DETERMINATION OF TOOL SIZE BASED ON HERMITE CURVE

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To my beloved family and my beloved fiancée for your love and support.

To my friends, for your wits, intelligence and guidance in life.

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ABSTRACT

Manufacturing is the industrial activity that changes the form of raw materials to create products. As the power of hand tool is limited, manufacturing is done largely by machinery today. Manufacturing technology constitutes all methods used for shaping the raw metal materials into a final product. There are a lot of machining technologies in the industrial today. In this project, the machining technologies that will used is Computer Numerical Control Milling Machine and the profile to machining is piecewise Hermite curve. There are a few problems occurred during milling profile, such as the generation of a finished part surface which does not satisfy product design specification or mostly gouging occur. Gouging can occur when the surface is uneven cutting and over cut the profile. For that reason, examination of cutter interference between profile and tool was carried out after the minimum tool size was found. The another problem in milling process is an inherently slow and expensive process. Thus, in this project, tested and simulated the profiles and obtained the time consumption for finishing the manufacturing process was considered because the minimum time taken to milling the profile is very important. For running all the equations and get the results, MATLAB software was utilized in this study. The size that suitable for milling the piecewise Hermite curve is $\frac{1}{2}$ inch tool radius end mill tool with no interference occurred. From this study, the result shows that the minimum time taken to milling the piecewise Hermite curve is 15.6880 minutes with $\frac{1}{2}$ inch and 1 inch of end mill tool size after used the minimization method.

ABSTRAK

Pembuatan adalah aktiviti perindustrian yang mengubah bentuk bahan-bahan mentah untuk mencipta sesuatu produk. Dengan kuasa alat tangan yang terhad, pada hari ini sebahagian besar pembuatan dilakukan oleh jentera. Teknologi pembuatan merupakan kaedah yang digunakan untuk membentuk bahan-bahan logam mentah kepada produk akhir. Terdapat banyak teknologi pemesinan dalam industry kini. Dalam projek ini, teknologi pemesinan yang akan digunakan ialah CNC mesin pengilangan dan profil yang dipilih untuk dipotong ialah kepingan lengkungan Hermite. Terdapat beberapa masalah yang berlaku semasa memotong profil tersebut, antaranya ialah generasi permukaan bahagian yang sudah siap dipotong tidak memenuhi spesifikasi reka bentuk produk atau kebanyakkannya berlaku ketidaksamarataan. Ketidaksamarataan boleh berlaku apabila permukaan pemotongan tidak sekata. Atas sebab itu, pemeriksaan gangguan pemotongan antara profil dan alat telah dijalankan selepas saiz alat yang minimum sudah ditemui. Masalah lain dalam proses pengilangan adalah pengilangan merupakan satu proses yang perlahan dan mahal. Oleh itu, dalam projek ini, profil akan diuji dan disimulasikan dan mendapatkan penggunaan masa untuk menamatkan proses pembuatan ini kerana masa minimum yang diambil untuk pemotongan profil adalah sangan penting. Untuk menjalankan semua persamaan dan mendapatkan keputusan, perisian MATLAB telah digunakan dalam kajian ini. Saiz alat yang sesuai untuk memotong kepingan lengkungan Hermite ialah $\frac{1}{2}$ inci saiz '*end mill tool'* dengan tiada gangguan ketidaksamarataan permukaan profil berlaku. Daripada kajian ini, keputusan menunjukkan bahawa masa minimum yang diambil untuk memotong kepingan lengkungan Hermite ialah 15.6880 minit dengan menggunakan saiz alat $\frac{1}{2}$ inci dan 1 inci selepas digunakan kaedah minimum.

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LIST OF SYMBOLS

$\boldsymbol{T(t)}$	-	Unit tangent vector
$\boldsymbol{N(t)}$	-	Unit normal vector
$\kappa(t)$	-	Curvature
ρ	-	Radius of oscillating circle
$c(x, y)$	-	Centre of curvature
x_c	-	Centre of tool placement in x-axis
y_c	-	Center of tool placement in y-axis
P_x	-	Point for the next segment in x-axis
P_y	-	Point for the next segment in y-axis
V	-	Variable feedrate
V_0	-	feedrate
δ	-	Depth of cut
r	-	Speed of spindle
cs	-	Number of material
D	-	Diameter of the tool
C	-	Chipload per tooth
N	-	Number of flutes (teeth) or number of edges
$\mathcal{L}$	-	Arc length
$H'(x_i)$	-	The derivative of piecewise Hermite equation
n	-	The number of Gauss points
c_i	-	Unknown coefficient and also called weights
x_i	-	The specific values of x and also called Gauss points, at which the integral is evaluated

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter introduces briefly the background of the study and statement of the problem. Besides, this chapter also included objectives, scope of the study, and significant of the study.

1.2 Background of the Problem

Manufacturing is the industrial activity that changes the form of raw materials to create products. As the power of hand tool is limited, manufacturing is done

largely by machinery today. Manufacturing technology constitutes all methods used for shaping the raw metal materials into a final product. There are a lot of machining technologies in the industrial today. One of the machining technology is Computer Numerical Control Technology (CNC). Computer Numerical Control (CNC) is the term used when the control system includes a computer. CNC machine are particularly suitable for the manufacture of a small number of components needing a wide range of work, such as those with complex profiles, parts requiring close tolerance and good repeatability, parts requiring expensive jigs and fixtures, parts that may have several engineering changes, parts that are needed hurry and short production runs. There are five types of CNC machine tools, which are NC drilling machines, NC milling machines, NC turning machines, NC machining centers, and NC turning centers.

Curvature or spline surfaces are frequently encountered in engineering applications. The definition of the surfaces and subsequent numerically controlled machining of the component part are still presents a considerable challenge for manufacturing units. Spline and surfaces design for engineering applications (complex shapes) are typically represented in a piecewise manner by joining primitive shapes. An important curve design property is fairness, which attempts to capture the visual aesthetic of a curve. Fairness is closely related to how little and how smoothly a curve bends. In this project, we focus on milling the Piecewise Hermite Curves. Hermite curves is a third degree spline with each polynomial of the spline in Hermite form. The Hermite form consists of two control points and two control tangents for each polynomial. To construct the Piecewise Hermite Curves, C^1 or G^1 continuity must achieved at the joints. C^1 continuity means that both the first and the second parametric derivatives of the two curve sections are the same intersection and G^1 means the parametric first derivative are proportional at the intersection of two successive sections. 6 We construct the piecewise Hermite Curves because we want to construct many curves. Polynomials with degree higher than three tend to be very sensitive to the positions of the control points and thus do not always make smooth shapes.

1.3 Statement of the Problem

Milling is the most common form of machining and a material removal process, which can create a variety of features on a part by cutting away the unwanted material. In this project we want to discuss the milling of complex profile which is piecewise Hermite curve. The important of milling profiles by using CNC machine are its accuracy and precision with good surface quality. There are a few problems occurred during milling profile, such as the generation of a finished part surface which does not satisfy product design specification or mostly gouging occur. Gouging can occur when the surface is uneven cutting and over cut the profile.

Although CNC machines offer a great precision and versatility in the fabrication of complex parts, machining is an inherently slow and expensive process.

1.4 Objectives of the Study

The objectives of this project are:

i. To formulate the piecewise Hermite curve equation by using modified divided difference basis.
ii. To find the minimum tool size base on the oscillating circle around the piecewise Hermite Curve.
iii. To examine the cutter interference with the part geometric when we have find the minimum tool size.
iv. To test and simulate the profiles in the CNC machine to obtained the time consumption for finishing the manufacturing process.
v. To find the smooth dynamics profiles by reconstructed smooth curvature radius curve and minimize the time consumption

1.5 Scope of the Study

The research study for this project is to determine the tool size of CNC machine based on piecewise Hermite curve as input. In CNC machine, there are a few of tool size can be use in milling the curvature surfaces. In this project, center end mill tool was selected. There are a few size that can be use such as $\frac{1}{4}$ inch, $\frac{1}{2}$ inch, $\frac{3}{4}$ inch, and 1 inch. The selection of tools is depends on the radius of curvature. There are two types of center end mill tool, which are capable of side cutting and capable of down cutting. In this project, we use center end mill tool who capable on down cutting because this tool also can do side cutting. In order to milling the curvature surfaces such as piecewise Hermite curve, selection diameter of tool is very important to avoid gouging. A suitable tool can be determine by finding the minimum oscillating circle along the curve. Material used in this project is aluminium. Due to the soft and sticky nature of aluminium, specific geometries and characteristics of a carbide end mill are required for efficient machining. Therefore Helmi A. Youssef and Hassan El-Hofy recommend us to use two flutes of center end mill tool. For the finishing process, we used ball end mill tool because E. Agson Ghani said that ball end mill does not cause a big problem in overcutting. Time consumption is also important in manufacturing. Therefore, the minimum time consumption is required by test and simulate the profile.

1.6 Significance of the Study

The significance of the study is to achieve the smoothness of the curvature machining process by selecting the suitable tools and suitable speed of spindle and the feed rate. The minimum time consumption of machining this profile is also considered because manufacturing cost is the key factor to the economic success of a product.

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