

Study Of Cutting Edge Temperature And Cutting Force Of End Mill Tool In High Speed Machining

Mohammad Ashaari Kiprawi¹, Abdullah Yassin^{1,a}, Syed Tarmizi Syed Shazali¹, M. Shahidul Islam¹ and Mohd Azrin Mohd Said¹

¹Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS), Malaysia

Abstract. A wear of cutting tools during machining process is unavoidable due to the presence of frictional forces during removing process of unwanted material of workpiece. It is unavoidable but can be controlled at slower rate if the cutting speed is fixed at certain point in order to achieve optimum cutting conditions. The wear of cutting tools is closely related with the thermal deformations that occurred between the frictional contact point of cutting edge of cutting tool and workpiece. This research paper is focused on determinations of relationship among cutting temperature, cutting speed, cutting forces and radial depth of cutting parameters. The cutting temperature is determined by using the Indium Arsenide (InAs) and Indium Antimonide (InSb) photocells to measure infrared radiation that are emitted from cutting tools and cutting forces is determined by using dynamometer. The high speed machining process is done by end milling the outer surface of carbon steel. The signal from the photocell is digitally visualized in the digital oscilloscope. Based on the results, the cutting temperature increased as the radial depth and cutting speed increased. The cutting forces increased when radial depth increased but decreased when cutting speed is increased. The setup for calibration and discussion of the experiment will be explained in this paper.

1 Introduction

One of the important process in manufacturing a metal product is machining process. The purpose of the process is to remove unwanted material from the workpiece to obtain a desired shape and high dimension accuracy of the parts or products. The precision of the surface finishing normally used a high speed machining process in order to increase consistency of surface's integrity. There are drawbacks when machining process is done in high speed. It affects the cutting edge of tool's bit, the workpiece surface integrity, chip formation mechanism, and contribute to the thermal deformation of the cutting tool [1]. This is due to the nature of friction energy accumulates at the contact point of workpiece and cutting edge of tool's bit. The friction resisting overtime and dissipates as thermal energy. This phenomenon has thermally weaken the mechanical strength of workpiece, and cutting tools. The degree of friction is associated with the cutting speed. It is important to determine the cutting temperature to study the performance cutting tools at particular cutting speed.

Several extensive studies on milling temperatures have been conducted. Sato et al. [2] have studied the temperature and force variation existed during milling process of titanium alloy Ti-6Al-4V. They showed that the cutting temperature gradient is higher when down milling compared to up milling. Richardson et al.[3] have conducted a research to study the effects of high cutting

speed to workpiece temperature. He found that the workpiece temperature decrease when cutting speed is increase at extreme rate. This finding was supported by Ye et.al. [1] as they found that increasing cutting speed will reduce finished surface temperature but increasing tool-chip contact temperature. Ueda et al. [5] have found that the cutting tool temperature of cemented carbide insert increase proportionally when the cutting speed increase. They also find the similar trend when the radial depth of cut increases. Interesting studies have been done by Komanduri et al [6] as they have determined the distribution of temperature in the chip, the tool, and the work material by using functional analysis approach. The analytical solution is based on the temperature rise distribution due to shear plane heat source in metal cutting.

The existence of wear in cutting tools is due to the presence of stress during cutting process. Tang et al. [7] have found the correlation between wear and cutting forces. As the cutting forces increases, the flank wear will also increase. This study is further studied by Ma et al. [8] as they have simplified analytical model of the cutting loads and stress zone during cutting process. Ma et al. [9] used a Finite Element Method (FEM) model and showed that initial tensile stress makes the cutting stress distribution within the workpiece become more tensile and diminishes the cutting forces and tool tip temperature.

^a Corresponding author: yabdulla@unimas.my