UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATING THE FORCE IMPOSED IN POLISHING PROCESS FOR COMAU ROBOT

This report submitted in accordance with requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing Engineering (Robotic and Automation) with Honours.

by

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I hereby, declared this report entitled “Investigating the Force Imposed in Polishing Process for COMAU Robot” is the results of my own research except as cited in references.

Signature	:	…….....
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APPROVAL

This report is submitted to the Faculty of Manufacturing Engineering of UTeM as a partial fulfillment of the requirements for the degree of Bachelor of Manufacturing Engineering (Robotic and Automation) with Honors. The member of the supervisory committee is as follow:

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ABSTRACT

Polishing is the process was used to rid scuff, rust, spot and others on a surface. It is aims to generate better surface and seem shine like mirror. Usually, this polishing process is committed by human skill. This polishing process also need enough force to eliminate the effect found on the polished surface. Nowadays, many polishing process already program to the robot. By using robot, the force imposed during polishing process can be measured. In this project, the robot used is COMAU robot in robotics laboratory. The force imposed during polishing process is measured by using the equipment which can measure the force such as Force / Torque sensor, Force Plate sensor and others. In this project, the force imposed during polishing process at three different surfaces patch is investigated and measured by using Force Plate sensor. The three of the surfaces are classified as soft surface patch, medium surface patch and hard surface patch. As a result, the force imposed on all three types of surfaces is different. In this final project, an analysis is made to identify how many forces is necessary and suitable to do the polishing process on surface types that need to be polished

ABSTRAK

Menggilap adalah proses yang digunakan untuk menghilangkan kesan calar, karat, tompok dan sebagainya pada sesuatu permukaan. Ianya bertujuan untuk menghasilkan permukaan yang lebih baik dan kelihatan bersinar seperti cermin. Biasanya, proses menggilap ini dilakukan oleh tenaga manusia yang mempunyai kemahiran. Proses menggilap ini pula memerlukan daya yang secukupnya sehingga dapat menghilangkan kesan yang terdapat pada sesuatu permukaan yang digilap itu. Pada hari ini, kebanyakan proses menggilap sudah mula di programkan kepada robot. Dengan menggunakan robot, daya yang terhasil semasa proses menggilap dapat diukur. Di dalam projek ini, robot yang digunakan adalah robot COMAU yang berada di dalam makmal robotik. Daya yang terhasil semasa proses menggilap pula dapat diukur dengan menggunakan alat yang boleh mengukur daya seperti Force/Torque sensor, force Plate sensor dan sebagainya. Di dalam projek ini, daya yang terhasil semasa proses menggilap pada tiga permukaan yang berbeza kecalarannya disiasat dan diukur dengan menggunakan Force Plate sensor. Ketiga – tiga permukaan tersebut dikelaskan sebagai permukaan calar yang sedikit, permukaan calar yang sederhana dan permukaan calar yang banyak. Hasil daripada keputusan yang diperolehi, daya yang dikenakan ke atas ketiga-tiga jenis permukaan tersebut adalah berbeza. Di akhir projek ini, satu analysis dibuat bagi mengenalpasti berapakah daya yang diperlukan dan bersesuaian untuk proses menggilap pada jenis-jenis permukaan yang hendak digilap.

DEDICATION

To my parents, without their patience, understanding, support, and most of love, the completion of this work would not have been possible. To my lecturer, for being receptive and critical, and challenging me to be a better student. To my friends, it is for your sacrifices, encouragement, and support.

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TABLE OF CONTENT

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES

LIST OF ABBREVIATIONS

PET	-	Poly Ethylene Terephthalate
3D	-	Three dimension view
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
NC	-	Numerical control
DC	-	Direct current
N	-	Newton
Kg	-	Kilogram
RPM	-	Rotation per minute
PC	-	Personal computer

CHAPTER 1
INTRODUCTION

This chapter will briefly discuss about the introduction to polishing process by industrial robot and the differences of surface patch. These chapters also include the problem statement, objective, and scope of the project. Besides that, this chapter will emphasize on the purpose of polishing process and it's important to manufacturing industry.

1.1 Introduction to Polishing

Polishing is the process of creating a smooth and shiny surface by using rubbing or a chemical action, leaving a surface with significant specular reflection and minimal diffuse reflection. In this project, polishing process is done by using rubbing where the end factor of the robot will be the tool. The movement of robot is referring to difference surface patch on the material.

A polished surface diverts from a matt one because the light incident rays reflect on it in an ordered way. A rough surface shows significant phenomenon of diffusion and the reflected image, so decomposed, is no longer recognizable. Each incident ray reflects, according to the reflection law, but, as far as the reflecting surface does not have a fixed position, the reflected rays spread in randomly distributed directions. Every light ray hitting the surface is reflected in a specific direction depending on both rays incidence direction and on orientation of the tiny portion of flat surface on which the ray reflects.

1.1.1 Polishing process in manufacturing industry

Polishing and buffing are finishing processes for smoothing a workpiece's surface using an abrasive and a work wheel. Technically polishing refers to processes that use an abrasive that is glue to work wheel, while buffing uses a loose abrasive applied to the work wheel. Polishing is a more aggressive process while buffing is less harsh, which leads to a smoother, brighter finish. A common misconception is that a polished surface has a mirror bright finish, however most mirror bright finishes are actually buffed.

Polishing is often used to enhance the looks of an item, prevent contamination of medical instruments, remove oxidation, create a reflective surface, or prevent corrosion in pipes. In metallographic and metallurgy, polishing is used to create a flat, defect-free surface for examination of a metal's microstructure under a microscope. Silicon-based polishing pads or a diamond solution can be used in the polishing process.

The removal of oxidization (tarnish) from metal objects is accomplished using a metal polish or tarnish remover. This is also called polishing. To prevent further unwanted oxidization, polished metal surfaces may be coated with a wax, oil or lacquer. This is of particular concern for copper alloy products such as brass and bronze.

Polishing is usually multistage process because the first stage is starts with a rough abrasive and each subsequent stage uses a finer abrasive until the desired finish is achieved. The rough pass removes surface defects like pits, nicks, lines and scratches. The finer abrasives leave very thin lines that are not visible to the naked eye. Lubricants like wax and kerosene are used as lubricating and cooling media during these operations. Buffing may be done by hand with a stationary polisher or die grinder, or it may be automated using specialized equipment. When buffing, there are two types of buffing motions. Firstly, the cut motion and the secondly is color motion.

The cut motion is designed to give a uniform, smooth, semi-bright surface finish. This is achieved by moving the workpiece against the rotation of the buffing wheel, while using medium to hard pressure. The color motion gives a clean, bright, shiny surface finish. This is achieved by moving the workpiece with the rotation of the buffing wheel, while using medium to light pressure.

When polishing brass, there are often minute marks in the metal caused by impurities. To overcome this, the surface is polished with a very fine grit, copper plated, then buffed to a mirror finish with an airflow mop. Polishing operations for items such as chisels, hammers, screwdrivers, and wrenches are given a fine finish but not plated. In order to achieve this finish four operations are required roughing, dry fining, greasing, and coloring. Note that roughing is usually done on a solid grinding wheel and for an extra fine polish the greasing operation may be broken up into two operations that is rough greasing and fine greasing. However, for inexpensive items money is saved by only performing the first two operations.

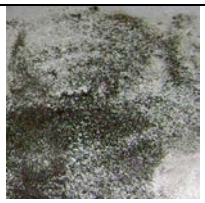
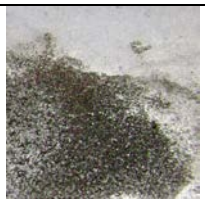
Polishing knives and cutlery is known as fine glazing or blue glazing. Sand buffing, when used on German silver, white metal, and others is technically a buffing operation because it uses a loose abrasive, but removes a significant amount of material, like polishing. Polishing may be used to enhance the looks of certain parts on cars, motorbikes, handrails, cookware, kitchenware, and architectural metal applications. Pharmaceutical, dairy, and water pipes are buffed to maintain hygienic conditions and prevent corrosion. Buffing is used to manufacture of high-quality lighting reflectors.

Surely, polishing process is the most important thing in manufacturing. There a re lot of work that must be finish with polishing process to protect their surface, smoother, enhance the looks of an item, prevent contamination of medical instruments, remove oxidation, create a reflective surface, and prevent corrosion in pipes. In metallographic and metallurgy scope, polishing is used to create a flat, defect-free surface for examination of a metal's microstructure under a microscope. This is show that, polishing process in manufacturing is very important and very beneficial to people.

1.2 Type of surface patch

The scratch surface can be deemed and classified in three figures state. A little scratch surface could be perceived as soft surface patch type and many scratch surfaces also could be perceived as medium surface patch type. Otherwise, for too much scratch and bad scratch surface, it is could be perceived as hard surface patch type.

Table 1.1: Type of surface patch

Soft Surface Patch Type Scratch surface that does not very bad and have just a little scratch could be perceived as soft surface patch.	 **Figure 1.1:** Soft surface patch on material
Medium Surface Patch Type Many scratch surfaces compared with soft surface patch could be perceived as medium surface patch.	 **Figure 1.2:** Medium surface patch on material
Hard Surface Patch Type Many scratch surface and bad scratch could be perceived as hard surface patch because that surface is very hard to polish.	 **Figure 1.3:** Hard surface patch on material

1.3 Problem Statement

The scratches surface usually unequal from their aspect and also their bad of scratch. As such, a little scratch could be perceived as soft surface patch and many scratches also could be perceived as medium surface patch. For too much and bad scratch, it is could be perceived as hard surface patch. Of course, polishing process on these three types of surface require a difference force pressure. The force imposed upper that surface patch can be gauged by using force plate sensor. However, many industrial robot use force torque sensor to measure and identify force for each pressure imposed upper surface material whether in polishing, drilling, grinding and any work type that involved a force. Each difference surface patch found in surface material is unknowable how many forces should be imposed. As such, this project will investigate how many force of necessity to do polishing process of three different surface patches.

1.4 Objective

The objectives of this project are:

a) To investigate the force imposed on difference surface patch.
b) To familiar with COMAU robot and force plate sensor application.
c) To test and collect the data for the force imposed during polishing process

1.5 Scope

The scopes of this project are:

a) Teaching the COMAU robot to do the polishing process for soft, medium and hard surface patch on mild steel.
b) Using the force plate sensor to investigate the force imposed during polishing process on three difference surface patches.

CHAPTER 2
LITERATURE REVIEW

This chapter includes some of the polishing process by robot that will be used in manufacturing industry nowadays. This chapter also loaded with the force of polishing process and theory of sensor use. Previous researches that have been done by other researchers will be reviewed, cited and credited. The information is found in reference journal, book and electronics media such as in the internet.

2.1 Polishing process by robot

Nowadays, most of the robot will be used to replace the human job to increase the productivity, quality, safety and reduce the cost from salary of workers. Apart from that, robot will use to do the polishing process on material such as mold and die, bumper car, furniture and others. Otherwise, several robotized systems have been developed in order to automate the polishing tasks. However, the practical use of these techniques has not progressed readily to mould and die operation because the shapes of most dies and molds are too complex to robotize. The small number of lots in the manufacturing process has also prevented the use of robots. One of the practical solutions to these problems is a human-machine cooperative system. If human flexibility is combined with robot systems, several complex tasks which currently can be performed only by human hands might be robotized. Operating robot systems based on this concept have been developed in various technologically advanced fields, such as medical, space and micro handling.

However, these techniques are not easily applied in industrial fields due to cost considerations. Although the advanced robot systems have been developed without consideration of cost, most of the die and mold industry consists of small businesses, and so the introduction of such expensive machines is difficult.

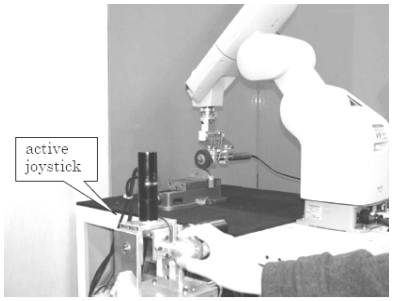


Figure 2.1: An image of a polishing task using the operating robot system.

The polishing robot was developed based on an open architectural industrial robot, where the kinematics and servo control are opened. In the manufacturing industry, such as of PET bottle molds and industry of wooden furniture, 3D CAD/ CAM system and NC machine tool are being used generally and widely, and these advanced systems have drastically rationalized the design and manufacturing process of the mold. However, the polishing process after NC machining has hardly automated yet. Although several polishing robots that applied a force control techniques have been proposed, but not introduced in manufacturing industry due to the poor polishing quality and complicated teaching.

Generally, since the repetitive position accuracy at the tip of industrial robots is 0.1mm or its neighborhood, it is so difficult to polish the surface of the metallic mold using only position control strategy. In the polishing process of the metallic surface, the accuracy of 50nm or less is finally required for mirror finishing. Especially, when a robot contacts to an object, several factors that decrease the total stiffness of the system are included. They are called a clearance, strain and deflection, all of which exist in not only the robot itself but also force sensor, abrasive tool, and so on.

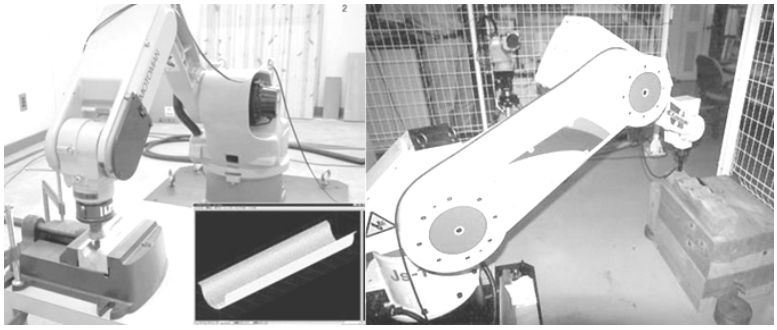


Figure 2.2: Polishing process on mould and furniture by robot

2.2 Force of polishing process

Polishing processes is the final stage of manufacturing, and almost all such tasks depend on the dexterity of skilled workers. The resulting low efficiency of the polishing tasks decreases the productivity of the overall manufacturing process. Thus, in order to increase the overall productivity, improvement of the polishing process using robot technology is necessary.

Several robotized systems have been developed in order to automate the polishing tasks and it was developed based on an open architectural industrial robot, where the kinematics and servo control are opened. Although several polishing robots, in which force control techniques are already applied and have been proposed. But, they are not introduced in manufacturing industry because due to the poor polishing quality and complicated teaching.

The polishing force is assumed to be considered as a composite force of the contact and kinetic friction forces, in which the friction consists of coulomb and viscous frictions. Velocities in the normal and tangent directions are delicately controlled so that the polishing force can track the desired value. However, this project is only doing the polishing process on the flat surface, so that the force will easily used to measure rather than a curve surface with include the tangent direction.

There are several commercially accepted methods of force control used to measure the polishing force by robot today. The first method is through-the-arm force control that applies force using the position of all the robot axes in unison. The second method is around-the-arm force control. It used the robot for positioning motion only, and applies a controlled force through an auxiliary compliant end-of-arm tool. Otherwise, the tool for measured this force is like force torque sensor, that place at the end effectors of robot. But, in this project, the force will be measured by using force plate sensor that place bottom of the material to polish. This force plate sensor also can measure the force imposed on surface material that place on it during polishing process.

In many robotic tasks in the manufacturing industry, the sensor and transducers of a robot needs to come into physical contact with the work piece. Examples include part assembly, polishing, drilling, deburring, and cutting. An automated and untended work-place with flexibility and efficiency is widely envisioned as an important factory of the future. The requirements of machined components with more stringent surface finish and higher machining accuracy have led to the demand for more precise and better control of automated machining processes.

Force is one of the important elements in human life. According to the Webster dictionary, force is “any physical cause capable of modifying the condition of movement or rest of a body, or of deforming it.” It also define as “a torque exerted on a gimbal, gyro rotor or accelerometer proof mass, usually as a result of applied electrical excitations exclusive of torque command signal.” Usually, force torque sensor can be used to measure the force imposed during the job. This sensor system can measures all six components of force and torque. It consists of a transducer, shielded high-flex cable, and intelligent data acquisition system. Force torque sensors are used throughout industry for product testing, robotic assembly, grinding and polishing. The force and torque sensor measured by a wrist sensor can be converted quite directly at the hand level. Wrist sensor is sensitive, small, compact and not too heavy, which recommends them for force controlled robotic applications.