UNIVERSITI TEKNIKAL MALAYSIA MELAKA

DESIGN AND SIMULATION OF MULTIPLE DRILLING END EFFECTOR

Report submitted in accordance with partial requirements of the Universiti Teknikal Malaysia Melaka for the Bachelor of Manufacturing Engineering (Robotics & Automation) with Honours.

by

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2009

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

BORANG PENGESAHAN STATUS LAPORAN PROJEK SARJANA MUDA

TAJUK: **DESIGN AND SIMULATION OF MULTIPLE DRILLING END EFFECTOR**

SESI PENGAJIAN: 2008/09 Semester 2

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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 & Autiomation) with Honours. The member of the supervisory committee is as follow:

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ABSTRACT

The Bachelor Degree Project is compulsory for UTeM student to pass the PSM before being award the degree. This project is about of Design and Simulation Multiple Drilling End Effector. The multiple drilling end effector is design to minimize the delay time during changing the tool bit to run the next process. The design should be consider on type of drilling process for example centering, drilling, reaming, tapping, counterboring, countersinking, and spotfacing. The multiple drilling end effector design is too important because it will affect on the precision and the accuracy of operations. There must have a good plan to carry out this task effectively. Then finite the analysis of design and lastly the simulation model will be developed.

ABSTRAK

Projek Sarjana Muda wajib bagi pelajar ijazah sarjana muda UTeM untuk lulus sebelum di anugerahkan ijazah. Projek ini adalah Rekabentuk dan Simulasi “Multiple Drilling End Effector”. “Multiple Drilling End Effector” direka untuk mengurangkan masa ketika menukar mata alat bagi proses pembuatan seterusnya. Perkara yang perlu dititik beratkan ketika mereka bentuk “multiple drilling end effector” ialah jenis proses membuat lubang seperti, menggerudi, mengulir, dan lain-lain lagi. Rekabentuk ini penting kerana ia akan mempengaruhi pada ketepatan dan kejituan bagi sesuatu operasi. Ianya memerlukan perancangan yang baik untuk memastikan projek ini berjalan lancar dan efektif . Analisis ke atas rekabentuk “Multiple Drilling End Effector” akan dijalankan untuk memastikan rekabentuk adalah sesuai digunakan, dan seterusnya ialah proses simulasi model pada perisian komputer yang dikehendaki.

ACKNOWLEDGEMENT

I would like to express my gratitude to all those who gave me the possibility to complete this report. I am deeply indebted to my supervisor Puan Silah Hayati Binti Kamsani for all the guidance and critics given to me directly or indirectly, and also her sacrifice in time to teach and explain to me without a word of complains. I want to thank to my family for all their help, support, interest and valuable hints. My friend was of great help in difficult times.

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

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CHAPTER 1

INTRODUCTION

1.1 Project Background

Hole making is among the most important operations in manufacturing, and drilling is a major and common hole making process. Most products whether it is small or large, in vast majority have several holes in them. Holes typically are used for assembly with fasteners such as bolts, screws and rivets, each of which requires a hole or for the design purpose such as weight reduction, ventilation, access to the inside parts, or for appearance.

Drilling can be defined as the operation of producing a hole by removing metal from solid mass using a cutting toll called a twist drill (Krar, *etc al* 1969). Although many other processes contribute to the production of holes, including boring, reaming, broaching and internal grinding, and the drilling accounts for the majority of holes produced in the machine shop. This is because it is simple, quick and economical. The other methods are used principally for more accurate, smoother, larger holes. They are often used after a drill has already made the pilot hole. The multiple drilling is common in industry, which is vastly used for CNC machine and the application of multiple drilling is used to increase the productivity, reduce time, minimum cost, and increase the accuracy.

In robotics , end effectors are a device or tool connected to the end of a robot arm. The structure of end effectors, and the nature of the programming and hardware that drives it, depends on the intended task. Applying industrial robotics to precision drilling operations is easier said than done. Drill bits play a large role in this challenge; their torque, speed, and possibility of breaking make them difficult to monitor robotically and require sensors for this monitoring.

In this project, all aspects with regards to design the multiple drilling end effectors for the purpose of drilling holes at the material will be discussed. The design should be consider on type of drilling process for example centering, drilling, reaming, tapping, counterboring, countersinking, and spotfacing. Then finite the analysis of design and lastly the simulation model will be developed.

1.2 Problem Statement

Drilling is a simple and easy process in industry, the problem that we can state on robotic drilling is the time that taken during change the tool bit, and when it have multi task of drilling processes for example first before making a hole we need to do a centering process, then we change the tool bit for the next process to drill a hole as instructed size. The problems that need to solve during this project is, to minimize the delay time during changing the tool bit.

1.3 Project Objective

The objective of this project is:

- To design the multiple drilling end effectors suitable for COMAU robot, that can solve the industrial problem.
- To simulate multiple drilling end effectors using CATIA

1.4 Scope of Project

The objectives of this project can be achieved based on scopes of project that had been decided. There are many factor need to consider during design the multiple drilling end effector for COMAU robot to perform the drilling process. Since the end effector will use for multi drilling process, the design has to be flexible movement, at least two tool holders and also considering the drilling capability of robot. So the end effector flexibility is limited on two types or sizes of drilling process for one time period. The material usages for the end effector also need to consider since it will be affected during the drilling process. Finally make a programming to move the multiple drilling end effector and simulate using the CATIA software.

1.5 Gantt Chart PSM 1 & 2

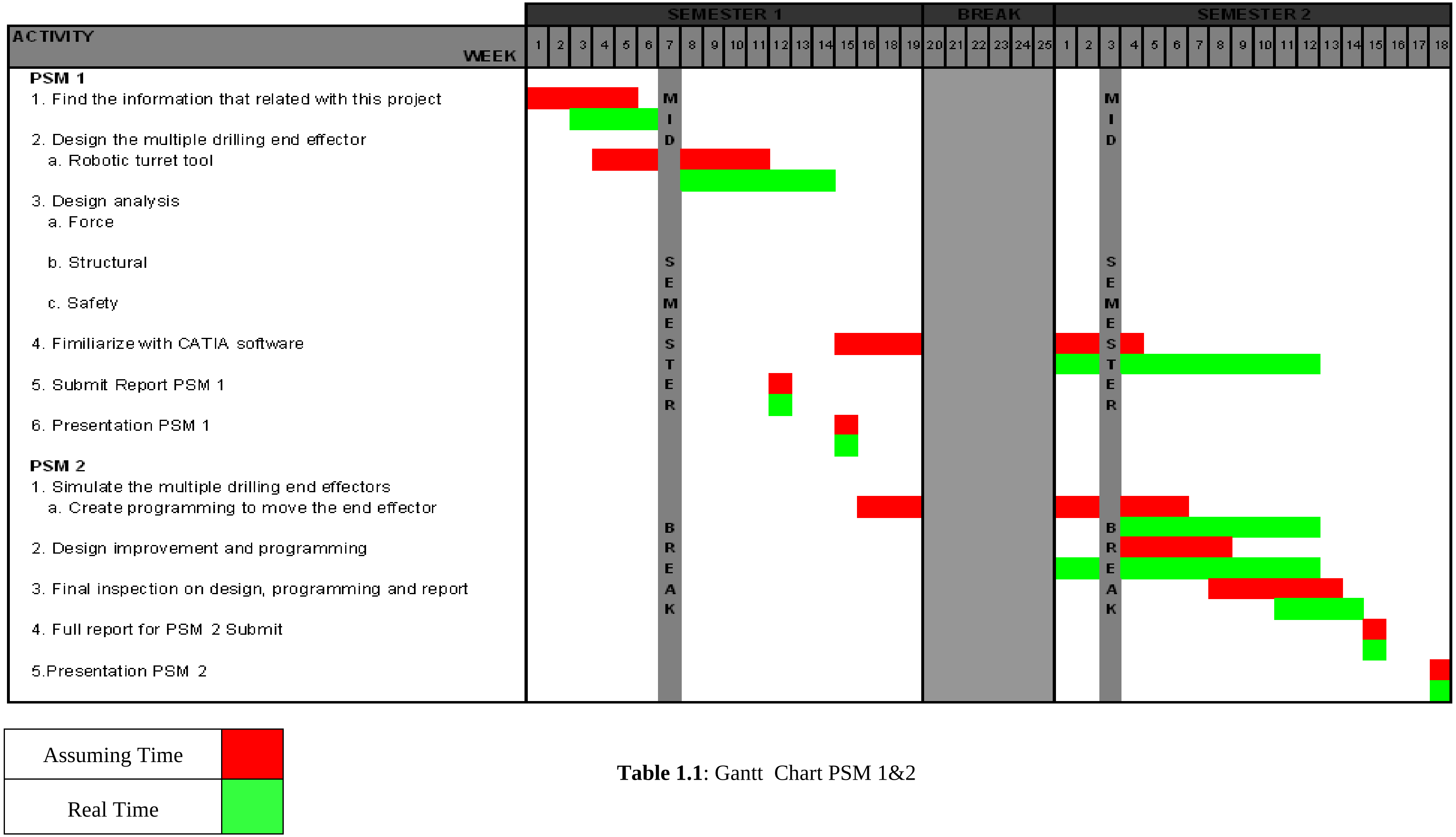

Table 1.1: Gantt Chart PSM 1&2

CHAPTER 2

LITERATURE REVIEW

2.1 Industrial Robot

Rehg (2000) explained that a robot is an automatically controlled, reprogrammable, multipurpose, manipulative machine with several reprogrammable axes, which may be either fixed in place or mobile for use in industrial automation applications. The key words are reprogrammable and multipurpose, because most single purpose machines do not meet these two requirements. Reprogrammable implies two elements; first the robots motion is controlled by a written program and second, the program can be modified to change significantly the motion of the robot arm in real time. Programming flexibility is demonstrated, for example, when the pickup point for a randomly placed part is located by a vision systems camera, and the program is changed while the robot arm is moving to the part. Multipurpose means a robot must be able to perform many different functions, depending on the program and tooling currently in use. For example, in one company a robot could be tooled and programmed to do welding, and in a second company the same type of robot could be used to stack boxes on pallets.

2.1.1 Robot System

According to Rehg (2000) a robot system is more than the hardware; it includes any devices interfaced to the robot for control of the work cell, mechanical arm, production tooling, external power sources, robot controller, and teach station. A basic system is illustrated in the block diagram in Figure 2.1. The system includes a mechanical arm to which the end – of arm tooling is mounted, a computer controller with attached teaching device, work-cell interface and program storage device. In addition, a source for pneumatic or hydraulic power is a part of the basic system. The work cell controller and other external devices that are part of the manufacturing system connect to the robot through the robot work-ell interface.

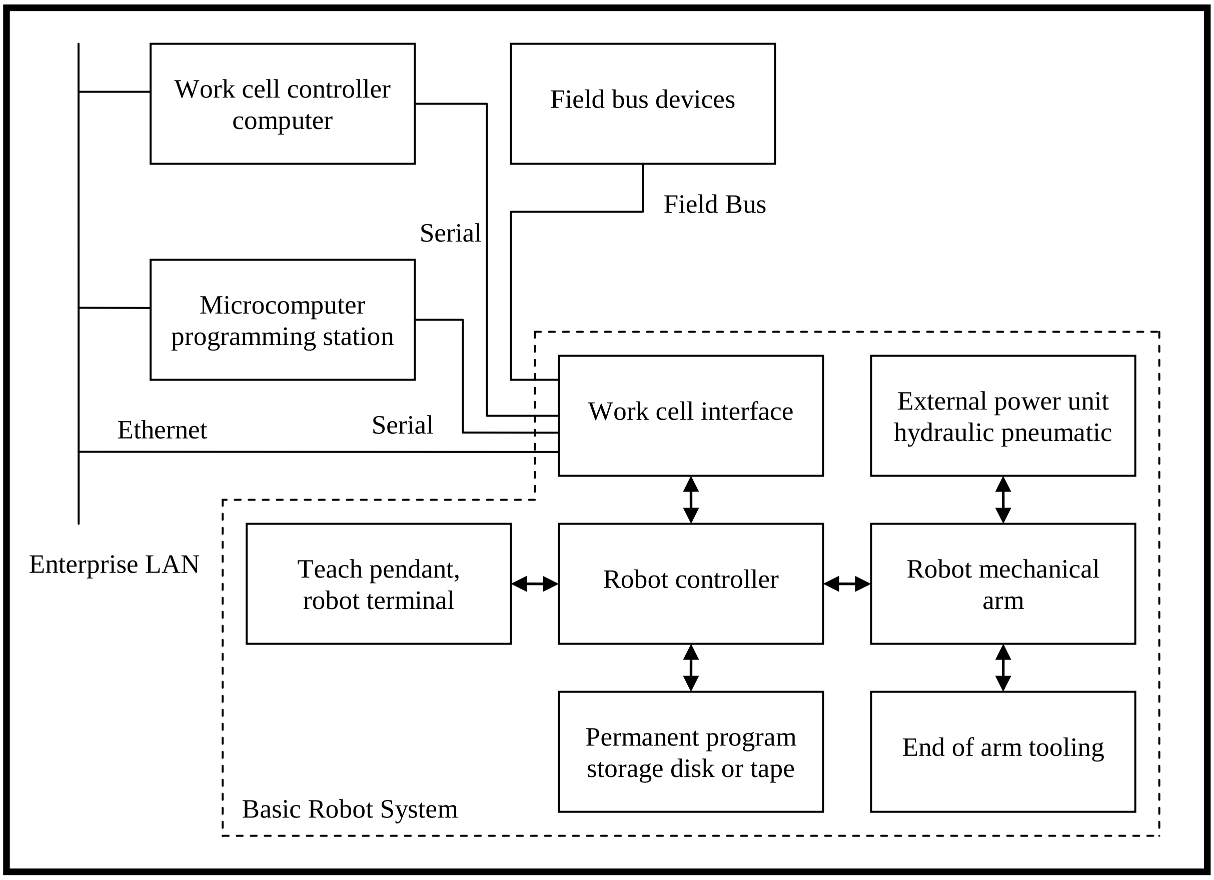

Figure 2.1: Basic robot system (Regh, 2000)

2.1.1.1 Mechanical arm

Arm is a mechanical device driven by electric-drive motors, pneumatic devices, or hydraulic actuators. The basic drive elements will be either linear or rotary actuators. The combination of motions included in the arm determines the type of arm geometry present. The basic geometries include rectangular, cylindrical, spherical and jointed spherical.

2.1.1.2 Production Tooling

The robot arm alone has no production capability, but the robot arm interfaced to production tooling becomes an effective production system. The tooling to perform the work task is attached to the tool plate at the end of the arm. The tool plate is usually part of the wrist. The tooling is frequently identified by several names. The terms used to describe tooling in general are end of arm tooling and end effectors. If the tooling is an open and closed mechanism to grasp parts, it is referred as a gripper.

2.1.1.3 External Power Sources

The external power required to operate a robot system includes sources to drive the arm motion (electrical, hydraulic or pneumatic) and electricity for the electronic controller. Because most of grippers are activated by compressed air, a source of compressed air is required for most system. Large robot arms using hydraulic actuators for motion require a hydraulic power source, and in some cases a compressed air source will also be necessary for the gripper. All electric drive arms require only electrical power for motion, but many need compressed airs for tooling.

2.1.1.4 Robot Controller

The all building blocks of a robot system, the controller is the most complex. Figure 2.2 is a block diagram of a typical controller used on electric robots. The controller, basically a special purpose computer, has all elements commonly found in computers, such as CPU, memory, and input and output devices. Most controllers have a network of CPUs, usually standard microprocessors, each having a different responsibility within the system. The distributed microcomputer network in the controller has the primary responsibility for controlling the robot arm and controlling and/or communicating with the work cell in which it is operating. The controller receives feedback from the arm on current joint position and velocity based on the program stored in memory. The controller can also communicate with external devices through the input/ output interface.

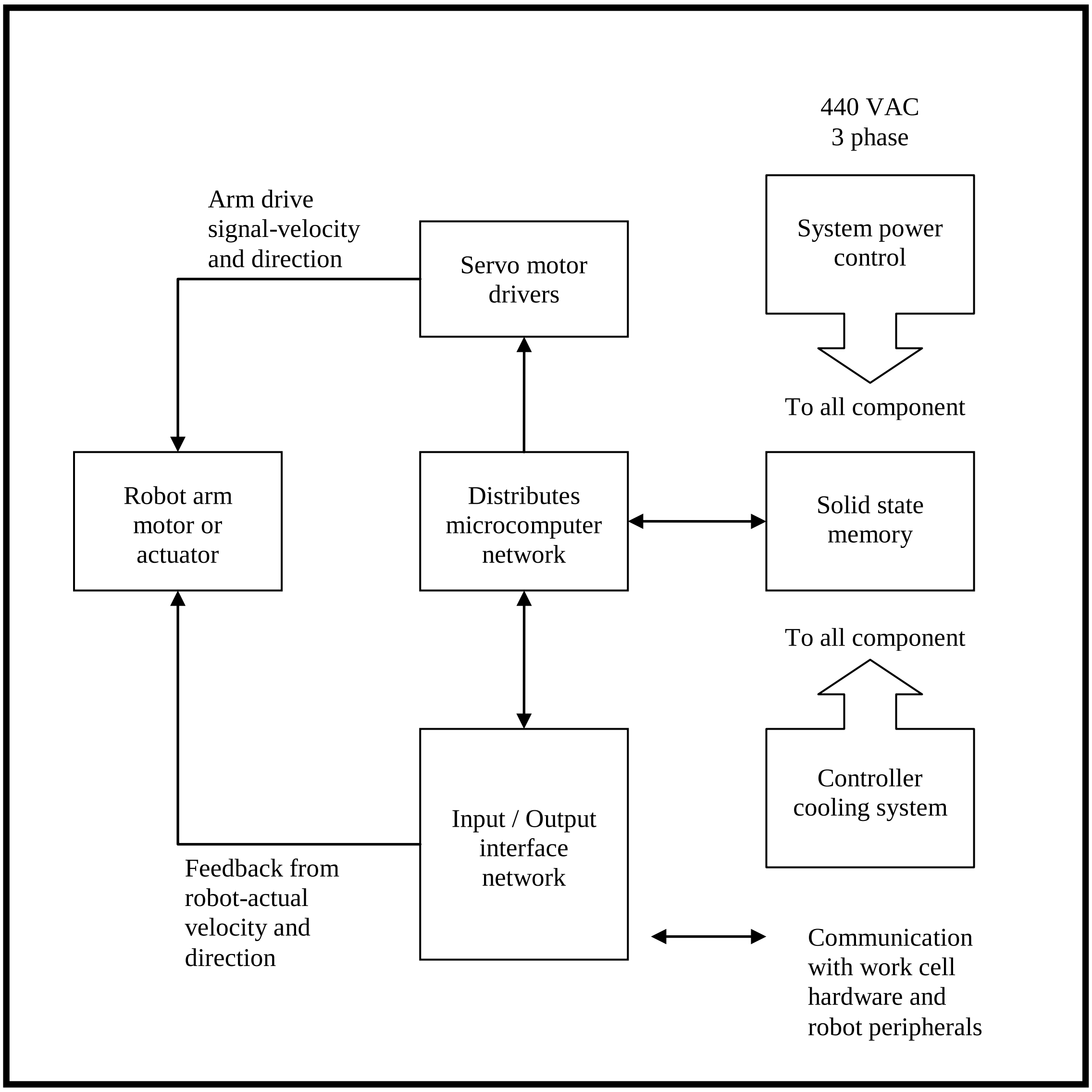

Figure 2.2: Robot controller block diagram (Regh, 2000)

2.1.1.5 Teach Stations

The teach stations on robots may consists of teach pendants, programming units, controller front panels, and DOS or windows based microcomputers. The teach pendant in Figure 2.3 is an example of a handheld terminal with a flat screen, multiline, touch sensitive display. Some robots permit a combination of programming devices to be used in programming the robot system whereas others provide only one system programming unit. In addition, some robots use DOS or windows based microcomputers as programming stations. Some robot vendors have programming units that are teach pendants with enhanced program creation and editing capability. All of the teach stations except the microcomputer support three activities, first robot power up and preparation for programming, second entry and editing of programs and third is to execution of programs in the work cell. The development of a program includes keying in or selecting menu commands in the controller language, moving the robot arms to the desired position in the work cell, and recording the position and command in memory.

Figure 2.3: Robot teach pendant

2.1.2 Robot Manipulator Degree

Man (2004) discussed that the robot manipulator consists of an arm with three rotations from the first three rotary joints, and a wrist with three rotations from the last three rotary joint. The robot arm has the features of human chest, upper arm and forearm, respectively. The wrist, connecting the robot arm to the robot hand, can make the robot hand contact an object in different orientations in the work-space. Therefore, the first three degrees of freedom of the robot are use to determine the position of the wrist, and the other three degrees of freedom of the wrist to determine the orientation of the robot hand. In the analysis of robot kinematics, the motion axes (z_0, z_1, and z_2) of the first three joint of a robot are called major axes to determine the position of the wrist, and other motion axes (z_3, z_4 and z_5) of the joints from the wrist are called the minor axes to determine the orientation of the robot hand. The work space of a robot in three dimensional spaces is the collection of the points which the wrist of the robot can reach. However, when the joints corresponding to the three major axes have different combination, the robot workspaces are different. Man (2004) also discussed about the type of robot movements such as Cartesian robot, cylindrical robot, spherical robot and articulated robot below.

2.1.2.1 Cartesian Robots

Cartesian robots have a common feature, in that; the first three joints corresponding to the major axes are prismatic (PPP), as seen in Figure 2.4. The advantages of Cartesian robots are that the configuration and design are simple, three prismatic joints are decoupled, and the motion control in Cartesian space can be easily carried out. The large Cartesian robots, which resemble overhead gantry cranes, are called gantry robots.

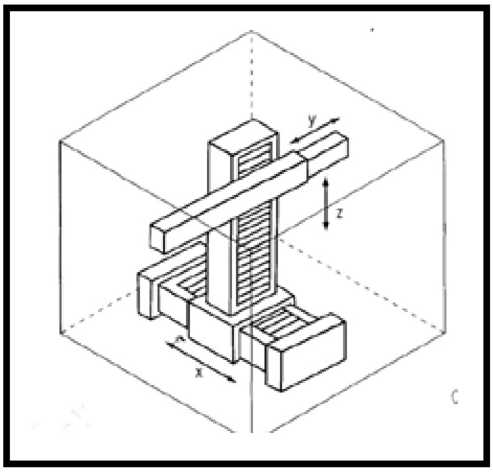

Figure 2.4: Cartesian robot

2.1.2.2 Cylindrical Robots

The typical cylindrical robot has a rotary joint and two prismatic joint (RPP) in order, as seen in Figure 2.5. The work space is actually between two concentric cylinders of the same height. The annular volume between the two cylinders is the zone in which the robot arm may operate, between fully retracted and fully extended.

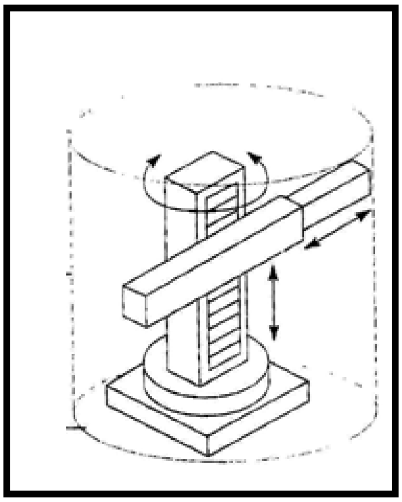

Figure 2.5: Cylindrical robot

2.1.2.3 Spherical Robots

A spherical robot is shown in Figure 2.6 below and the position of the wrist is determined by two rotations and one translation through two rotary joints and a prismatic joint (RRP). Theoretically, two rotational angles could change between 0 and $\underline{+}$360 degrees, the work space should be between a spherical surface and a cylinder. In practice, the minimum height of arm above floor level is *h.* Therefore, the workspace is between a semi spherical surface and a cylinder. The reader is asked to draw the work space of the spherical robot.

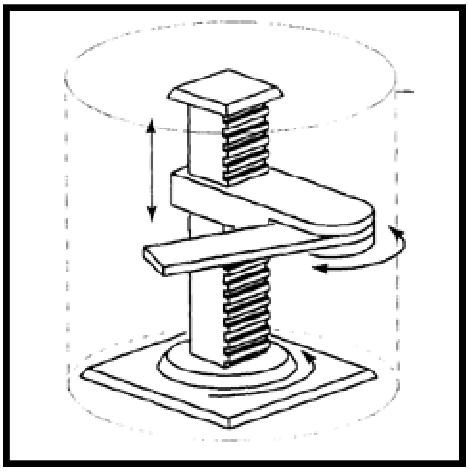

Figure 2.6: Spherical robot