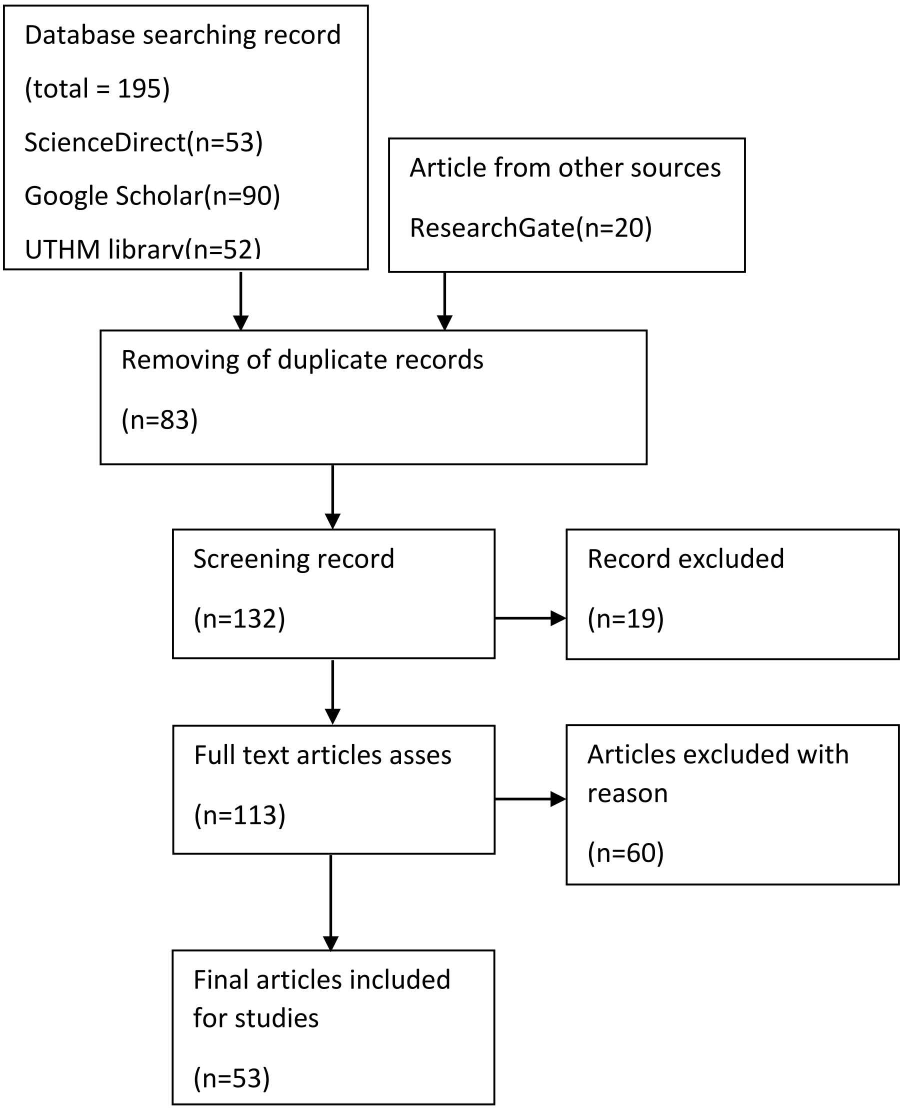


Figure 1: Flowchart of method of reviewed study

A search on the reviewed literature have been conducted and get the result for 215 articles including 53 articles from ScienceDirect,90 articles from Google Scholar,52 thesis from UTHM library and 20 articles from ResearchGate. From this article's discovery, the scanning of the titles and abstracts was performed, screening and remove all the duplicate and unneeded articles before 2011 with total 83 articles. All the remaining articles become 132 articles were included for a full evaluation assessment. The remaining articles were evaluated and read in full text to get a full detailing of the research studies. The focus of this review studies in on the chip formation in dry and flood cutting by using material AISI 1045.First part review will be focusing on chip formation under orthogonal cutting which the other cutting style such as milling and drilling will be removed. So that the result will be 19 articles out of 132. After reading process finished, the file such as using MQL as cutting fluid will be remove with total 60 out of 113. Lastly, only 53 articles that meet the characterization for this research topics.

3. Results and Discussion

This chapter will present all about the results regarding the chip formation on dry and flood cutting based on the valid articles and journals.

Table 1: Cutting speed and cutting depth comparation on 1,2 (dry cutting) and 3,4 (flood cutting)

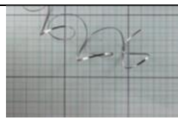
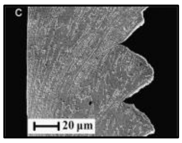
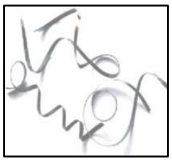
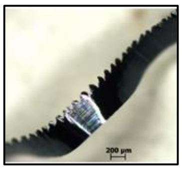
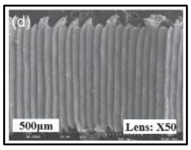
Item	Author	Cutting Parameter	Chip Formation
		Cutting Speed	
1	[6]	V_c = (150,200,250,300)m/min f_r = 0.15mm/rev D = 0.8 mm	 Snarled chips[6]
2	[7]	V_c = (30-200)m/min D = 0.05mm	 Secondary serrated chips[7]
3	[8]	V_c = (40.51,94.2,145.1)m/min f_r = (0.051, 0.096, 0.143,0.191)mm/rev D = 1 mm	 Snarled chips[8]
4	[9]	V_c = 125.6 m/min f_r = 0.2mm/rev D = 1 mm	 Ribbon spiral chips[9]
		Cutting Depth	
1	[10]	V_c = (110,193,276)m/min f_r = (0.05,0.1,0.15)mm/rev D = (0.1,0.2,0.3) mm	 Continuous ribbon chips[10]
2	[11]	V_c = 100–1000m/min D = 0.1 mm	 Serrated chips with curling chip flanks[11]
3	[12]	V_c = (100,125,150,175,200)m/min f_r = (0.1,.15,0.2,0.25,0.3)mm/rev D = (1.5,1.25,1.00,0.75,0.50) mm	 Thick snarled chips[12]
4	[13]	V_c = 59.69 m/min f_r = (0.1,0.15,0.23)mm/rev D = (0.5,0.1,0.23) mm	 Silver grey segmented chips[13]

Table 2: Comparation of rake angle between dry and flood cutting

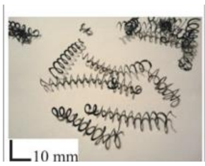
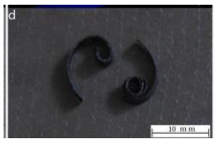
Item	Author	Cutting Parameter	Chip Formation
		Dry Cutting	
1	[14]	V_c = (250,350)m/min f_r = 0.15 mm/rev D = 0.5 mm γ_o = -8º	 Continuous chip, curly tight[14]
2	[15]	V_c = (100, 150, 200)m/min f_r = (0.08, 0.14, 0.20, 0.26) mm/rev D = 2.5 mm γ_o = -5º	 Flat spiral chips[15]
3	[16]	V_c = 150 m/min f_r = (0.05, 0.10, 0.15, 0.25, 0.40, 0.60) mm/rev γ_o = -5º, 5º, 10º, 20º	 Low segmentation chips[16]
		Flood Cutting	
1	[17]	V_c = (50,100,150)m/min f_r = (0.1,0.15,0.2)mm/rev D = 1.0 mm γ_o = 5º	 Snarled ribbon chip[17]
2	[18]	V_c = 225 m/min f_r = 0.1mm/rev D = 1.2 mm γ_o = -7º	 Cork screw helical shaped chips[18]
3	[19]	V_c = 100 m/min f_r = 0.12 mm/rev D = 0.5 mm γ_o = 6º	 Long cork screw chips[19]

Table 1 and Table 2 is the articles that has used systematic analysis to get all those information for data gathered. On cutting speed at dry cutting session, it can be concluded that both experiments produce continuous chip formation at the beginning and during the cutting speed increase, the chip has shifted to serrated chip formation with saw-tooth appearance. In cutting fluid, the first author gets the result from short arc chip to snarled chip while the second author got the ribbon chip formation during the cutting process. Next, for cutting depth in dry cutting has transform from continuous chip formation to serrated chip for first article and there is segmentation and serrated chip formation on the next article. For flood cutting, the first article has result in long ribbon chips at the beginning. As the depth is increase, it has change to long tubular chips. For rake angle, the result from three articles that has been analyzed it shows when it comes to negative rake angle, it will produce continuous chips but not too long compared to positive rake angle. Negative rake angle also produce segmentation during cutting process. During the analysis on rake angle for flood cutting, three articles has produced on most similar chip which at the end of the process they produce snarled tubular chips, cork screw helical chips and long cork screw chips.

3.4 Tool Wear and Tool Wear Reason

Table 3: Tool wear and tool wear reason in each of articles studied.

Item	Author	Tool Wear	Tool Wear Reason
Dry Cutting			
1	[8]	Critical flank wear and crater wear	Increasing the cutting speed, increased the cutting tool's wear rate, increased chip friction and consequently shortened its tool life.
2	[14]	Production of flank wear and abrasive wear	Speed of cutting increases, the width of wear band increases and abrasive wear increase due to increased strains on the main cutting edge
Flood Cutting			
1	[20]	Critical on crater wear and absence in flank wear	Material adhesion in the cutting process that developed those wear. Flank wear only at minor edge when there is cutting fluid
2	[21]	Lowers crater wear and flank wear occur	Cutting with fluid gives no existence of significant crater wear occurs and the flank wear.

4. Conclusion

A systematic review has been used in this study as we can see that too many pros and cons between dry cutting and flood cutting. Dry cutting can give benefit of saving production cost. In term of coolant, it need money to be spent during cutting. It is good when there are low expenses and gain high profit. Next, dry cutting can save the environment system as it does not use any lubricant or any cooling fluid because sometimes the lubricants or fluid can harm to the environment. The non-benefit of dry cutting from the reviewed study is the high temperature from the cutting process. It can be affected to the decreasing cutting tool life. Other than that, dry cutting also easy to happened any wear including flank wear or crater wear which can give a bad effect to workpiece as the cutting tool not sharp as initial. Flood cutting also give a good and bad effect in machining. The evaluated study concluded that reducing the friction between the cutting tool and the workpiece is possible using flood cutting. As a result, the cutting tool's life can be extended and it can be used frequently. Next, flood cutting also gives a good machining accuracy and good surface finish because lubrication or coolant fluid significantly enhances the metal-removal process with minimum friction force. The disadvantages of using flood cutting will be high-cost production and can be a bad effect to the human and environment due to the coolant chemicals from fluid residual.

There are several views toward further studies regarding from this thesis. First and foremost, this reviewed study is the theory in machining base on the previous study and too many data limitation on these writings. Thus, further study needs to do the analysis by experiment. The data from the experiment need to be use to confirmed that all the simulation and experiment are in correct information. Secondly, the further study needs to find for cutting tool life in both condition and did some cost calculation whether one cutting tool can be done 10 production or more with cost details. The data that has been did can be propose to any company in Malaysia for use the data to calculate in company budget. Last but not least, a study on the potential of machining AISI 1045 in using the least force so that the bill of electricity would be low. It will be a great idea for cutting AISI 1045 with low cost and gain more profit.

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