EFFECT OF TOOL PATH GENERATION WHEN MACHINING MOLD-CAVITY

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Dedicated to my beloved family...

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ABSTRACT

Studies on the tool path generation for free form surface have been conducted extensively and most of these studies were focused on the effect of tool path generation on the tool wear and surface texture. In this study, the effect of tool path generation on tool wear, surface finish, machining time and dimensional accuracy were evaluated during ball end milling of a mold cavity. UGS CAD/CAM software was used to simulate the tool path and actual during machining at various cutting parameters was conducted on CNC machining centre to machine a concave shape of the mold-cavity component. Workpiece of 6061 aluminium alloy and HSS ball end mill were used in this study. Four types of tool path strategies were investigated; they are Follow Periphery, Parallel Line, Concentric Arc and Radial Lines. Result showed that the highest value of 0.04μm flank wear was obtained when using Concentric Arc and the lowest value of 0.01μm was recorded with Parallel Line. Follow Periphery tool path strategy demonstrates the shortest machining time of 115 min and radial line recorded the longest machining time of 352 min. Radial Line and Follow Periphery recorded the lowest and highest surface roughness of 0.95μm and 2.76μm respectively. In average, the smallest error value in dimension was from Radial Line strategy with 0.04% while the biggest error was recorded using Follow Periphery with 0.6%. Based on the result obtained, it can be concluded that Parallel Line and Radial Line produce lower tool wear, smaller error in dimensional accuracy and better in surface finish but longer in cutting time while Follow Periphery and Concentric Arc produce shorter cutting time, higher tool wear, bigger error in dimensional accuracy and poor in surface finish.

ABSTRAK

Kajian terhadap penjanaan perjalanan matalat bagi permukaan pelbagai bentuk telah djalankan secara meluas dan kebanyakan kajian tertumpu kepada kesan ke atas penjanaan perjalan mata alat terhadap geometri mata alat dan tekstur permukaan. Di dalam kajian ini, kesan penjanaan mata alat terhadap kehausan, kemasan permukaan, masa pemesinan dan ketepatan dimensi telah dinilai sepanjang menjalankan pemesinan kaviti acuan cekung. Perisian *UGS CAD/CAM* telah digunakan untuk simulasi perjalanan mata alat dan pemesinan sebenar pada pelbagai parameter pemotongan dengan menggunakan mesin berangka computer berpusat. Bendakerja yang digunakan di dalam kajian ini adalah 6061 *aluminium alloy* dan matalat pengisar bebola berhalaju tinggi. Empat jenis strategi perjalanan matalat yang diselidik adalah *Follow Periphery*, *Parallel Line*, *Concentric Arc* dan *Radial Lines*. Keputusan menunjukkan nilai tertinggi bagi kehausan rusuk adalah 0.04μm yang diperolehi dari *Concentric Arc* dan nilai terendah adalah 0.01μm dari *Parallel Line*. Strategi perjalanan matalat *Follow Periphery* merupakan masa pemesinan terpendek iaitu 115 minit dan *Radial Line* mencatatkan masa pemesinan terpanjang iaitu 352 minit. *Radial Line* dan *Follow Periphery* mencatatkan bacaan kekasaran permukaan terendah dan tertinggi iaitu masing-masing sebanyak 0.95μm dan 2.76 μm. Secara purata, nilai ralat terkecil di dalam dimensi adalah dari *Radial Line* iaitu sebanyak 0.04% manakala ralat terbesar yang direkod adalah dari *Follow Periphery* dengan 0.6%. Berdasarkan kepada keputusan yang dicapai, boleh disimpulkan bahawa *Parallel Line* dan *Radial Line* menghasilkan kehausan matalat yang rendah, ralat dimensi yang kecil dan kemasan permukaan yang baik tetapi mengambil masa pemesinan yang panjang manakala *Follow Periphery* dan *Concentric Arc* menghasilkan masa pemesinan yang pendek tetapi kehausan matalat yang tinggi, ralat yang besar di dalam ketepatan dimensi dan kemasan permukaan yang kasar.

TABLE OF CONTENS

LIST OF TABLE

LIST OF FIGURE

CHAPTER 1

INTRODUCTION

1.1 Background of the study

Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) is one of the versatile tools used in engineering practice in many ways including drafting, design, simulation, analysis and manufacturing. There are various applications of existing CAD/CAM system whereby each application has its strength which is usually targeted to a specific market and group of users. According to Ibrahim Zeid (2005), CAD/CAM system is classified into four groups depending on the market they serve, the tools, functionalities and flexibilities they provide. The four groups are low end, mid range, high end and specialized.

Low-end systems are used for unsophisticated and simple product which consists of small number of product and uncomplicated geometry. The user can focus on basic geometry modeling and drafting such as AutoCAD, Autodesk Inventor and CADKEY. The midrange system is for users who require complex modeling and a large number of parts per product. Unlike low end system, midrange system support design together with manufacturing application such as SolidWorks, Pro/E and MasterCAM. High-end system supports modeling, analysis and manufacturing of complex products such as airplains, cars and others. Examples of this high-end system are Unigraphics, Parasolid, SDRC I-DEARS and CATIA (Ibrahim Zeid, 2005).

One of the most important technique in manufacturing is to produce a part with free-form or parametric surfaces. Efficient machining of these surfaces has become very important in many manufacturing industries, such as the automobile, consumer electronics, die-making and toy industries (Jian-Zhong Yang et al, 2007).

Research on cutter path generation techniques has been carried extensively over the past decade. Proper selection of cutter path strategy is crucial in achieving desired and quality machined surfaces. Without considering the effect of cutter path selection with adequate consideration of the machining outcome such as cutting forces, vibration analysis, tool life, cutting temperature and workpiece surface integrity, the result can lead to catastrophic cutter failure and therefore lead to unnecessary waste of time, cost and poor surface quality (C. K Toh, 2004).

This study is conducted in order to gain a better understanding on the type of cutter path strategies and their effect when ball end milling of mold cavity part.

1.2 Problem Statement

The development of the aeronautic and automobile industries brought new technological challenges, related to the growing complexity of the products and the new geometries modeled in Computer Aided Design (CAD) systems. These more complex geometries impose new challenging manufacturing situation for milling of moulds and stamping tools (R. Baptista, 1999).

The utilization of Computer Numerical Control (CNC) machine to manufacture complex surfaces has driven extensive research works especially in the area of tool path generation. According to Cevdet Gologlu (2008), the implementation and selection of cutting path strategies with appropriate cutting parameters have significant effect on surface roughness. Study on optimal tool path generation has been aiming at achieving two conflicting objectives which is quality and efficiency. Hui wen Li. et al, (2001) reported that a large tool path interval results in a rough surface while a small interval increases machining time, resulting in the inefficient of the process.

Most of previous studies were focused on the effect of tool path generation on tool geometry and surface texture. In this study, the effect of tool path generation on tool wear, surface finish, machining time and dimensional accuracy is being evaluated when ball end milling of mould cavity.

1.3 Objective of the study

The main objective of this study is to evaluate the effect of various tool path strategies via CAD/CAM on tool wear, surface finish, machining time and dimensional accuracy of a mold cavity.

1.4 Scope of work

The scope of the study covers the following aspects:

1. UGS CAD/CAM software was use to run the simulation and experiment with selected cutting parameters.
2. MAHO 700S CNC machining centre was used to machine the mold-cavity component.
3. 6061 aluminium alloy was selected as the workpiece.
4. High Speed Steel (HSS) ball end mill was used as the cutting tool.
5. Focus on the study was on finishing operation.
6. Cutting conditions such as cutting speed, feed rate and depth of cut were kept constant.

1.5 Significant of the Study

It is expected that the study will contribute to the following achievement:

1. Better understanding on the effects of tool path generation when ball end milling a mold-cavity part.
2. Proposed predictive results that can be achieved by using UGS software that is currently used in Production laboratory, Faculty of Mechanical Engineering, UTM.
3. Established the tool path generation and their outcomes when milling 6061 aluminium alloy.

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