TOOLPATH AND HOLES ACCURACY OF ROBOTIC MACHINING FOR DRILLING PROCESS

This report is submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for Bachelor Degree of Manufacturing Engineering (Hons.)

by

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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of Universiti Teknikal Malaysia Melaka as a partial fulfilment of the requirement for Degree of Manufacturing Engineering (Hons). The member of the supervisory committee is as follow:

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(Dr. Mohd Shahir Bin Kasim)

ABSTRAK

Pemesinan robot adalah teknologi baru yang membangunkan sistem pembuatan fleksibel yang menyumbang untuk melakukan secara automatik seperti proses penggerudian, penggilingan, dan penyahgeriggis. Matlamat projek ini adalah untuk menyiasat ketepatan perjalanan mata alat dan lubang pada kedudukan robot lengan yang berlainan, orientasi lubang dan jenis bahan, untuk membina dan mengesahkan model ramalan untuk ketepatan perjalana mata alat dan lubang dan untuk mencadangkan kedudukan lengan robot yang terbaik. Tiga parameter iaitu kedudukan robot lengan, jenis bahan dan orientasi berkaitan antara satu sama lain dan dibina reka bentuk untuk eksperimen. Dengan menggunakan metadologi permukaan sambutan, experimen telah dirancang dengan mempertimbangkan tiga faktor yang telah dinyatakan di atas. Dua bahan yang berlainan telah digunakan dalam percubaan ini yang digunakan ialah polietilena berketumpatan tinggi dan aluminium 6061. Berdasarkan reka bentuk experimen, percubaan dilakukan ke robot COMAU dan data telah dikumpulkan. Kemudian, menggunakan mesin CMM ketepatan perjalanan mata alat dan lubang yang dihasilkan dianalisis dengan menggunakan perisian Design Expert dan ANOVA analisis dijalankan. Model ramalan telah dibangunkan dan disahkan. Dua faktor iaitu kedudukan lengan robot dan jenis bahan ketara kepada ketepatan lubang manakala orientasi lubang tidak penting kepada tindak balas. Faktor yang paling ketara terhadap ketepatan perjalanan mata alat adalah jenis bahan dan orientasi lubang. Model ramalan telah dibangunkan untuk kedua-dua tindak balas dan pengesahan dilakukan dengan ralat peratusan purata sebanyak 1% untuk kedua-dua tindak balas. Kedudukan robot lengan terbaik yang menyumbang kepada ketepatan perjalanan mata alat dan lubang yang lebih tinggi ialah 1000mm.

ABSTRACT

Robotic machining is the new technology that develop flexible manufacturing system which contributes to perform automatically such as drilling, milling, grinding and deburring process. This aim of this project is to investigate the toolpath and holes accuracy on different arm robot positioning, holes orientation and materials type, to develop and validate prediction model for toolpath and holes accuracy and to propose the best robot arm positioning. Three parameters that are the arm robot positioning, materials type and orientation was relate to each other and are design for the experiment. By using response surface methodology (RSM), design of experiment (DOE) is planning by considering the three parameters mentioned above. Two different materials were used in this experiment that are High-density polyethylene and aluminium sheet 6061 are used. Based on the DOE the experiment is conducted to the COMAU robot and data had been collected. Then, using CMM machine the toolpath and holes accuracy produced was analysed using Design Expert software of ANOVA analysis. The prediction model was developed and validate. Two factors that are arm robot positioning and materials type significant to the holes accuracy while holes orientation is not significant to the response. The most significant factor to the toolpath accuracy is materials type and holes orientation. The prediction model was developed for both response and validation was done with average percentage error of 1% for both responses. The best arm robot positioning that contribute to higher toolpath and holes accuracy is 1000mm.

DEDICATION

my beloved father, Rosli Bin Jai

my appreciated mother, Sepiah Binti Jaafar

my adored sister, Nurain Rosli

for giving me moral support, money, cooperation, encouragement and also understandings

Thank You So Much & Love You All Forever

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LIST OF ABBREVIATIONS

ASTA	-	American Society of Travel Agents
CAM	-	Computer-aided Manufacturing
CMM	-	Coordinate Measuring Machine
CNC	-	Computer Numerical Control
DOE	-	Design of Experiment
FYP	-	Final Year Project
GDT	-	Geometric Dimensioning and Tolerancing
HDPE	-	High-Density Polyethylene
ISO	-	International Organization for Standardization
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode
LMC	-	Least Material Condition
MATLAB	-	Matrix Laboratory
MFEE	-	Multifunction End Effector
MMC	-	Maximun Material Condition
MRR	-	Material Removal Rate
ONCE	-	One-sided Cell End Effector
RSM	-	Response Surface Methodology
USB	-	Universal Serial Bus

LIST OF SYMBOLS

°C	-	Degree Celcius
A	-	Ampere
GPa	-	Giga Pascal
kg	-	Kilogram
kW	-	Kilowatt
m	-	Meter
mm	-	Milimeter
MPa	-	Mega Pascal
N/um	-	Newton per micron meter
º	-	Degree
psi	-	Pound per square inch
rpm	-	Revolution per minute
V	-	Poison Ratio
W/m-K	-	Watts per meter-Kelvin

CHAPTER 1
INTRODUCTION

This chapter explained the introduction on the study for toolpath and holes accuracy for the robotic machining of drilling process

1.1 Background of Study

Recent development in the technologies especially the machining operations to fulfil the desired demand of the customer based on the requirement. For examples for the drilling process, compared to the conventional way with the robotic machining, conventional ways require more man and require time. In case is the requirement for the product is higher, by using conventional method will give the hardest time to the industry to produce on time. The highest requirement such as high surface quality, dimensions and accuracy and quality of the products produced. This requirement thus results in the machines tools that are more advanced that can produce more product based on the requirement (Pandremenos & Doukas, 2011).

Statistically, data from the International Federation of Robotics proved that there is a high demand on the industrial robot sale every year excluded in the year 2009 due to the global economy and economy issues. In the year 2016 shows the higher accelerated to the robot sale as the sales increased by 16% to 294,312 units (Robotics, 2017). Two major customers of the industrial robot are an automotive industry with 35% of the total supply and electronic or electrical industry with a share of 31%. Trending of these two industries leads the demand for the product is high thus lead to using of the robotic machining to increase the product produced. The invention of the robotic machining has given a huge impact to the other machining type that is by manual or by the latest trend also CNC

machining. A conventional method such as drilling manually had been rarely used especially for the mass production of the product instead CNC machine is chosen.

CNC machine has often been compared with the robotic machining because of advantages offered by robotic machining. Robotic machining can be done for almost all type of process starting from the easy and the highest level of the position. Furthermore, the high consistency offers by the robotic machining which CNC machine cannot do. Thus, robotic machining highly used in the industry at the production line. When robotic machining is used it is proved that it can reduce the cycle time which is benefits to the company thus can increase productivity at the same time. The manufacturer has come to the realization that by using robotic machining instead of using CNC machine or manual drilling it can benefit more. In terms of labour, the manufacturer just needs to pay for robotic machining once and can be used 24 hours rather than need to pay for the labour work every month but only work for a specific required time.

Kevin McManus, leader of Robotic Production Technology expressed that robots are turned out to be quicker, progressively adaptable and are considerably heartier and more dependable when contrasted with standard CNC machines. CNC machine needs to be a program using G-code or M-codes which is defined variously. Some applications still need tolerance and accuracy produce by CNC machines. However, many do not require quite the same level of precision.

The drilling process is the process of the cutting process that uses a drill bit to cut a hole of a circular cross-section in solid materials. The bit is pressed against the workpiece and rotated at rates of from hundreds to thousand revolutions per minute. This force the cutting edge against the workpiece and cutting the chip from the hole as it drilled. Along with the technologies, manual drilling that require manpower and energy to handle the machine is not the choice. Due to that, the robotic machining function to smooth the drilling process based on the required diameter. Different type of research had been done related to the kinematic and the stiffness of the robot. Furthermore, to make sure the drilling in a flexible way. Drill effector is been apply to the robotic machining for drilling (Liang & Jia, 2017). Different parameters are been analysed to achieve a flexible robotic drilling.

The hole produce from the robotic drilling is important to ensure that the size is accurate based on the desired diameter require. The limitation of the robotic machining for drilling is the accuracy for the product produce. The accuracy is important especially in the

industry to fulfil the demand and at the same time produce accuracy and good products. With the help of the research on every single parameter, drilling process using robotic machining performance can be increased.

The purpose of this study is to investigate the toolpath and holes accuracy on different arm positioning, holes orientation and materials type. The specific robotic machining that is used is CAMOU robot with air spindle to allow the drilling process with the different type of material. Furthermore, to investigate the toolpath and accuracy of holes produced, CMM was used to test the accuracy of the holes produce.

1.2 Problem Statement

Robotic machining is one of the issues that arise at the industry recently. Thus, to fulfil the demand of the customer and increase the production of the product produce, automation is needed to make the work easier and faster. Without using man to operate the machine instead just set up the program, turn on the machine and it will operate based on the programming. This application widely apply at the heavy industry such as automobile industry (Karim & Verl, 2013). In the production line, since the part produce is large in volume by apply this application the production line is more faster and can increase the work flexibility (Alexandr Klimchik *et al*., 2017) and it is time efficient (Pandremenos & Doukas, 2011). However, the issues that arise in the robotics machining is the accuracy. Now, the accuracy produce for robotic machining still cannot win over CNC machine. Some researcher stated that the accuracy of the robotic machining is worse than the conventional machine but is better compared to the rapid prototyping machine (Iglesias *et al.*, 2015). Low stiffness of robot, vibrations, lack of experience and information in handling robots are some of the problems that related to the robotic machining. If this problem does not minimize, it can affect the accuracy thus, will lead to lower quality of product produce which it will affect the manufacturer. Therefore, a study that can be related or prove the accuracy of the robotic machining in term of toolpath and holes accuracy should be investigated by considering the parameters that had been stated above. In this experiment, three parameters are observed that is the materials type for the drilling process, the arm robot positioning and holes orientation. These three parameters are chosen to determine the toolpath and holes accuracy of the robot machining for the drilling process. Thus, these parameters can be considered when each drilling process using robotic machining is uses.

1.3 Objective

The purposes of this study are:

1. To investigate the toolpath and holes accuracy on different arm robot positioning, holes orientation and material type.
2. To develop and validate prediction model for the toolpath and holes accuracy.
3. To propose the best robot arm positioning.

1.4 Scope

The main scope of this study is to investigate the toolpath and holes accuracy of the robotic machining for the drilling process. The three important parameters that are the type of materials, the arm robot positioning and holes orientation. Two different type of materials was used in this study that is HDPE and aluminium sheet 6061. The machining process is conducted by 6-axis robotic machining (CAMOU) robots. The performance of the robot was observed. The strategy of machining is the materials undergo the process of drilling using the robotic machining. The experiment was carried out under normal condition and based on the required parameters and five respective holes were produced by drilling and L shape was formed. The robotic machining was program as desired and the process of drilling took placed. After the experiment been conduct considering the three parameters mentions before, the toolpath and holes produced was measured using Coordinate Measuring Machine (CMM) for the accuracy based on the diameter of holes and angles of orientation. Then, the data received was interpreted and analysed using ANOVA analysis to develop and validate the prediction model.