Micromilling performance analysis – cold air assisted aluminium machining behaviour observation

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Abstract: The primary goal of this work is to investigate the performance of micro mill tools in terms of tool wear, average surface roughness, and chip size when machining aluminium alloy, as well as to evaluate the effect of cutting fluid application, using a 0.9 mm tungsten carbide (WC) tool with two flutes. This is because it is recognized that one of the essential factors in the micro-cutting process is the micro-cutting tool itself. The tool failure or wear affects the cost, average surface roughness, functionality, and the quality of the finished product greatly. The research is conducted under different cutting conditions with a varying feed rate of 0.001mm/tooth to 0.005mm/tooth and a cutting speed of 3.142m/min to 9.425m/min using a side milling process where the side flank face wear progression of the tool is measured. Then, the average surface roughness and chip size data are collected using a 3D laser measurement microscope. Based on the results, there is a similar tool wear trend in the micro-cutting process with the conventional methods. The results show that the use of cutting fluid has a significant impact on the quality of machined parts, both in terms of burr formation and machined surface quality. The relative size of the burrs formed is much larger than in macro machining operations, depending on the cutting conditions. Tool life and surface finish are impacted by built-up edges on cutting tools. The premature tool failure of the dry condition micro-cutting process is often focused on the entrance of the work-piece. Other than that, it is found that there are some instances where the average surface rough-ness decreases abruptly when it is reaching the fracture zone which is caused by the geometrical effect from the worn edge of the tool. This could be applied in the future design of the micro tool suitable for high-speed machining in dry conditions. It is also concluded that an appropriate selection of machining conditions has the potential to reduce tool wear rate and encourages longer tool life.

1. Introduction

In this era of technological advancement, micro-sized products and components have shown increasing demand in various fields. This further presents newly found obstacles to be overcome in the manufacturing aspect. A market is in need of current low cost, significant accuracy, and high-quality processes capable of producing mini-sized products are brought to focus through downsizing or miniaturization. Most of the conventional manufacturing processes, such as turning and conventional end milling, are not suitable for micro-product production because of their restricted capacities. Their limitations include geometric tolerances, shape intricacy, and the material properties of the product in question [1-6].

Micromachining processes are emerging as the preferred candidate for high-precision metal cutting processes. Starting from the medical field, as it needs micro-scaled devices for tissue construction, instruments, and minimally invasive components such as prostheses, stents, and aneurysm clips, there is an expanding need to work with high tolerances, unique textures, and sharp features [5].

Furthermore, the aerospace industry has high demands for much smaller components due to their lightweight, high-load, and high tolerance to extremely harsh environments. Thus, producing these small-sized components with stated characteristics requires high accuracy and a low average surface roughness value. It is suggested that the micro cutting process is one of the methods that is able to fulfil such a requirement. Micro cutting not only can achieve great accuracy and surface integrity but also has reasonable power expenditure and good efficiency performance [6]. However, a structure is simply as reliable as its weakest individual component when various components are working in tandem. There are still a lot more to study on micro cutting tool wear since its behaviour is completely different from the conventional machining process such as end milling, drilling, and turning [1-6].

The machining process has been one of the main components in our world's manufacturing industries, and any advancement in this field will act as a catalyst for the development of new advanced technology. As before, machinists are facing difficulties in predicting tool wear and breakage. A machining process with broken tools can cause significant damage to the workpiece due to its geometrical error. This then will contribute to extra costs, an increase in downtime and extra workload [4–12].

There has been much research on the tool wear phenomenon during conventional machining but much less on the micro-cutting process itself. This behaviour might be related to the tribological performance of that particular machining process [12–18]. Tool wear is an important parameter in determining the product quality and accuracy since it directly effects the surface roughness of the product after the machining process. However, it is more difficult to study due to its small size scale and size effect compared to

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