THE SPRING RESEARCH AND MANUFACTURERS' ASSOCIATION

EXPERIMENTAL ROBOT LINE FOR TESTING SPRINGS

Report No 385

by

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SUMMARY

With increasing pressure from customers to reduce the price of manufactured items with improved quality, more and more emphasis is being placed on automation with the inclusion of robots in the production lines as a means of obtaining this. SRAMA has investigated the use of a modular, air powered pick and place robot in an automatic free length sorting and load testing line. This was to determine the performance of such a device and to assess the potential for relatively low cost robotic units within the spring industry.

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1. INTRODUCTION

The use of robots in manufacturing industries is becoming more common as robot technology advances and their cost becomes within the reach of smaller companies. However, the price range for robots, from the simple pick and place machines up to the continuous path units, is still considerable and places the latter type machines outside the reach of many small companies. In general the sophistication of the continuous path robots is not required in the spring industry as many of the handling jobs can be carried out by the simpler pick and place robots.

To investigate the technical problem involved with using a robot in conjunction with other equipment SRAMA undertook a programme of work to install a robot in a testing line to pass springs from one machine to another.

2. FACTORS TO BE CONSIDERED WHEN INSTALLING ROBOTS INTO A PRODUCTION LINE

The major problem common to all robots is an inability to pick out objects separately from a bin or stillage. Thus the robot requires the springs (or other item being handled) to be presented to the gripper/tool assembly accurately and repeatably. If not the robot cannot be expected to transfer the work piece accurately and this can cause all manner of problems down the line from the robot.

It should also be remembered that simple robots will continue working through the preprogrammed series of movement should the supply of springs cease, unless some form of sensing is built into the robot. This can be accomplished by using a sensor to detect when a spring is ready for transferring, this this will cause the robot to wait until that signal goes true.

The presenting of the workpiece to the robot can be a very great problem and should not be underestimated.

The second possible problem with the simpler robots can be an inability to work in confined spaces due to its limited movement capabilities. Although this can usually be overcome by careful programming to move each axis step by step to clear obstacles, this will invariably slow down the total cycle time which is usually at a premium.

Lack of speed is the third major factor common to all robots and can, under certain circumsances, slow down manufacturing operations. However, production output can often be regained by the ability of the robot to operate continually or by reorganising the overall layout of the robot system to minimise time consuming movements.

Gripper design also needs to be considered carefully so that the robot is capable of picking a spring up correctly without causing damage. This can be accomplished by constructing grippers from spring steel strip so that dimensional changes in the spring, or variations in the spring's orientation at the point of collection can be absorbed.

If the robot is to be used for more than one design of spring, or used with different machines, it is obviously advantageous if the gripper design is suitable for all or at least several spring designs.

3. TYPE OF ROBOT USED FOR INVESTIGATION

It was decided that the experimental work should be carried out using the simpler point to point (or pick and place) type of robot. This decision was based on the economics and the good handling ability of pick and place robots. The more sophisticated multi-point or continuous path robots cost approximately £17,000-£50,000 depending on their size capacity and would not in the majority of cases offer significant savings in production cost to offset the high purchase price. Maintenance of continuous path robots can also be expensive, often requiring trained servicing personnel when major breakdowns occur. However, with the simpler air powered robot being an extension of industrial pneumatics, little specialised knowledge is required and hence repairs can often be undertaken by in-house maintenance staff. The machine chosen is manufactured by Martonair Ltd and is of modular type, which enables the customer to purchase only the movements required. The total hardware price for the system constructed at SRAMA was approximately £8,500. A simpler system with fewer movement capabilities could be built for as little as £4,500. The SRAMA system allows operation within the space envelope shown in Fig 1.

Each axis uses pneumatic power and is essentially an air cylinder or air torque unit. This means that each axis only has two positions of rest, either in or out, with the exact position being set by adjustable mechanical stops.

The movement between these positions is controlled by an electronic programmable controller which is able to control up to 16 axes at any one time. The programmer works on a sequence system in which air is sent to the axis as designated by the user's program. The system then looks for the movement to be completed, the sensing of the completed movement being made by electrical proximity switches. It should be noted that once air is switched to an axis there is no control, other than limited speed control by air regulation, on how that movement is accomplished. The controller is only interested in receiving a movement completed signal to complement the output signal.

When the programmer receives the 16 signals from the robot, which indicate that it has completed its movements for that program step, it then, and only then, moves onto the next program step.

When fewer than 16 axes are required the redundant outputs on the program are simply connected to a corresponding input to make the controller think a movement has occurred. More usefully the redundant outputs can be used to control other machines in the robot line, or to produce some form of interlocking between the various machines that make up the robot cell so that the system is fully synchronised.

The programming of this type of controller is simple and uses switches on the front panel to set an output to either + or - (out or in) in the program. Both the output and input conditions are indicated by L.E.D's on the front panel. No computing type language is used for programming which makes for very easy and quick programming (see Fig 2 for an example program) but does limit the capabilities of the robot when compared with the more sophisticated robots which have decision making capabilities available with the high level programming languages used.

4. EXPERIMENTAL SPRING TESTING LINE

The robot was built into a testing line to transport springs which pass free length grading onto a pneumatic powered load testing machine providing a robot cell capable of fully automatic 100% inspection and sorting on free length, two lengths and spring rate.

The SRAMA free length sorting unit ejects good springs by rolling them down a channel, which leaves them in an ideal position to be picked up by the robot. Two sensors were placed on the output chute of the free length sorter, one to sense when a spring is ready for collection by the robot, and a second to stop the free length sorter should the output chute become full.

The robot transports the springs to the load tester where, under control of the robot program, the spring is load tested using SRAMA's 'pass through' electronic system. The load tester grades the springs into +, OK, or - on either load 1, load 2 or spring rate, and under control from the robot's controller, uses air jets to eject the spring into the relevant bin.

The total cycle time for this operation was 6.5 seconds, giving a throughput of 550 springs/hour.

5. DESCRIPTION OF PROGRAM USED IN TESTING LINE

The ability of the programmer to control more than one axis each program step allowed the total number of steps required for the load testing cell to be reduced to five. Initially the machine was programmed by allocating each single movement of an axis to a program step. Hence the program was much longer (16 steps) and the total cycle time of this machine excessively long, taking 14 seconds compared with 6.5 seconds. This is, however, the sensible way to proceed, as attempting to combine several movements into a single step can cause unforeseen problems such as the arm not clearing parts of the feed system or moving before the grippers are closed. Only when the robot runs successfully should the movements, where possible, be combined into fewer steps.

On inspection of Figure 2 it will be seen that each of the 16 output/input channels (A to P) has been designated a use. For example, the small linear module is controlled by channel 'A', the rotary base by channel 'G' etc. It will be noticed that channels M and N are not connected and for this application redundant. Channels J, K and L are used for the sorting jets which blow the load tested spring into the relevant tolerance bin. Channel O controls the up and down movement of the load testing machine, which uses air power. Channel P is used for feedback to the robot to indicate when a spring is present in the output chute of the free length sorter ready for processing. The rotary base stop F, G and H are not used in this program. A standard convention for movement has been adopted, the plus sign indicates the axis is 'out', the negative indicates it is retracted.

Step 0

Here the robot is at its initial or reset position in front of the output chute of the free length sorter and waiting for a spring. It should be noted that CH.P (Channel P) is positive to check for the presence of a spring. All the other channels are in their respective reset positions.

Step 1

Once a spring has been detected, step 1 is executed which moves the small linear module and hence the grippers towards the spring. CH.P is now switched minus as the spring has been detected successfully.

Step 2

The spring is now gripped by the grippers (CH.E) and lifted clear of the free length sorter (CH.D). Here two movements have been combined into one step.

Step 3

This step moves the spring from the free length sorter to the load tester. The short stroke module (CH.D), the wrist action (CH.C) which rotates the spring from the horizontal to the vertical position and the rotary base (CH.I) which turns the robot are all used simultaneously. Hence three movements have been combined into one step.

Step 4

This step again combines several movements. The gripper (CH.E) opens to stand the spring onto the platen of the load tester. The arm (CH.A) then retracts to remove the grippers from the test area and the load tester (CH.O) starts to compress the springs. Again, three movements have been combined into a single step.

Step 5

The robot now rotates (CH.I) back to its reset position with the wrist (CH.C) at 90°. The load testing platen (CH.O) rises and the air jets (CH.J, K, L) switched on. The electronic measuring system on the load tester controls which jet is allowed to operate depending on the result of the load test. On completion of step 5 the program returns to Step 0 and repeats until stopped by an operator. Here a total of four movements are controlled in one program step.

Changes to the Existing Program

The existing program can be simply and quickly modified to introduce other operations. For example, should the spring now require scragging once before load testing the program could easily be modified by reprogramming step 5 similar to step 4 but with CH.O set to minus to raise the platen after compressing the spring solid. Introduce a new step 6, identical to step 4, to undertake the load test and a step 7 identical to the old step 5 for the air jet sorting. This type of change would take about five minutes to program into the controller and would cause minimal down time.

Change of Spring Design

Whilst the program changes can be implemented very quickly, changes in spring design, if large, can be more troublesome and time consuming. The difficulties will usually occur in the equipment which presents the spring to the robot and in the equipment on the exit side of the robot.

Most standard set ups will allow a small amount of flexibility to cope with small variation in length and diameter of the spring. However, if the dimensional change is considerable the time and money spent in retooling may be large.

Thus when installing a robot it is prudent to build in as much flexibility as possible into the input and output equipment.

The robot cell constructed for this project was used to batch test clutch springs and was capable of testing a large portion of the standard size range. However, it would need considerable retooling if it were to handle valve springs, although it should be noted that the robot itself would only require a small change in gripper design.

6. POTENTIAL AREAS OF APPLICATION FOR ROBOTS

There are many operations in the spring industry where robots could be successfully applied. However, due to the batch type of production which often is used, it will not always be economic to install robots unless the production runs are sufficiently long.

Load Testing and Scragging Operations

As shown by the work reported, robots can easily handle springs for load testing and/or scragging. The major problems occur in feeding of the spring to the robot in the first instance. Although there are a number of feeding devices available they do tend to need close tailoring to the specific spring design and hence can be very limiting in flexibility.

Looping and Leg Forming

Where these functions are carried out as a secondary operation a robot could be used to interconnect the coiling machine to the looping/forming tool. This would eliminate the feeding problem to the robot as the spring would be orientated correctly and constantly just before cutoff. The speed of the robot and the secondary operation would usually require the coiling machine to run at a reduced rate, however it is often found that the total throughput is improved due to the combining of the two operations.

Presswork Operations

The feeding of blanks into and between presses is an ideal operation for a robot to undertake. The safety interlocks fitted to presses allow the robot to be synchronised to the press or presses relatively easily with the robot's program controlling all the machinery. The raw blanks can often be stacked in a vertical magazine to allow accurate picking up and placing by the robot arm.

Wire Forming

This application is similar to that of feeding presses and has the same advantages.

Dirty or Hazardous Environments

Most robots will operate satisfactorily in hostile conditions providing protection is adequate. Bearings, cables, air pipes and the programmer are the areas where failures will occur if suitable guarding is not installed. It should be remembered that bellows, splash guards etc may, if incorrectly designed, limit the robot movement and/or reduce its load carrying capacity.

Possible areas for robotic applications are corrosion protection plant such as paint, plating and temporary inhibitor applications.

7. CONCLUSIONS

1. In general, the pick and place type of robot should be capable of accomplishing many of the handling operations found in the spring industry.

2. The pneumatic powered robots are simple and readily understood by personnel familiar with normal air systems.

3. The speed of operation of the robot may be limiting in some applications.

4. The modular construction of the Martonair system is ideal for part or total automation of existing production facilities.

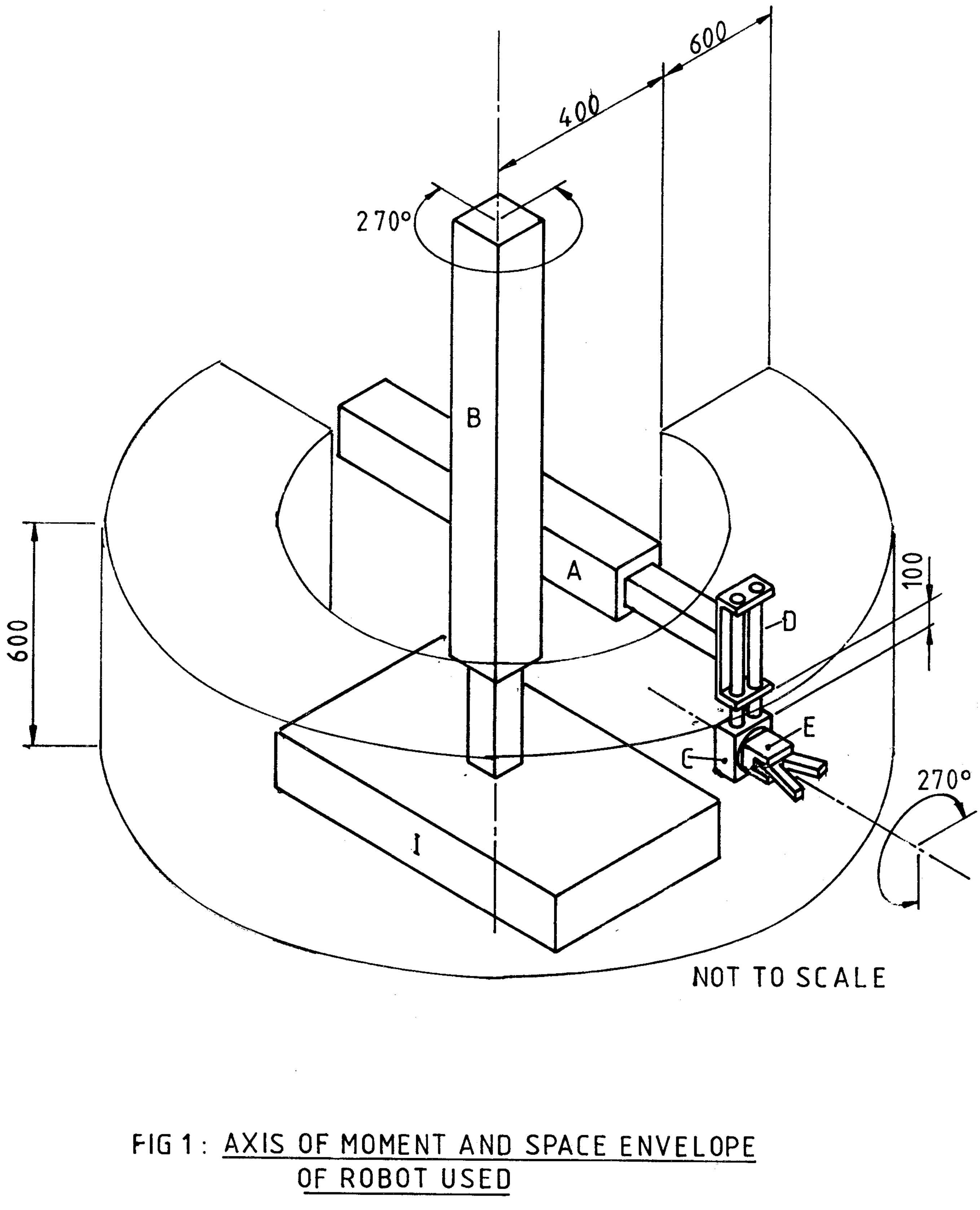

FIG 1 : AXIS OF MOMENT AND SPACE ENVELOPE OF ROBOT USED

Step No \ Axis	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Comments
0	-	-	-	+	-	-	-	-	-	-	-	-	+	+	-	+	At rest, waits for spring:- Air jets off, gripper open.
1	+	-	-	+	-	-	-	-	-	-	-	-	+	+	-	-	Small linear module extends.
2	+	-	-	-	+	-	-	-	-	-	-	-	+	+	-	-	Spring gripped and lifted clear of free length sorter.
3	+	-	+	+	+	-	-	-	+	-	-	-	+	+	-	-	Turns to load tester, rotates spring to vertical orientation, short stroke module drops.
4	-	-	+	+	-	-	-	-	+	-	-	-	+	+	+	-	Open gripper, retract linear module and start load tester.
5	-	-	-	+	-	-	-	-	-	+	+	+	+	+	-	-	Turn back to free length sorter, rotate wrist, finish load test, air jets on.
	Small Linear Module	Large Linear Module	Wrist Action	Short Stroke Module	Grippers	Rotary Base Stops	Rotary Base Stops	Rotary Base Stops	Rotary Base		Sorting Jets		NC	NC	Load Tester	Check for Spring	

Fig 2 Example of Program for Spring Testing Cell