

COLNE ROBOTICS

The

Colne Robotics

A R M O R I O

Construction and Operation Manual

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Introduction

The word Robot comes from the Czechoslovak language and means simply worker. It entered the English vocabulary when a play by Karel Capek was translated in 1923 for the London stage entitled R.U.R. (Rossums Universal Robots). In the play Rossum created humanoid devices to work for him. Almost all that is left of the play is the word Robot and all that it now means to us.

The image of the robot has been created in part by science fiction writer and part by the manufacturers of industrial robots. As a result most laymen do not have a clear idea of the capability or limitations of a robot or even in some cases what exactly a robot is. The Robot Institute of America puts it like this:-
" A robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools or specialised devices through variable programmed motions for the performance of a variety of tasks". In other words it is an intelligent handling device. There are of course specialised pieces of machinery which are able to handle industrial work which are not robotic. What then is the difference? The significance is in the word specialised. A robot is not a specialised piece of machinery and is in fact a part of a flexible automated production line which comes "off the shelf". The robot can be programmed and is therefore infinitely variable. That is the difference and it is a big one.

The industrial robot has been in existence for a number of decades but the development of microelectronics and microprocessors over the last couple of years is the technology that has made them cost effective. Five years ago a robot had a cost ratio of about 60% electronics and 40% mechanical content. The effect of the silicon chip revolution is that it is now 20% electronics and 80% mechanics. The drop in the total price of robots as a result of the cost ratio has been dramatic. This and the rise in wage rates has caused the increase in the usage of industrial robots.

The development of the small robotic arm was largely accidental. The decision to design this small arm came from what was intended as a survey of industrial robots. It was noticed that the micro-computer hobbyist in the USA was experimenting with medium and small robotic devices of all kinds. There was however, no educational or experimental robotic device on sale anywhere in the world that gave the capability of control and handling at a price which made the robot a good microcomputer peripheral.

The design of the robot as a kit is deliberate policy of the Colne Group. It enables the person assembling the device to understand the principles of the robot, although of course the machine is also available in made up form. The main opportunity that the kit form gives to hobbyists and experimental roboticists is the possibility to modify or add to their robot. There are, even at this time of writing a number of experimental projects planned. These will obviously increase in a number of developments and to keep owners of robot arms informed of events we intend to run a newsletter.

Typical of the projects will be the fitting of sensors on the grippers. This will enable the arm to have feedback from the manipulator to give a closed loop control of the device. Another form of feedback could come from sensors such as fibre optic or electro/optic devices on the joints of the machine to sense the exact position of those joints. Variations can be made around the manipulators, the substitution of the gripper for the other kinds of handling device such as a pneumatic sucker for handling sheet or paper or an electro magnetic handler for picking up ferrous metal workpieces, are planned.

Other variations will be seen in the computer programs which will drive the machine. The basis of these programs and the intelligence that they can have are shown in the chapter on software. The variations in mechanical and electronic drives in the robot give the operator the ability to simulate many of the functions of a real industrial robot. The various projects about which we are informed will be the subject of articles in the monthly newsletter which robot arm owners can subscribe to (see details in the appendix of this manual).

We are hoping that this robot arm will serve as a helpful pilot scheme for the evaluation, economical analysis and hopefully installation of its big industrial brothers in manufacturing facilities. The factors that you will have to take into consideration are:-

- Ability of the gripper and machine to handle jobs in the factory.
- Economic factors and evaluation
- Social impact of the robot

Some consideration on the three aspects are given below.

Handling jobs in the Factory

Non Gripping Applications

Cleaning
Drilling
Spraying
 Paint
 Power
Welding
 Arc
 Flame Cutting
 Spotwelding
 Stud

Low Precision Gripping

Investment Moulding
Diecasting
Forging
Foundary Practice
Press Work Applications
Plastic Moulding

High Precision Gripping

Interstage Tooling
Transfer between Stations in Forging
 " " " in Metal Stamping and Drawing
Loading and Unloading Tools in General Work
Inspection Probing
Filament Winding
Wire Wrapping
Sprue Cutting
Sorting and Packing
Precision Drilling
Precision Routing
Deburring

Advanced Assembly and Parts Control

Palletizing
Brick Manufacturing
Glass Manufacturing

These applications are listed in order of difficulty for robotic handling. It would be unwise for the inexperienced to consider attempting more than those in the first two categories.

In surveying the existing use of industrial robots nearly 90% of all applications fall within the first two areas where no gripping or standard gripping surfaces are available. Such applications require low levels of precision, say plus or minus a couple of millimeters. It is in these two areas that the most cost effective applications will at this time be found until robots can be made more intelligent.

The other important parameters are weight of workpieces and speed of handling required. Light handling is generally associated with speed of operation and it is normally difficult for a robot to compete with human response in this kind of handling. The speed of robots is much more suited to handling forgings etc. but this often leads to a variable scenerio which require intelligence, and the variation of the machine by operator or computer.

It is possible for the production technician who is inexperienced in robots to identify a robot application in his own manufacturing facility. He must bear in mind that the above mentioned limitations and possibilities but a robot installation starts with the requirements of the production line. The first thing that he must look for is what skills are needed at a particular workstation, by the operative. His work must be assessed for the use of:-

- a. Sight
- b. Touch
- c. Hearing

and how often does the pattern for the use of these skills repeat or be made to repeat without variation. For the purpose of this excercise we will assume that the production engineer is looking for robotic installation opportunities in the non gripping or low precision gripping application areas.

Having looked at a,b and c he will probably discard 'c' as a factor in most operations. Therefore any workstation that needs hearing to do the job will not be a candidate for robotics. The 'a' aspect will now have to be considered from the point of view of how sight is used. It is necessary to decide if sight is used in establishing position or has it got other functions such as quality control etc? If anything other than position is involved then this application must also be discarded.

You will see that we are coming down one factor and that is position. Such a positioned workpiece must have little variability. The workpiece must be offered up to the robot at the same place (+ a small discrepancy), in the same orientation and with little or no variation in the receiving station although now it can be reorientated by other machinery if required and possibly may not need the accuracy of placement. Timing may or may not be important in this last operation but speed to integrate the working of the robot into production line is obviously important.

It will be obvious to you that we are looking at a single robot installation as a hybrid approach using both robots and workpeople on the production line. We are also looking at the possible installation of the simplest robotic device. This of course means safety considerations such as not mixing machines and people in the workspace of the robot. It does however, give a bonus which will allow the robot to work within the safety guards of a machine and could therefore speed up cycle times of the machines working.

You will see that an installation will require modifications both to the robot and to the production machinery. It may be that you need to change parameters of the production line such as workpiece flow and timing, size of batches of items, positioning of the workpiece but remember that the robot, through the computer that controls it can also be very variable to meet a production situation. The main variability of the robot being given by the programming (see the chapter on software).

Economic Factors

The evaluation of the installation of a robot in your factory include cost versus savings and the throughput of your factory. The details of costs and savings are as follows:

Financial Evaluation - Robot Costs

1. Purchase price of robot.
2. Purpose made tooling. This cost may be considered as a part of the cost of the robot for your specific task and may be regarded as part of the cost of the robot.
3. Installation costs may be a constituent of the robot project or may be partially carried as a part of plant changes that were to be made in the normal programme for production machinery depreciation and replacement.
4. Maintenance can be a variable figure depending upon usage. Such costs in foundry work are usually more than in plastic moulding. There is a general rule of thumb with production equipment that maintenance costs are about 10% of the purchase price per annum on a two shift basis.
5. Operating Power is a minor cost which can be assessed in conjunction with the robotic device manufacturer.
6. Finance allows for the current cost of money or alternatively estimates the expected return on investment.
7. Depreciation of ordinary general purpose multi shift equipment is usually about 10 years on a straight line basis.

Robot Savings

- a. Labour displaced is the crux of robot usage although protection of workers in hazardous working conditions is a close second. It is obvious that if a robot can be made to work more than one shift the savings will be greater. This cost should also include fringe benefits and be shown as an hourly rate.
- b. Quality improvement is a considerable factor particularly if the job is repetitive to the extent of becoming intensely boring so that the task is subject to moods and attitudes of the workers. In addition there can be aspects of environment to be taken into consideration such as physically hazardous or demanding which enables robotic control to produce a better or more thorough job.

- c. Increase in throughput either from higher quality or increased output or a mixture of both gives a capability which might be mixed. If the throughput increases the workpieces available in a certain part of the production scheme could mean a modification of the installation (Robot Costs 3). This will have to be costed and set against the savings seen in this item of increased output. The improvement of utilisation of capital assets should not be ignored any may assist the benefit of one for one displacement of a worker.

These lead to a simple payback formula which would give you a timespan, say eighteen months which will be the time that the robot will take to return its investment.

Payback Formula

$$\text{Payback years} = \frac{\text{Robot Cost (1, 2 \& 3)}}{\text{Labour (a) - Robot Expense (4, 5, 6, 7)}}$$

This simple formula does not include 'b' and 'c' in the robot savings.

Example

Single Shift Operation

$$P = \text{£25,000}$$

$$\text{£12 (250 x 8 hrs) - £1.20 (250 x 8 hrs).}$$

$$P =$$

The capacity and throughput of your factory is an important factor in the installation of a robotic installation and must be examined.

Here are some of the questions that the robot manufacturer will ask you. You will probably find that it is not worth installing a device unless you have a throughput of two or three million workpieces a year. Production should be fairly steady and the need for the level of the production to last for some years is important to the payback calculation. Other aspects of the handling of the workpiece are more complex but the potential installer must know these answers so do your homework.

Capacity and Throughput

Volume of Throughput

1. Number of workpieces per annum
2. Is the volume of production steady?
3. If there is a variation can you give an indication of the throughput over 12 months.
4. Is the annual production going to last at the present level or above over the next three years.

Workpiece Configuration

1. What is the size of the Workpiece?
2. What is the weight of the workpiece?
3. Will it deform under its own weight?
4. Will it break or crack if dropped from a height of 3 inches onto a hard surface?

Social Impact of the Robot

This checklist enables you to evaluate the positive and negative aspects of robot acceptance in your workforce. This is quite different to factors in management acceptance and should be treated as two separate parts of the total equation in robot installation.

Each item has a positive and negative share of the total percentage of the checklist findings. The total can be treated as an indicator and the points can be modified by item and total using management action.

	<u>Total points</u>	<u>Positive</u>	<u>Negative</u>
1. Will workers be given assurance of keeping their jobs	20		
2. Can displaced workers be retained in equal rated jobs	15		
3. Will workers benefit in terms of			
Relief from Boredom	5		
Health	4		
Safety	2		
Difficult or dirty tasks	7 total	15	
4. Is present worker management climate in favour of discussing			
Economic Conditions	3		
Labour Unrest	5		
Is it usually distrustful	7 total	15	
5. Has the company enough economic strength to guarantee promises are kept	5		
6. Have management particularly in the engineering department shown ability to establish dialogue with the workers	5		
7. Is management concern for the quality of the job or is it only for the economic aspect	5		
8. Will there be a plan to upgrade workers who will supervise robotic systems	5		
9. Will workers pay rates suffer by robot breakdown etc.	5		

