AUTOMATIC INSPECTION AND PACKING OF MOULDED COMPONENTS.

Lyla Cobiac

Department of Mechanical Engineering, The University of Adelaide, Adelaide SA 5005, Australia.

ABSTRACT

This paper addresses the issues of automatic inspection and packing of moulded components in the Moulding Department at Schefenacker. The paper discusses the reasons behind the procedure taken in analysing the machine systems. That is, the reasons for selecting one-moulding machine and one component from that machine. The paper contains an analysis of the component, the J13 Rear Case, from moulding machine 10. Through the analysis of one product a series of Quality Control (QC) Requirements have been concluded for that specific component. To achieve the QC requirements by automation, detailed research, analysis and testing have been carried out with Machine Vision Inspection Systems (MVIS) and Laser Inspection Systems. The paper then proceeds to discuss the design criteria and several design concepts for the automation procedures of the J13 Rear Case. Associated with each concept are their advantages and disadvantages. A further inclusion in the design section is design concepts of an automatic bin transferal system. Included at the end is a discussion of the project feasibility.

KEYWORDS: QUALITY, AUTOMATIC INSPECTION AND PACKING, FEASIBILITY.

1.0 Analysis of the Machine Systems

Initially the project had been scoped for the analysis of 24-moulding machines. After spending several weeks analysing each machine system for the production of one part, it was decided, early in the project progress to focus on simply one machine. Within that one machine, only one product was to be analysed. The reasons for proceeding through the project in this way were to enable a solution to be obtained, given the time constraints and to also be able to provide an ease of analysis. Time permitted the other components produced by that machine will be analysed. Finally the design concepts developed for machine 10 will be applied to other machines.

Machine 10 was selected because it produces a variety of parts, both grain and gloss surfaces. The parts produced require both manual inspection and manual packing. Machine 10 also uses a Motoman robot that is common to several other machines. The intention of Schefenacker in future moulding operations is to use the Motoman robot.

1.1 Analysis of the J13 Rear Case – M/C 10

The J13 Rear Case (machine 10 part) was the first part selected for analysis. The part is a grain surface part and can be seen in Figure 1.

Figure 1: Photo of J13 Rear.

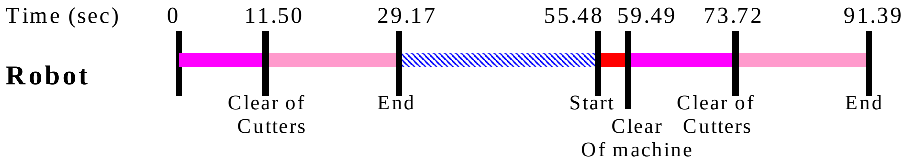

Figure 2: ‘Dummy chart’ of robot for J13 Rear Case production.

Included above in Figure 2 is the ‘dummy chart’ of the Motoman robot for machine 10. The chart shows the timing operations of the robot. The broken line indicates the period of non-operations. The reason for including the chart is that it will be utilised in the design section. The total cycle time is 62.18 seconds. ‘Dummy charts’ have been created for machine 10 and the tray associated with machine 10.

1.2 Quality Control (QC) Requirements

A series of tables for the J13 Rear Case have been established that analyses the QC requirements of that component. All features of the component to be inspected and their inspection techniques have been tabulated. Since, if the inspection is to be done automatically, then a list of features to inspect will be required.

The frequency of current and desired (by Schefenacker) inspection of each feature has also been tabulated. The frequency varies from some features being inspected at the start up of operations and every eight hours to some being inspected for every component produced.

A pass / fail criteria table has been established that defines whether a component will pass or fail inspection. Currently an operator defines where the line is drawn. Since operators are human and are rotated (i.e. several operators used,) therefore this pass/fail line will vary. The use of automation will provide consistency.

The packing requirements of the components in the bins have further been documented. Since each operator packs the parts in a different way, if the parts are to be packed automatically, then only one technique is required.

2.0 Machine Vision Inspection Systems (MVIS)

To enable the QC requirements to be achieved, several months have been spent exploring the concept of using a machine vision inspection system.

2.1 DVT System

Initially it was recommended to use the Digital Video Technology System since it was already in use at Schefenacker. To ensure whether the system would be able to meet the QC requirements, a series of tests were carried out with the consulting firm, Micromax. From the tests, it was concluded that the system would be unable to meet the requirements. The system was unable to detect surface defects and instead detected light reflections as defects.

2.2 MVIS Criteria

Since the DVT system was unable to meet QC requirements, a list of criteria for a MVIS was formulated. Such criteria included the ability to inspect part surface finish, the ability to perform inspections in the presence of lighting configurations, the inspection time and the ease of usage of the system.

2.3 Internet Research

Research was carried out over the Internet to establish a list of companies and products dealing in MVIS. From this research, information about the different systems available was compiled. Systems differ in the fact that they may have all components in-built (stand-alone capability) or components may be externally connected. Systems further differ in their programming abilities. Some systems require programming via the use of a PC whereas other systems are self-learn devices.

From the research, two companies were selected to perform preliminary testing of their systems. The companies, both Melbourne based were Sci Tech and Pulnix. Australian-based companies were selected as a first choice for their closeness of location and ease of interaction. (That is, spare parts or service will take less time to obtain than if a foreign company is used.) Parts (gloss and non-gloss surface) sent to these companies were received by the end of July. Before sending the two different gloss parts, 'dummy charts' and quality control requirement tables were created as done for the J13 Rear Case. To date, the outcomes from the testing are still unknown.

Two further companies were chosen to perform testing. Parts were sent to the companies Fabrication Australia (FAH) and National Instruments (NI) at the end of August. FAH uses laser inspection systems as well as MVIS. Such systems use laser beams to perform surface inspections. Furthermore an overseas company may be chosen, to perform testing, depending on the outcomes of the Australian testing.

3.0 Design

3.1 Preliminary Design Concepts

Initially, before it was decided to use a MVIS, more than 30 different preliminary design concepts were formulated. These concepts included ideas for use of the original robot to inspect and pack, use of two robots to inspect and pack and concepts for an automatic bin transferal system. A series of tables were established to evaluate each of the concepts.

3.2 Design Selection

Design selection at this stage has been for the J13 Rear Case for Machine 10. It was decided to use the original robot and not a second robot due to the high costs of purchasing a second robot and also because there is enough spare capacity for the existing robot, as revealed by the 'dummy chart'.

From the use of the "dummy chart" of the robot, it was determined that there is 44 seconds per cycle, available for further manipulation (spare capacity), after the robot has performed necessary operations (i.e. after the sprue feature has been cut).

3.3 Design Concepts

At this stage, two concepts have been selected from the 19 applicable concepts. These concepts are the most applicable for the J13 Rear Case. It should be noted that until the MVIS has been selected, then the design concepts cannot be finalised.

3.4.1 Concept One

The step-by-step operations of the design can be seen below in Figure 3.

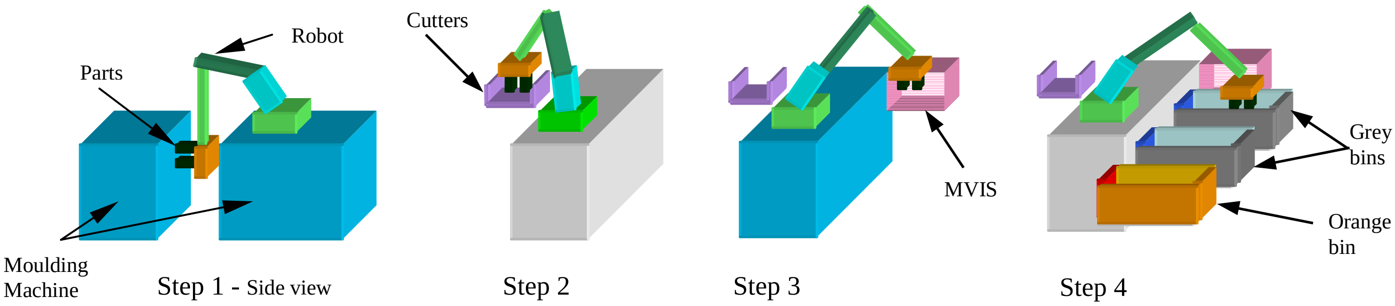

Figure 3: Concept 1 – steps 2-4 are an end view from the rear inner die

Step 1: Parts are removed from the die by the robot.

Step 2: Robot moves parts to cutters where sprue is cut off (necessary operation as indicated on the 'dummy chart' by the words 'clear of cutters').

Step 3: Robot moves parts to MVIS where parts are inspected.

Step 4: Robot packs good LH part in one grey bin and good RH part in other grey bin. Note that reject parts by the MVIS would be placed in an orange bin.

Time: This concept, as an estimate would require 4 seconds to move the parts to the MVIS, 10 seconds to inspect the parts, 18 seconds to pack the parts and a further 4 seconds for the robot to move back to its start position. Thus concept one occurs within the 44 seconds allocated for further robot manipulation.

The advantage of concept one is that the part orientation is retained. The disadvantage is that there is a short time allocated for inspection. Depending on the MVIS used, this may not be a disadvantage.

3.4.2 Concept Two

Operation step 3 of the concept can be seen in Figure 4.

Step 3:

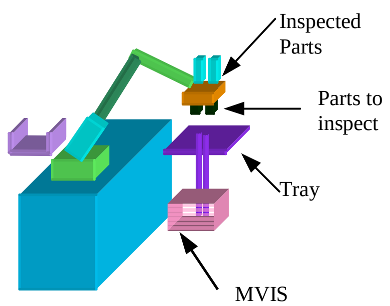

Figure 4: Concept two.

Steps 1,2 and 4 are the same as concept one (see Figure 3). This concept differs in that a double-sided end-effector that can collect parts on both sides is used, as seen in Step 3.

Step 3: The robot collects the inspected parts from tray. The robot flips the end-effector and places the parts to be inspected on the tray. The tray lowers to the MVIS where the parts are inspected and rises after inspection. This process occurs simultaneously with Steps 4 and 5.

Time: Estimated time for step 3 would require 10 seconds to collect the inspected parts and 8 seconds to place the parts to be inspected on the tray. Thus concept two occurs within the 44 seconds allocated for further robot manipulation. Note that 20 seconds would be allocated for the tray and MVIS operations.

The advantage of concept two is a longer period of time for inspection. Depending on the MVIS used, this may not be an advantage. The disadvantages are the loss of part orientation and a new end-effector is required.

3.5.1 Bin Transferal Concept One

As with the design concepts, two concepts of the 14 bin transferral concepts have been chosen as possible solutions. Figure 5 shows the step-by-step operations.

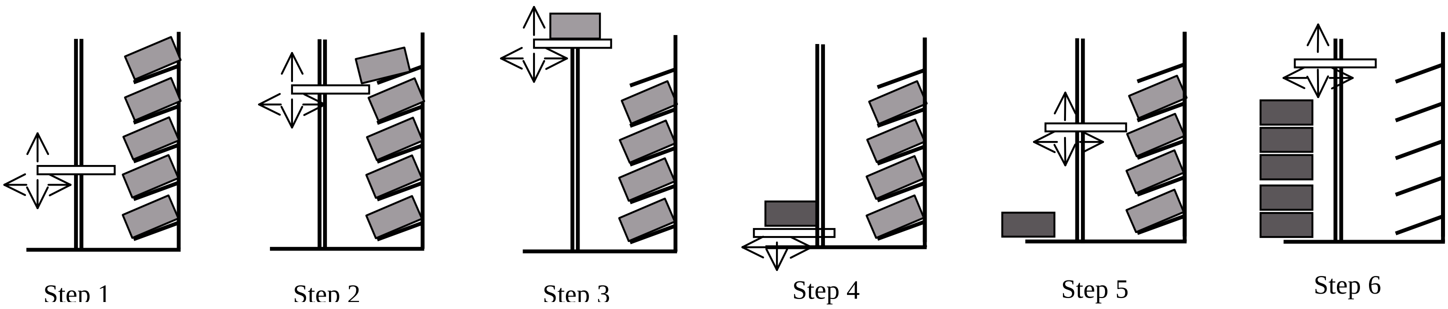

Figure 5: Concept one – side view

Figure 5 shows the bin transferral for one part (i.e. LH). Note that a second system would be set up parallel (i.e. into the page for the RH part).

Step 1: Bins are brought in and fed into the shelves.

Step 2: The tray moves vertically and horizontally to an empty bin. Rollers on the shelf and tray are activated. The bin slides from the shelf to the tray.

Step 3: The tray rises to its maximum vertical position where the bin is packed.

Step 4: Once the bin is packed, the tray lowers and slides to the left. The rollers are activated on the tray and simultaneously, the tray moves to the right. Consequently the bin slides off onto the ground or stack of packed bins.

Step 5: The tray moves to the next empty bin in the shelves.

Step 6: Eventually all packed bins will be stacked in a pile.

Time: This concept, as an estimate would take 5 seconds for the tray with the packed bin to lower. A further 10 seconds for the bin to roll off the tray, 5 seconds for the tray to rise, 10 seconds for an empty bin to roll onto the tray and 3 seconds for the tray to rise to the top. Thus a total time of 33 seconds is required to transfer a bin. This time occurs within the cycle operation time of 62.18 seconds.

3.5.2 Bin Transferal Concept Two

The step-by-step operations of the concept can be seen in Figure 6 below.

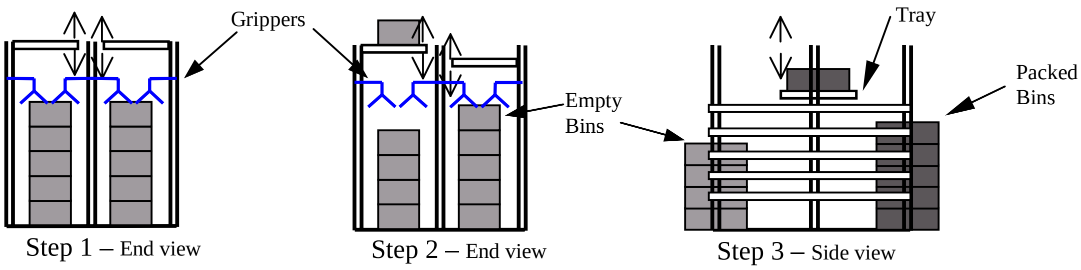

Figure 6: Concept two

Step 1: The grippers collect an empty bin and place it on the tray.

Step 2: The tray rises to its maximum vertical position where the bin is packed.

Step 3: The tray then lowers and the grippers collect the bin and place it on a stack of packed bins. Note that the grippers can move up and down the three vertical tracks and horizontally along the horizontal tracks. The tray can only move up and down the middle track.

Time: Estimated time is 5 seconds for the tray to lower to the packed bin level, 15 seconds for the grippers to grip the bin, transport it to the stack and release the grip. The next step of collecting the next empty bin and placing it on the tray would take 15 seconds. A further 5 seconds would be required for the tray to rise to the packing position. Thus a total 40 seconds to transfer a bin. This time occurs within the cycle time of operations of 62.18 seconds.

4.0 Feasibility

The costs involved with this project can only be estimated at this stage until the MVIS has been selected. The costs will be that of a MVIS and also that of a bin transferal system. MVIS range from $4 995 to approximately $60 000 - $70 000. A bin transferal system of a similar nature already in use at Schefenacker cost $14000 to implement. It is expected that both concepts of section 3.5 would be of a similar cost. Note that the benefits and savings of the project will be a reduction in labour costs, the packing of quality assured components and an increase in the usage of the robot.

5.0 Discussion

Throughout this project, I expected to be able to find a MVIS within the time period of a week. Thus far, more than two months research, testing and work have been spent. The difficulty in selecting a suitable MVIS lies with the inability of the systems to be able to inspect plastic surface finish for defects. A future recommendation if the MVIS prove unsuccessful is to develop a system as part of a joint project with the Adelaide University.

6.0 Conclusion

It is expected that the implementation of a MVIS and further robot manipulation will result in quality assured components being packed. The use of an automatic bin transferal system will fully automate the procedure for machine 10 and as such will result in both benefits and savings to Schefenacker.

7.0 Acknowledgements

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