UNIVERSITI TEKNIKAL MALAYSIA MELAKA

INVESTIGATING THE BEHAVIOR OF FORCES USING COMAU ROBOT'S FORCE SENSING DEVICE

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

NUR ANIS BINTI A. RAHMAN

FACULTY OF MANUFACTURING ENGINEERING

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA

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DECLARATION

I hereby, declared this report entitled “investigating The Performance of Force Sensing Device for Comau Robot” is the results of my own research except as cited in references.

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Author’s Name	:	Nur Anis Binti A. Rahman
Date	:	22 Mei 2009

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 Honours. The members of the supervisory committee are as follow:

(Signature of Supervisor)

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Pensyarah
Fakulti Kejuruteraan Pembuatan
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ABSTRACT

Force and torque sensor is one of the important equipment for several automatic and industrial robotic applications. Its can control the interaction of the force to get the successful finishing product and good in performance. Force and torque sensor used to measure the force and torque and as control mechanism. The force and torque sensor use in application of finishing process such as grinding, drilling and deburring. In this project the use of the force torque sensor is investigate to know its application from the past researcher. The process of profiling using deburring tool set are one of the method are choosing to investigate the performance of force sensing device for COMAU robot. The related equipment was identified to make sure the objectives of the project are achieved. The relevant data that related to the experimental set up was analyses to know the suitable specimen to measure of force and torque sensor for this project. The relationship is made for different selected material. The material that selected is aluminium, acrylic and Teflon. In theoretically the expected result was analyses for the selected material base on its mechanical properties.

ABSTRAK

Penderia daya dan daya kilas adalah satu peralatan penting untuk beberapa aplikasi automatik dan dalam industri robotik. Ia juga mengawal interaksi bagi daya kilas untuk menghasilkan produk akhir yang bagus dan perlaksanaan yang sempurna. Daya dan daya kilas penderia digunakan untuk mengukur daya dan daya kilas dan juga sebagai mekanisme kawalan. Ia selalunye digunakan dalam proses akhir pembuatan seperti mencanai, menggerudi dan membuang serpihan pada permukaan.
Dalam projek ini, penggunaan penderia daya dan daya kilas dikaji untuk mengetahui aplikasinya daripada pengkaji terdahulu. Proses "profiling" (pembentukan) menggunakan peralatan deburring merupakan kaedah yang dipilih didalam projek ini untuk menjalankan ujikaji berkaitan perlaksanaan pengunaan penderia daya pada robot COMAU. Perkakasan dan peralatan yang berkaitan juga dikenal pasti untuk memastikan objektif untuk project ini tercapai. Data yang berkaitan dengan eksperimen di analisis untuk mengetahui specimen yang sesuai digunakan untuk mengkaji penderia daya dan daya kilas. Data yang berkaitan dianalisis untuk mengetahui keputusan yang akan diperolehi. Bahan yang dipilih untuk ujikaji ialah aluminium, acrylic dan teflon. Jangkaan keputusan dianalisis secara teori berdasarkan ciri – ciri mekanikal bahan tersebut.

DEDICATION

For my parent, A.Rahman bin Abu and Imah Binti Idrus, for my siblings and lovely friends.

ACKNOWLEDGEMENT

First of all, I want to thank The Almighty God because of His permission that gives me strength to finish this report even many difficulties that had come. For my beloved parents A.Rahman bin Abu and Imah Binti Idrus, for my siblings and lovely friend's thanks for all support that have been given in finishing this PSM.

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Especially, I would like to give my special thanks to my lovely mom, family and friends whose patient loves enabled me to complete this work.

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CHAPTER 1

INTRODUCTION

1.1 Background

Nowadays it necessary if the robot replace the humans for maintenance work and in industrials tasks such as drilling, milling or assembly parts. Its can control the interaction of the force to get the successful finishing product and good in performance. A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. The force and torques encountered by the robot can be measure the force by joint the force sensing, wrist force sensing, and finger force sensing (Ian Sinclair). During the mechanical assembly operations, at the robot hand level can be measured by sensors mounted on the joints or on the manipulator wrist. The force and torque measured by a wrist sensor can be converted quite directly at the hand level. The major advantage of sensing arm joint forces in manipulator is that the resulting of the forces measurement does not always provide an accurate indication of the exchange of forces between the robot and end effectors and its surrounding. To get the accurate force measurement, one must create such as joint friction and the load of the arm. Where the major disadvantages of sensing arm joint forces in a manipulator are the measurements do not provide the accurate indication of forces between the robot end -effectors and its surrounding objects. To get the accurate force information, one must evaluate things like the inertial forces created through arm movement, joint friction, and the load of the arm itself.

1.2 Problem Statement

Most of the robot require on the efficient execution of tasks when they involved the interaction between robots and their environments including constraints on the environment. Those contact forces depend on the stiffness of the tool and working objects, and surface of the material. It should be properly control.

The different of the mechanical properties effected the measurement of the force and torque sensor. The torque sensor is attached at the end of the six degree of freedom of the robot arm. The six degree of freedom is the best application because of the maximum of the angle movement.

Profile process consists of the more or less complex outline of a shape to be cut in a sheet of material. The operation is supported by the force torque sensors, which are integrated into the end effectors. These sensors allow the measurement of the force between workpiece and environment. The sensing system combines the information from force and vision sensors during profiling to provide improved depth measurement.

1.3 Objective

Objective of the project are:

a. To investigate the force behavior of different material.
b. To investigate the force behavior of different path geometry.

1.4 Scope

The scope of the project can be classified as follows:

a. To select the proper material for investigate the force behavior using different material selections.
b. To planning the experiment path geometry for different material.
c. Do analysis by using the result of the experiment especially for different material.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

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, 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.”

A sensor is a device that detects or measures a physical quantity. Sensing means, for sensing both magnitude and direction of forces along three mutually orthogonal axes intersecting at the wrist and for sensing magnitude and direction of torques, are provided at the wrist intermediate to the manipulator hand and hand supporting means. The sensing means includes a plurality of sensing units radically spaced from the longitudinal axis of the manipulator at equal distances. The major use of sensor in industrial robotics and other automated manufacturing systems can be divided intro three basic categories. The categories are safety monitoring, interlocks in work cell control and part inspection for quality control.

Force torque Sensor system 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.

Force or torque sensor is usually placed near the working tool, generally in the manipulator wrist in industry robotic application. This means that the sensor must be reasonable small, built in several sizes to adapt the different bolt patterns and load capacities, mechanically resistant (Pires et al, 1999).

2.2 Previous Achievement of the Process

Even in today's most fully automated factories it is automated factories it is still a common sight to see dozens of workers manually deburring parts produced by CNC machines. In manual deburring machining burrs are offer removed from parts edges by chamfering. The deburring specifications can require the chamfer depth to be within tight tolerances. Consequently, much of robotic deburring research has been research has been concerned with controlling the depth of cut when chamfering with non compliant cutting tools. Due the poor accuracy of most industrial robots, part positioning errors, and deflections of the robot arm due to cutting forces, position control cannot be used alone to control the depth. The deburring force has been shown to be approximately proportional to the material removal rate (the federate times the chamfer plus burr areas). It can therefore be controlled by adjusting the feedrate tangential to the edge. This strategy is most suitable to applications where the burr area is variable and is a large percentage of the chamfer area.

The sensing and control elements of a system for automated robotic edge deburring were described. The system's objective of accurate sensing and control of the deburring chamfer depth was achived through sensor fusion of force and vision information during the deburring pass, and new form of adaptive GFC combined with learning control, termed GPCL (Mohamed A. Elbestawi, 1994).

In this section, a set of software tools designed to program, control and monitor the industrial robot (ABB IRB 6400). The main objective is to design tools to add force control capabilities to the original setup (robot and controller). A PC based wrist mounted force/torque sensor (from *JR3* Inc.) was installed on the robot. The basic setup is shown on Figure 2.1. The software is divided into four main parts which are robot communication software, force/torque sensor access and configuration software, connectivity to windows applications and force control application software.

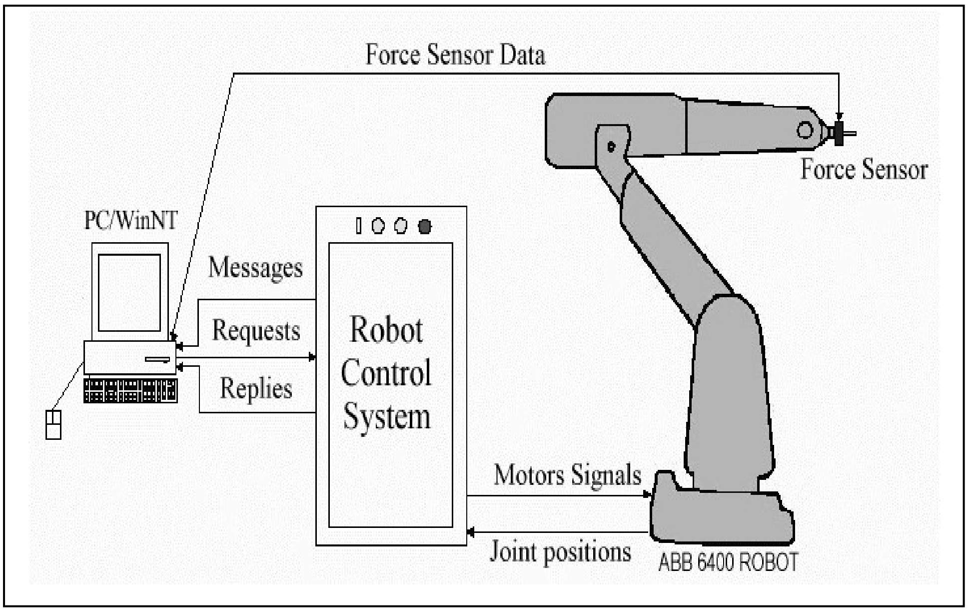

Figure 2.1: Sensorization System (Ricardo Araújo et al, 2002)

In the development of a human-friendly robot, the safety of the interacting human is of critical importance. The use of robots in a human-oriented environment will inevitably result in some sort of interaction between the robots and both humans and the environment. Such interaction will typically be a collision resulting in an induced force at the contact surfaces. In order to control the contact force below a safe level so that the human is not injured, a collision detection module is necessary to check whether collisions occur and to identify the possible contact force and position if possible. Some researchers use a wrist force/torque sensor to measure the force/torque between the tip of a manipulator and the environment to realize collision detection. However, this method is unable to detect the contact that occurs at parts of the arm other than the end-effectors. When the end-effectors of a manipulator follows a desired trajectory under the constraints of the environment, external tip forces from the environment can be measured by the wrist force/torque sensor. If the robot arm collides with a human or the environment, additional contact forces are exerted at the contact point (Steven A. Velinsky, 2005).

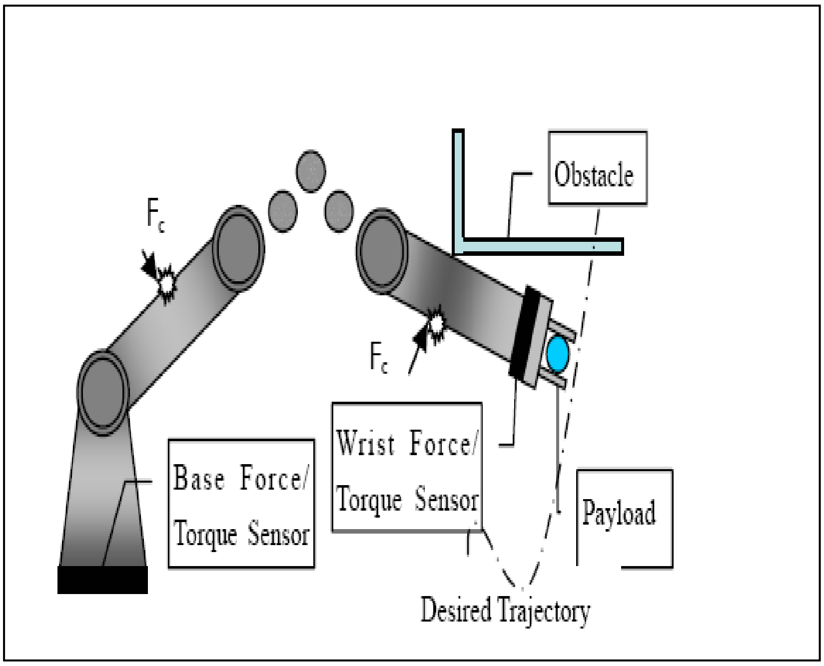

Figure 2.2: Manipulator with two Force/Torque Sensors (Steven A. Velinsky, 2005)

Figure 2.3 shows the force/torque sensor setup. The computer will control the robot position. Sometimes the robot motion will not follow the direction and instruction that had programmed before. In order to overcome this situation, the computer will be act to make robot motion corrections. It also controlled the forces and torques whiles the deburring process in progress.

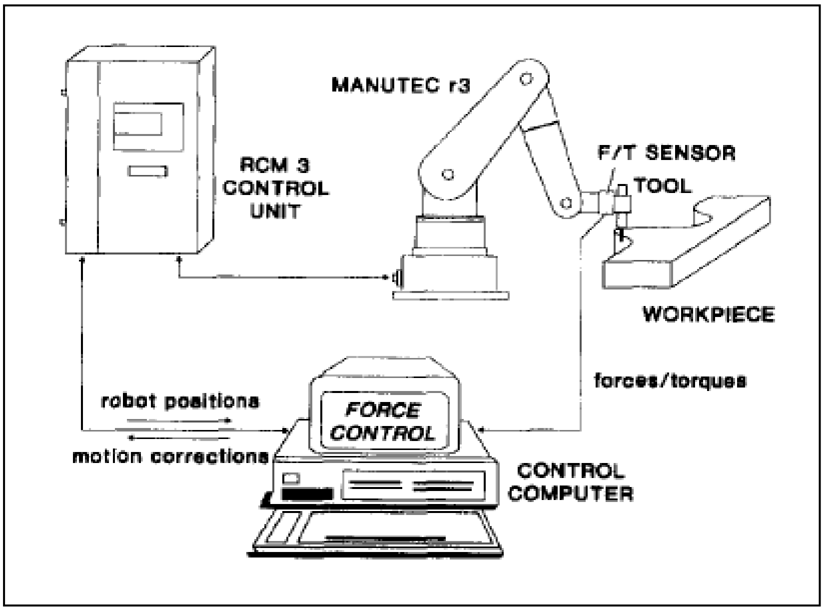

Figure 2.3: Force /Torque sensor setup (Liu. M. H, 1995)

2.3 Path Planning or Geometry

Force control for robotic drilling**.** Force control is essential for robotic drilling because position control of a manipulator to the desired accuracy is difficult because of its lack of rigidity and the forces involved in drilling, the system must be robust against manipulator and workpiece positioning errors, the experiments conducted to evaluate the influence of compliance on the robotic drilling performance, reveal that a major concern impact wear and scraping when the contact force is not sufficient to penetrate the workpiece, and the actual drilling operation involves maintaining a desired thrust force along the drill axis. A drilling operation requires the drill axis to be perpendicular to the workpiece surface while cutting. This implies that the force in the direction perpendicular to the drill axis must be zero. However, when the manipulator comes in contact with the workpiece, the force X, Figure 3, can be non-zero due to the manipulator and workpiece positioning errors. Most importantly, the inconsistency between the desired path coordinate system and the control coordinate system can deviate the end point path of the manipulator away from a straight line. So, the force in X direction must also be controlled (Ron W. Daniel).

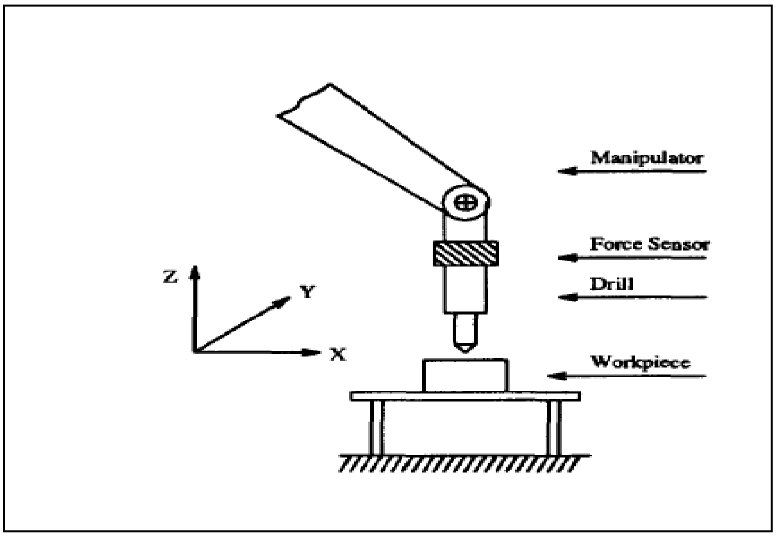

Figure 2.4: Set up for robotic drilling (Ron W.Daniel)

An n-joint manipulator mounted on a six-axis base force/torque sensor as shown in Figure 2.5.The manipulator is mounted on a base force/torque sensor. Sensor measurements and joint velocities recorded during manipulator motion are used to identify the inertial parameters.

The sensor measurements are used to identify the inertial parameters. The manipulator has n+1 links, where link 0 and link n is the base and the terminal link, respectively. The wrench measured by the base force sensor is denoted as Ws. (Liu.G. et all, 1998).

These parameters can be estimated using the manipulator’s joint torques and forces along with the joint positions and velocities. Most robot manipulators are not equipped with joint force/torque sensors. A typical estimate is from the motor current. A major difficulty with this method is that the joint force/torque estimation accuracy is limited by unmodeled joint friction and actuator dynamics. A base-mounted force/torque sensor has been used to estimate mass properties of a manipulator statically.