PLC Programming of A Machine Tending Robot for CNC Operations

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***Abstract*— Machine Tending refers to the process of automating the loading and unloading of industrial machine tools in a manufacturing plant, primarily using robot automation systems. While loading and unloading is the primary function of machine tending systems, often the robot performs other valuable functions within the automation system such as part inspection, blow off, wash, deburring, sorting, packaging and gauging.**

The advent of CNC machine tools caused a revolution in machine manufacturing industries. Manufacturing doubled and tripled due to high productivity of these machines. Rejection of machined components reduced extensively as CNC machined parts were more consistent compared to manually machined parts. The next step was automation of CNC machines. Machine tending is a boring monotonous simple job, but it is an essential job which can adversely affect the production target. Lack of consistent availability of manpower is one of the most common problems encountered in machine tending. Hence CNC manufacturers introduced automation customized for machine tending. These systems faced hurdles such as high capital investment, space constraint. Part manufactures introduced wanted a cost- effective solution that could be retrofitted into their existing setup. This need was identified by automation service providers and economical Advanced Machine Tending Robots (MTR) were designed that could be retrofitted in the current setup. However, the mechanisms designed and used were not able to handle delicate components.

***Keywords*— *Machine Tending Robots, loading and unloading system, CNC machine, automation system*.**

I. INTRODUCTION

Advanced Machine Tending Robots is an ever-increasing demand for mass produced auto components. The manufacturers of these machines outsource the production of machine components and only focus on assembly and testing of the machines. In order to meet the manufacturer's demand, the machine component suppliers have switched from traditional machining to CNC machining for improved productivity and quality. Even though the requirements for highly skilled manpower for machining is resolved, the CNC machines still need an operator for tending the machine for activities such as component loading and unloading into the CNC machines. This is a monotonous job where the operator has to do the same adversely affect demand. Hence suppliers are now installing MTRs for effective part loading and unloading on CNC machines.

One of the robots used for machine tending is the industrial articulated robot. This is an extremely versatile solution as it has 6 degrees of freedom and can load components in any given orientation. This solution requires high capital investment and larger workspace given its work volume. In most cases, the suppliers have a well-established and running setup and they need a solution that can be retrofitted on an existing CNC machine without occupying more floor space. Current MTRs are designed and built up to be retrofitted for a set of CNC machines of a given standard. They may have two or more moving axes to achieve desired manipulator motions to get the job done. Hence, they are very economical compared to standard industrial robotic solutions.

Gravity Feeding Method

This MTR uses a single magazine or multiple magazines for feeding components to the loading gripper. This method is most suited for components that can be picked up by internal grippers as an external gripper cannot pick up the component due to magazine constraints. The magazine is designed and mounted at an inclination sufficient enough for the components to slide down. The finished component dropped into the delivery chute. The delivery chute is gravity acting having suitable shock absorbing material lined inside to prevent component dents and scratches. It ends at finished component bin.

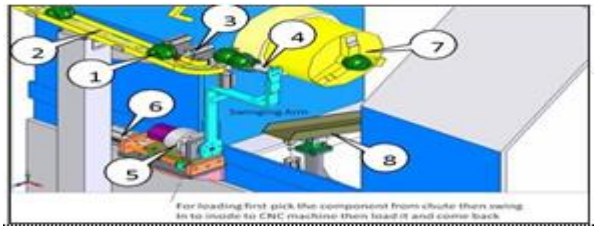

Fig.1: Initial condition (Ready for loading)

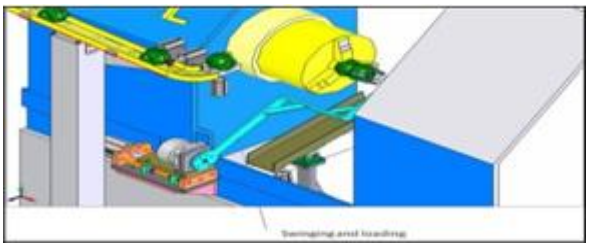

Fig.2: Final Conditions (Loading and Unloading)

The Component (1) is fed by specially designed chute (2). In chute the parts fed one by one using singling cylinders

(3). The three-point gripper (4) is used to pick the component from the picking location. This gripper assembly is mounted on the swivel module (5) which will swivel from 0 to 60 degree and then return 0 degree. Zero's position is component picking location from chute and 60-degree position is loading position to chuck. The whole assembly is mounted on cylinder (6), this cylinder will actuate for picking and loading of the component.

The unloading of the parts automatic, after the completion machining cycle chuck (7) will open, then the parts will be drop into the output chute (8) and the part is diverted nearer to the outer diameter inspection setup next to machine by chute. The loading of the part will have continued until operator intervention to modify the depth of cut according inspection of outer diameter.

II. METHODOLOGY

The methodology involved in programming the of a machine trending robot for CNC operations is as shown in the below flowchart.

- Analyze the 3D model mode by the design team for the new system. Note all moving axis, actuators, Sensors.
- Based on motion control concepts, list out all required electrical accessories and I/O of the machine.
- Prepare a BOM and make a control panel layout design such as auto CAD.
- Estimate control Panel size based on layout and prepare a wiring diagram
- Assemble Control panel as per approved panel layout drawings.
- Complete machine field wiring and mount the panel on the machines
- Identifying the conditions to be satisfied.
- Configuring the PLC Hardware.
- Writing the ladder logic program on the PLC software based on the application requirements.
- Simulating the program and checking for faults in the program.
- Downloading the program to the PLC memory.

III. THE FUNCTIONS PROGRAMMED IN PLC

The following are some of the functions of the machine that are achieved through PLC programming.

1. Auto Mode: This is the production running mode in which the machine runs continuously, once started. It is in this mode that the actual production happens. The machine is programmed so as to run in the auto mode once the homing is done. In case of faults during this mode, the machine comes to a halt either instantly or after reaching home position, depending on the priority of the fault. The conditions to be considered while programming for the auto mode are as follows-

- The Emergency PB should be released.
- The Selector Switch should be turned on to Auto mode.

2. Jog Mode: The machine will run only for the time that the Jog push button is pressed. The machine can be made to move in very small steps. The movements of the machine can be carefully observed to find eventual problems in the working cycle of the machine. The conditions to be satisfied for the jog mode include-

- The emergency PB should be released.
- The selector switch should be turned on to manual mode.

3. Manual mode: - Operation carried out by human labour rather than automatic.

4. Homing: Used to define a multi-axis homing sequence HOME ALL and enforce homing order (e.g., Z may not be homed if X is not yet homed). If two axes have the same HOME_SEQUENCE, they may be homed at the same time.

5. Loading and unloading cycle: The Component is fed by specially designed chute. The three-point gripper assembly is mounted on the swivel module which will swivel from 0 to 60 degree and then return 0 degree. Zero's position is component picking location from chute and 60-degree position is loading position to chuck. The unloading of the parts automatic, after the completion machining cycle chuck will open, and then the parts will be drop into the output chute.

6. Door: The programming ensures operator safety by enabling the machine to run only when all the doors are closed. To achieve this, the doors are provided with sensors.

7. Faults: The faults that would cause damages to the machine or would result in hazard to the operator are treated on first priority by making the machine stop immediately if those faults occur. Robot has safety interlocks/Poka-yoke, by using sensors, prevents accidents and eliminates risk to men and machines. The faults are displayed on the HMI screen when they occur.

IV. CONCLUSION

The MTR that is auto loading and unloading system is made of pneumatic system. The operating time for single work piece were 90 secs in the existing system. The work piece machining time is 35 secs. The work piece loading and unloading for the component is 55 secs. And the system is more reliable and overall cost of the machine is reduced. The system is made simple to install in customer place. The aluminum frames are made easy to assemble with gusset and t-nuts. The system is made reliable since it can be stopped in any intermediate position

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