UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DEVELOPMENT OF ROBOT MOVEMENT FOR POLISHING PROCESS USING WORKSPACE

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 Honors.

by

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ABSTRACT

This project presents the development of polishing robot movement that based on robotic simulation using appropriate and effective simulation software. The development starts with creating the path for polishing robot based on simple polishing movement. The path for the robot that already plans is then will be transferred into simulation software to simulate the movement of the robot. Simulation software that will be used in this development is Workspace 5 that is very flexible to use for creating the movement of robot. Based on this particular movement, the path programming of robot is developed for the usage of real polishing robot.

Keywords: *Polishing Process, Polishing Robot, Robotic Simulation, Robot Movement, Path Programming.*

ABSTRAK

Projek ini menyampaikan berkenaan pembinaan pergerakan robot pengilap yang berdasarkan kepada simulasi robotik menggunakan perisian simulasi yang sesuai dan berkesan. Pembinaan ini bermula dengan mencipta perjalanan robot pengilap berdasarkan pergerakan gilapan yang mudah. Perjalanan robot yang sudah dirancang ini kemudian dipindahkan ke perisian simulasi untuk melakukan pergerakan robot secara simulasi. Perisian simulasi yang akan digunakan didalam pembinaan ini adalah dengan menggunakan Workspace 5 yang fleksibel untuk mencipta pergerakan robot. Berdasarkan pergerakan robot ini, pembangunan pengaturcaraan perjalanan robot dilakukan untuk digunakan pada robot sebenar.

Kata Kunci: *Proses Pengilap, Robot Pengilap, Simulasi Robotik, Pergerakan Robot, Pengaturcaraan Perjalanan.*

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LIST OF ABBREVIATIONS

3D	-	3 Dimensional
ACIS	-	AutoCAD Color Index Standard
AGV	-	Automated Guided Vehicle
APG	-	Automatic Path Generation
CAD	-	Computer Aided Design
CAM	-	Computer Aided Manufacturing
CL	-	Cutter Location
CMM	-	Coordinate Measuring Machine
CTRM	-	Composites Technology Research Malaysia
GP	-	Geometry Point
ID	-	Information Data
I/O	-	Input and Output
IGES	-	Initial Graphics Exchange Specification
MSDs	-	Musculoskeletal Disorders
PC	-	Personal Computer
PET	-	Poly Ethylene Terephthalate
PLC	-	Power Line Communications
PUMA	-	Programmable Universal Machine for Assembly
RSS	-	Realistic Robot Simulation
SCARA	-	Selective Compliant Articulated Robot Arm
SRI	-	Stanford Research Institute
TCP	-	Tool Center Point
U.S	-	United States of America
VBA	-	Visual Basic for Applications
WCS	-	World Coordinate System

CHAPTER 1
INTRODUCTION

1.1 Background

Some processes are very complicated and needed effective result with minimum time to produce result which can reduce time and cost. Polishing process is one of those processes that needed efficient result and it must be improved for the future of time being. From the information in Wikipedia (The Free Encyclopedia), 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. Also referred to as "polishing" is the application of a liquid that dries to a shiny finish, as in nail polish.

Today's overall polishing needs and requirements are rapidly changing in the metal-finishing industry worldwide, and also, the ratio of the finishing process time to the whole process time is increased with the increasing demand for surface quality. Therefore, manual and old conventional machine polishing methods are gradually becoming obsolete, and the need for better parts quality and flexible, more efficient and cost effective manufacturing and finishing methods, integrated with computer science, have encouraged new mechanized polishing approaches and the automation of the polishing process. This automation is commonly used robot to do the polishing process.

Robots are extremely important nowadays as instruments in factories that it is unusual to find a business without robot. Robot can perform complicated, repetitive and dangerous tasks, and currently most production companies use robot as a very important tool. Automation of the polishing process requires four basic development

steps: (1) tool paths generation is obtained from a CAD system; (2) a controller with force feed back is needed to maintain constant tracking on real surface;(3) the polishing process is modeled by means of a computer application in order to predict the roughness values reached during the finishing of the surface; (4) this application also provides algorithms for controlling the process in order to reach the target finishing grade.

Although the final aim is real robotics, it is often very useful to perform simulations prior to investigations with real robots. This is because simulations are easier to setup, less expensive, faster and more convenient to use. Building up new robot models and setting up experiments only takes a few hours. A simulated robotics setup is less expensive than real robots and real world setups, thus allowing a better design exploration. Simulation often runs faster than real robots while all the parameters are easily displayed on screen. Simulations make it possible to use computer expensive algorithms that would need ages to run on real robot microcontrollers, like genetic algorithms and the simulation results are transferable onto the real robots. Simulation is a good tool for engineers to build virtual spaces, check information about robots, creating robot path, and discuss about the best position and working area that the robot can perform. In this way, it is possible to try different ways to get the most efficacious and efficient solution and also to save cost and time.

This project discusses the developing of polishing process that can be automated using polishing robot and to know how the movement of polishing robot can be developed using simulation software. In this case, the project involves software as a tool to simulated the movement of the robot, to create an idea for path planning, adjusting the work cell of the movement of the robot and furthermore to program movement of the robot for the application of real movement for the robot. Thus, this project will involve the study of polishing robot’s movement, same as movement of human when doing the polishing process but it is more efficient and continuously better in quality.

1.2 Problem Statements

Polishing process, is a task where in the industry is the final stage of manufacturing, have not yet been automated, and almost all such tasks depend on 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.

Polishing robot is the solution to give efficiency result on polishing tasks to increase the productivity and to improve the polishing process. While using simulation software, a tool that is low cost and efficient is a first step to develop a polishing robot in industry.

1.3 Objectives of the Project

The objectives of the project are as follows:

1) To identify the tool path for polishing process.
2) To simulate the movement by using Workspace simulation software.
3) To develop the programming for particular movement to support further research activity.

1.4 Scope of the Project

The scopes of this project are as follows:

1) Determination of path using Workspace simulation software.
2) Transfer the path information to determine the program.
3) Construct programming based on the robot movement using programming language.

CHAPTER 2
LITERATURE REVIEW

This chapter discusses about the polishing process, polishing robot, and robotic simulation which is rapidly implemented in manufacturing industry especially in die and mold manufacturing. Besides, this chapter also discusses about the recent development of polishing robot and simulation software in recent years and also types of robot path.

2.1 Polishing Process Using Robot

In recent years, there are so many researchers try to overcome the solution of automating the polishing processes by using robot system. Nagata and Watanabe (2000) proposed a joystick-control teaching system that allows a polishing robot with an impedance control made to perform polishing tasks on an object of an unknown shape. Fusaomi *et al.* (2002) proposed a high precision polishing robot with a learning-based hybrid position/force controller for polishing PET (Poly Ethylene Terephthalate) bottle molds. Min-Cheol *et al.* (2004) developed a user-friendly automatic polishing robot system that consists of two subsystems, a three-axis machining center that control by FANUC controller, and the polishing head by DSP controller. Shin-ichi *et al.* (2004) developed an operating robot system for die and mold polishing that consist of an industrial robot and a joystick. Lin and Lu (2005) introduced the robot system to polish complex surfaces based on CL data. Kuhlenkoetter (2006) developed an intelligent robot system that obtain sensory skill due to the linkage of innovative robot technology and image processing system via new software for grinding and polishing processes to achieve high quality manufacturing processes.

Figure 2.1: Polishing Scene of a PET Bottle Mold

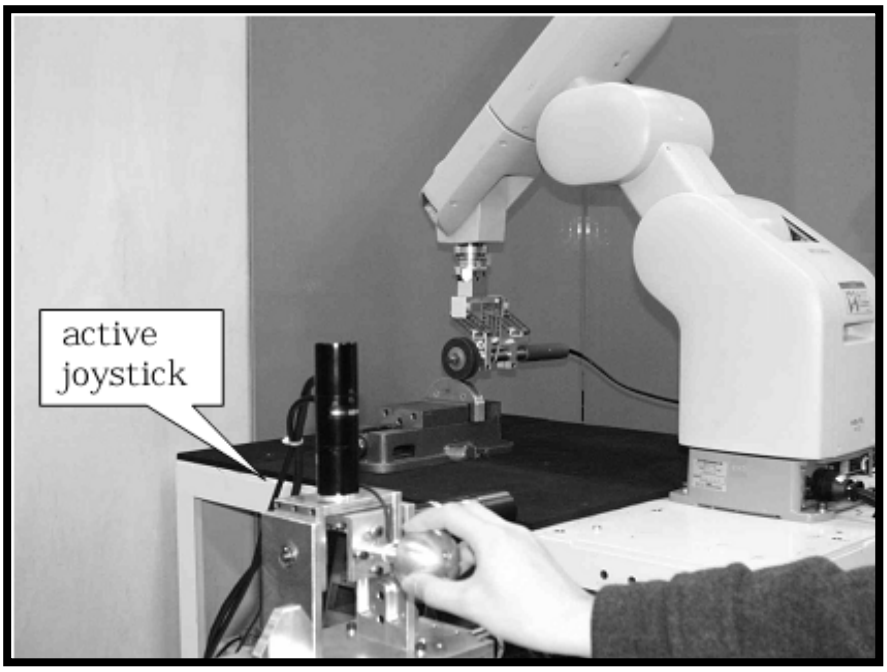

Figure 2.2: Developed Operation Robot System Using Joystick

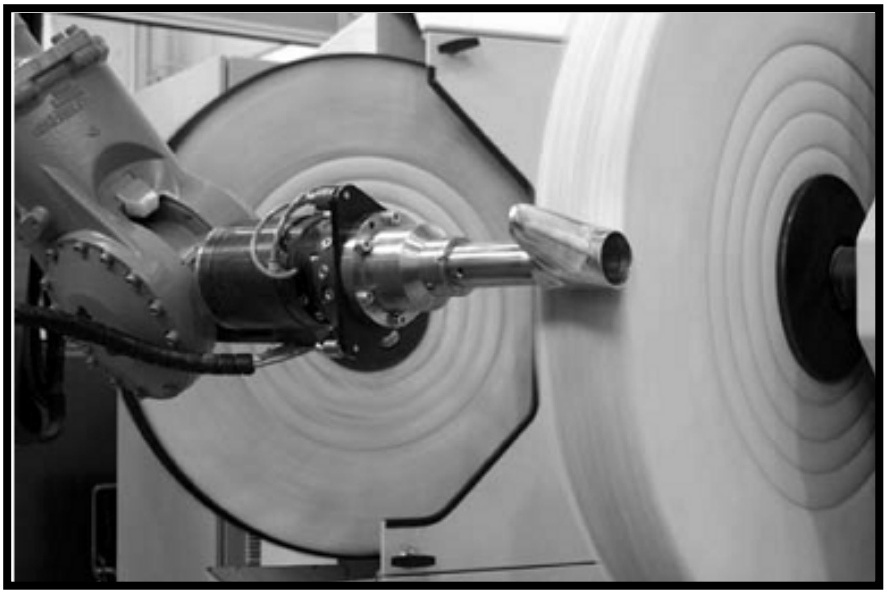

Figure 2.3: Robot Aided Polishing in the Sanitary Fitting Industry

2.1.1 History of Robot

The beginning of robotic was the result of three (3) technologies born after or during the World War II. First, servo-mechanism theory then digital computation came into its own after World War II, and finally, solid state electronics made it all economically feasible.

Since the early twentieth century, design and research in robotics have accelerated with the developments of electronics, computer, and industrial automation in America, Japan, and Europe. In 1930s, American Pollard and Roseland developed an automatic spray-painting machine, which was re-programmable and resembled a modern industrial robot. In the middle 1950s, American George Devol, “the father of robot”, developed the first programmable robot with a magnetic process controller.

The remarkable time in the development of robot system was 1954. In this year, Devol patented his robot manipulator, which was the first robot with playback memory to perform the point to point motion. In the late 1950s, the first commercial robot was marked by Planet Corporation. In 1960, Harry Johnson and Veljko Milenkovic designed a robot called the Verstran, with an automatic and

programmable controller, at American Machine and Foundry. In 1962, General Motors installed the first industrial robot on a production line. (Man, 2004)

In the year 1961, Unimation Inc. created the first industrial robot that is 75% electronic and 25% hydromechanical and that prototype worked well. Japanese executives watched a good future in that. The Japan Industrial Robot Association (JIRA) started out with an opening membership of 46 companies and with representatives having personal clout in the industrial community. From mid-1970s a lot of different robot applications were under constant testing and evaluation including cleaning of castings, gluing and polishing. As a result, many of the experimental tasks in those laboratories, in the early to mid 80's the robot industry grew very fast due to large investment by the automotive industry. (Veiga, 2006)

Figure 2.4: The First Industrial Robot by Unimation Inc.

In 1970s, Stanford University developed a computer-controlled robot arm with electric drive motors, known as the Stanford Arm. In 1973, the first industrial robot equipped with a minicomputer-based control system was developed in Cincinnati Milacron Corporation. In 1977, a European company, ASEA, also developed electrical powered industrial robots equipped with microcomputer-based control systems. In the same year, a robot vision system was developed by Stanford Research Institute (SRI) at Stanford University. In 1978, the PUMA (Programmable Universal Machine for Assembly) robot was developed based on the Stanford arm in America. This robot uses servomotors equipped with an advanced control system using a few microprocessors and advanced software. In 1979, Sankyo and IBM developed the famous SCARA (selective compliant articulated robot arm) at Yamanashi University in Japan.

In 1983, small mobile robot systems were developed in U.S, designed for home and educational purpose. In 1984, SRI developed a mobile robot called Flakey. It has 2 drive wheels with encoders, and 12 sonar range finders obstacle avoidance and navigation in real spaces. It also uses a video camera and a laser detector to determine distance and range information over a small area in front of the robot. (Man, 2004)

2.1.2 Benefits of Robots

Robots have lot of benefits. If introduced correctly, industrial robots can eliminate labours dirties, borings and dangerous work. Maybe, it is true that robots can cause unemployment but also can create jobs such as, robot technicians, salesmen, engineers, programmers and supervisors. The benefits of robots in industry include improving management control and productivity and high quality products. Industrial robots can work night and day on chain of production without a loss in performance. So, they can reduce the costs of goods. As a result of these industrial benefits, countries that effectively use robots in their industries will have an economic advantage on world market. (Veiga, 2006)

2.1.3 Polishing Process

In industry, polishing is a very common process that is very important for the quality of the products. It will be the indication of how quality the product is and how good the technology of the manufacturer has. There are so many different types of polishing processes and it depends on the material and how it will be done. 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. By the mean of that definition, polishing must be good in quality.

Shin-ichi *et al.* (2004) stated that polishing processes is the final stage of manufacturing, have not yet been automated, 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. This statement is more concrete when Lin and Lu (2005) emphasized that most polishing processes are depending on their skill and experience. However, manual polishing is expensive, time consuming, labour intensive and error prone.

Min-Cheol *et al.* (2004) discussed about some polishing work must be performed to remove the tool marks and to improve the smoothness and flatness of die surfaces. However, the polishing process still depends on the experience of an expert. Also, even though an expert polishes, it takes a lot of time to obtain the required degree of smoothness. This represents a major problem because the polishing process consumes 30 - 40 % of the total die manufacturing time.

2.1.3.1 Human Factors of Polishing Process

Polishing process is the final process of any of the product that manufactured in certain industries. This is the main part before the product is being packed and then being distributed to the customer. In general, the polishing process used the human working ability and skill to complete the task. But when working procedure is related to human working ability, there are some considerations that must be taking place such as human factor or ergonomics. Ergonomic is a scientific study of fitting a work