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Safety Issues of Robotics in an Automated Manufacturing System

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Abstract - ***The paper highlights the safety issues of robots along with the design in an automated manufacturing system. Safety is an important factor in robotic design. The issue of robot safety in an automated manufacturing system deals with the design of a reliable control system to prevent malfunctions. The design of the work station layout and training of plant personnel are important. Robot application designers need to give more careful thought to persons who work within the confines of the robot workspace. The worker and the operator safety is the most important concern. The discussion follows the practical sequence in which one must think when designing a piece of automatically acting equipment.***

Keywords: *Reliable control, robotic design, work station, plant personnel, work safety*

INTRODUCTION

A quiet revolution is going on in the manufacturing world that is changing the look of the factory. Computers are controlling machines and robots are performing processes, and both are doing it far more efficiently than human operators. The high degree of automation, that until recently was reserved for mass production only, is applied now, with the aid of robots and computer, also to small batches. This requires a change from hard automation in the production line to a flexible manufacturing system which can be more readily rearranged to handle new market requirements. Flexible manufacturing system combined with automation assembly and product inspection on one hand, and CAD/CAM system on the other, is the basic components of the factory of the future. The supervision of this factory will be performed by computer-integrated manufacturing (CIM) system, in which the production flow, from the conceptual design through the finished product, will be entirely under computer control and management. CIM is the term used to describe the vision in which digital data is linked seamlessly from the design of the automated manufacture of the product. This involves the steps of design, including analysis and simulation, documentation, manufacturing planning and control, including material and machine scheduling, and factory automation, including materials processing, inspection, assembly, and materials handling. The application of robotics in companies implementing CIM requires that robot system become a part of the total CIM concept. Implementing a CIM system enterprise-wide requires extensive planning, many months and hard work, and a substantial investment in people, hardware and software.

HISTORY OF ROBOTS

The Czech word "robota" means forced worker. The conceptual origins of the modern robot lie in a symbolic stage play written in 1920 by Czech writer Karel Capek. The theme of the play was a population of human-like machines, manufacturing to replace human workers, ultimately turning against human co-workers, killing them all. Capek's play, Rossum's Universal Robots, captured the imagination of a wide audience. George C. Devol was awarded the first patent for what could be considered as the first robot. He and Joseph Engelberger formed Unimation Inc., the first

INDUSTRIAL ROBOTS

An industrial robot is essentially a device that can move materials, parts, or tools from one point to another under programmed control without human intervention. It can also be easily taught to perform simple tasks such as pick-and-place or spot welding or painting. An industrial robot has many attributes in common with an NC machine tool. The same type of NC technology used in machine tools is used to actuate the robot mechanical arm. The types of servomechanisms used to control the motion along each axis are similar in each case.

BASIC ROBOT ELEMENTS

There are three basic components of an industrial robot: Manipulator, Controller, and Tooling.

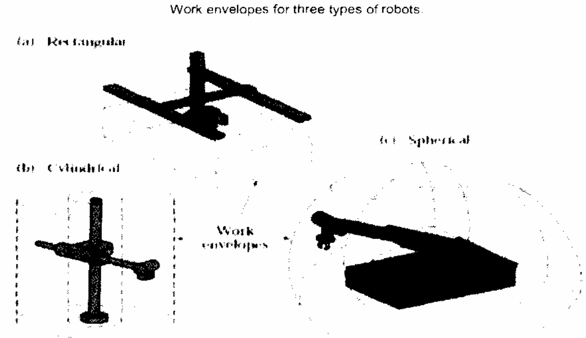
(i) **Manipulator:** The manipulator consists of the base and arm of the robot, including the power supply, which may be electrical, hydraulic, or pneumatic. The manipulator is the device that provides movement in any number of degrees of freedom. The movement of the manipulator can be described in relation to its coordinate system, which may be cylindrical, spherical, anthropomorphic, or Cartesian. Depending on the controller, movement can be point-to-point motion or continuous-path motion.

(ii) **Controller:** The versatility of a robot arises from its multi-axis mechanical configuration and the robot controller. The ability to reprogramme the robot controller gives the flexibility to the robot to perform a wide range of actions. The controller contains various interfaces with both command devices and sensing units. The controller has to define the trajectory of the robot gripper with time and transform this trajectory, which is in Cartesian, into its base-frame coordinate system and finally into joint movements. Many of these tasks are to be performed in real time. Several easy-to-use robot programming languages such as VAL, MCL, and APT are available.

(iii) **Tooling:** Tooling is what enables the robot to do a particular job. Tooling is sometimes used synonymously with end effectors, although the latter has a more restricted meaning to apply to end-of-arm fixturing to grasp, lift, or turn. Tooling, on the other hand, has a broader context which can apply to power tools for drilling and grinding, as well as for painting and welding guns. Typical end effectors include electromagnets, hooks, vacuum cups, adhesive fingers, and bayonet sockets. There are six basic motions, or degrees of freedom, which provide the robot the capability to move the end effectors through the required sequence of motions. The six, motions consist of three arm and body motions and three gripper motions. The three arms and body motions consist of vertical traverse, radial traverse, and rotational traverse. The gripper motions are yaw, pitch, and roll.

Different robot configuration generates different characteristic working envelop shapes. The work volume refers to the space within the robot can operate.

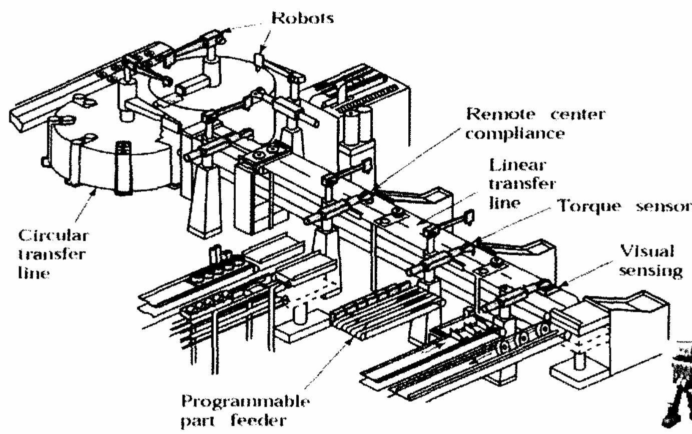
Work envelopes for three types of robots



INDUSTRIAL APPLICATIONS OF ROBOTS

Industrial robots have a wide range of potential applications in manufacturing systems because they are flexible and programmable themselves. The use of sensors allows the robots to see, hear, and smell the environment. The robot controllers can be generally integrated easily into the manufacturing system environment and are capable of communicating with other programmable controllers. In hostile environments, such as foundries or forges, robots are often used for high-temperature handling, particularly in stamping operations. Feeding and unloading of machine tools is an area in which robots are used, especially with automatic lathes.

Automated assembly operations using industrial robots and circular and linear transfer lines.



Welding is an unpleasant and repetitive task, and one for which robots are already widely used, and are likely to be used more extensively, due to the progress made in the development of sensors. The technique of spot welding is well developed, and is used frequently, especially in the motor industry. Continuous arc welding is a far more delicate operation, the main problems being to follow the joint, and find a sensor which can function properly near a welding torch. The market for robots in continuous welding is optimistic. Some manufacturing offer robots specifically designed for this purpose. Robots are also widely used for assembly, either of printed circuit boards, into which components are automatically installed, or of small systems. The scale of use of robot in painting operations has not been spectacular, even though the task is unpleasant, and potentially dangerous. There are however several robots available which have been designed solely for this function.

EMPHASIS

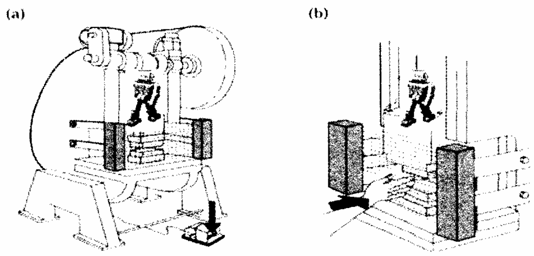
Strong emphasis is given to the following laws:
1. A robot must not harm a human being, nor through inaction allow one to come to harm.
2. A robot must always obey human beings, unless that is in conflict with the first law.
3. A robot must protect itself from harm, unless that is in conflict with the first and second laws.

It is, therefore, the responsibility of the designers to consider measures to diminish the possibility of accidents to both hardware and humans. A robotics installation is still a new occurrence in most factories, therefore, that some type of protective barrier be placed around the work envelope to prevent unauthorized workers from getting too close to the robot work cell and to restrict traffic flow in the area. Both physical barriers and electronic detectors can be employed.

Some examples are:

- Painted lines on the floor
- Chains and guard posts
- Safety rails
- Wire mesh fencing

(a) Presence-sensing device, with light beams forming a curtain across the zone of operation.
(b) Breaking the curtain of light beams by operator's hands sets brake on machine and disconnects clutch.



In addition to physical barriers, detectors such as electronic curtains, motion detectors, and pressure - sensitive floor pads can also provide protection. A typical robotic installation might include a combination of barriers and protection devices. Another approach states that only robots themselves are able to detect the approach of humans. Therefore, the solution to the safety problem is to provide sensor systems, which can detect intruders that enter the robot area while it is operating.

CONCLUSION AND FUTURE TREND

Safety is an important factor in robotic design, from the beginning of the design to the implementation of the process. Specific areas of safety awareness in a robotic installation include types of barriers for worker protection, general personnel safety, and operator and maintenance personnel safety. The uses of robotics in the manufacturing no doubts will bring a lot of benefits as mentioned above. But the introduction of the robot into the work place may have a significant impact on the workers, management, and the organizational unit. To effectively use this new technology, managers need to identify the critical points of impact and develop mechanisms to effectively adjust to this new technology. There is no way to escape from using robots in the manufacturing in the future. Factories could survive in the future only by renewing their technological base and utilizing new strategies of management and production. That is exactly what the concept of the factory of the future offers: a revolutionary change in manufacturing techniques founded on unprecedented involvement of robot system and computer technology in factory production and management.

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