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Machine Logic Program Development and Electrical Design of H Gantry Automation System for Compressor Housing

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Abstract-Automation is one of the growing fields ,and is being used at levels from small scale industries to very a large scale industries due to the advantage of increase in productivity and quality, along with it recently new revolution in the automation 4.0enabling the data monitoring possible which helps in better control and monitoring of machineries and equipments. The objective of the work is to design electrical circuit and perform suitable control actions such as loading and unloading of heavier components to machines, indexing, providing suitable safety for the devices and improvising productivity and quality rate in the production line. These activities are being done by a control system adopted to gantry system, in such control systems there will be provision for manual control, auto mode, jog mode & edit mode to enable the work to be carried out smoothly and effectively. Such complete system is designed to reach the customer required production cycle time with 6 axis (y,z1,z2,x1,x2,c), these axis are controlled by CNC controller and all other Stations like IPC, OPC, tilting stations are controlled by the PMC controller, which is the part of CNC.

Keywords— Industrial Automation; Gantry Systems; Productivity; compressor housing component, CNC, IPC, OPC, PM

I. INTRODUCTION

Automation has been achieved by combining various inter disciplinary areas mainly, mechanical, hydraulic, pneumatic, electrical, electronic and computers. Usually in combination of complicated systems are used in industries, airplanes and ships [1]. Industrial automation is the technology which is used to increase production rate and quality of production in the industries. Many automation techniques are used to automate the industrial production, gantry automation is one of the major automation techniques for in line production automation. It is a kind of flexible automation method which can produce a variety of products with virtually minimum time loss for changeovers from one product to the. Gantry Controller is a combination of CNCs, computer software, and hardware. The CNCs are soft wired system that makes its flexible for the different operations [2].

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In gantry as the number of devices in the system grows, field devices need to exchange rapidly increasing amount of data among them. Conventionally, these devices are connected with point-to-point or direct connections where each piece of information is exchanged via at least one cable [3].In order overcome this type of complex communication profibus is used which is economical and efficient

II. GANTRY LAYOUT FOR MACHINING COMPRESSOR HOUSING

The aim of the project is to build the machining and inspection line for different types of compressor housing. The Fig1.shows the typical compressor housing, there are 4 types of compressor housing run in different production cycle, which is to be handled by designed gantry. The gantry should be cable of picking different compressor housing from different height. The layout of gantry consists of series of automated stations along with machining station. Each station can be operated through auto mode and jog mode, the stations are discussed individually in the subsequent section. . housing.

Fig1: Typical compressor

A. IPC:Input Product Conveyor(IPC)

Is an input conveyor where the casted parts are loaded on indexing conveyor. The gantry layout has 2 rows of IPC; the IPC is designed in such a way that it carries different parts at different production cycle. Poka yoka arrangement provided for detection of wrong part in wrong product cycle, the loader always prefers row 1 while picking the part from IPC. If part is not present in row1 then it will prefers row 2.The IPC conveyor layout is shown in Fig 2. The designed gantry system consists of two turning machine connected to IPC for turning operation on compressor housing. A special station in the middle next to turning centre is used to store seat rejection part from the machine, this station is provided with light curtain to initiate the over flow of rejection part.

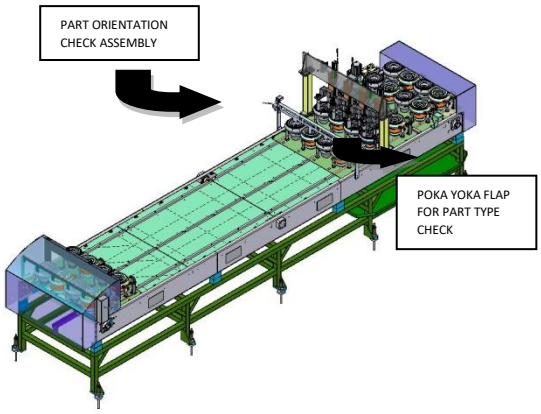

Fig2: Layout of IPC.

B. Tilting station:

Tilting station is provided to achieve change in part orientation between the machine stations and tilting station orientation, these are achieved through servo drive along with lifting cylinder. The Fig.3. shows the layout of tilting station.

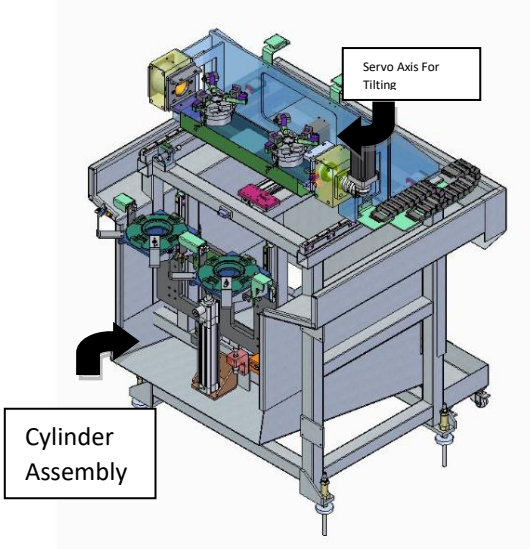

Fig3: Layout of tilting station.

C. OPC:

Output Product Conveyor is designed to eliminate two separate operations namely laser marking and air cleaning stations. In the conventional system the product has to pass through two different station and which involve material handling and more labour, which is eliminated through a single *(*OPC) output conveyor. The output conveyor is palletizing conveyor, which is driven through induction motor and provided with individualiser to avoid collusion of pallets. The pallet locking cylinder is provided at picking and dropping end of OPC, the layout of OPC is shown in Fig4.

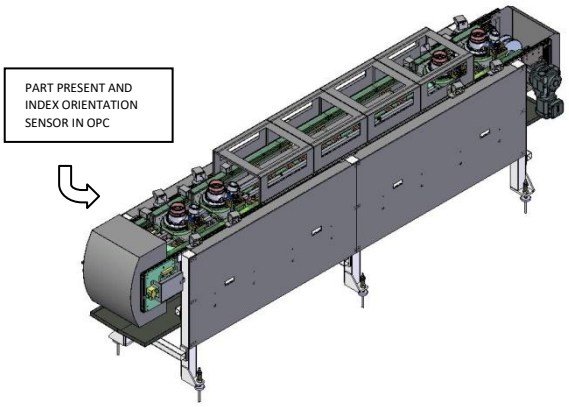

Fig4: Layout of OPC.

The product so produced is inspected using SPC.

D. SPC:

Special purpose chute, this is a special station which is used to request the part for manual inspection. It is added to the sequence only when request or reload signal is given, otherwise SPC will be bypassed. The Fig 5 Shows layout of SPC.

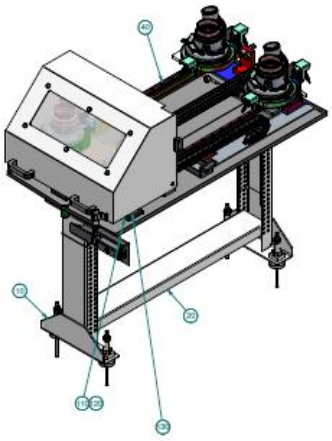

Fig 5: Layout of SPC.

The sequence of operation of gantry loader's is listed in table 1.

Table1: loader sequence of gantry

SLNO	STATION	LOADER	OPERATION
1	IPC ROW1	LOADER-1	UNLOAD IPC R1
2	NOK	LOADER-1	DROP AT NOK
3	IPC ROW1	LOADER-1	UNLOAD IPC R1
4	OP 10 MACHINE	LOADER-2	UNLOAD OP 10
		LOADER-1	LOAD OP 10
5	TILTING STATION	LOADER-1	UNLOD INDEX STATION
		LOADER-2	LOAD INDEX STATION
6	OP 20 MACHINE	LOADER-2	UNLOAD OP 20
		LOADER-1	LOAD OP 20
7	AIR CLEANING	LOADER-1	UNLOAD AIR CLEANING STATION
		LOADER-2	LOADING AIR CLEANING STATION
8	LASER MARKENING	LOADER-2	UNLOAD LASER MARKING STATION
		LOADER-1	LOADING LASER MARKING STATION
9	SPC SHUTTLE	LOADER-2	LOAD SPC
		LOADER-2	UNLOAD SPC
10	OPC	LOADER-2	LOAD OPC

III. ELECTRICAL CABINET AND SAFETY CIRCUIT DESIGN:

In gantry system the I/O's are distributed throughout the gantry, in order to power such a distributed system electrical design has been developed. Electrical panel is the system which provides power to the entire system, while designing the electrical system the main concerns are systematic power distribution, machine and human safety. Before designing panel these are divided into different circuits like power circuit, power modulation circuit, distribution circuits, drive circuit, safety circuit, control circuit, field distribution circuit etc. In each division of circuit design the safety of the circuit is considered by using different protection devices like MCB, MCCB, phase monitor device etc. with safety, considering ease of maintenance of the system suitable lugs, terminal blocks, junction boxes, ferules are used.

A. Power Circuit:

Power circuit supplies power to the entire system, and there will be provision provided for isolation of power from the system for maintenance. While designing power circuit we should also consider cabinet cooling and lighting circuit.

B. Power Modulation Circuit

In electrical panel different electrical peripherals require different voltage or current, in order to get this different power rating, SMPS (switch mode power supply) are used as power modulators. The number of SMPS is decided by load current and voltage level.

C. Drive Circuit:

The drive circuit is designed as per the number of servo axis along with their configuration, an isolation transformer is provided for the servo supply circuit. The isolation transformers for servo axes are calculated for the 60% of total load current of servo configuration. In gantry system at a time only one servo axis will be driving, servo brakes release coil will be energized only if servo is healthy and ready.

IV. CONTROLLER CONFIGURATION

The above gantry layout has six servo axis; the servo drive for each axis is selected as per the rating. The highest load capacity of y axis servo has independent drive, the two same rated servo z axis are combined in one servo drive, rest of the three servo axis are combined together in one single servo drive as shown in Fig 6. The servo axis is to be controlled along automated gantry station in order to achieve systematic control. CNC is used as the master control of the system

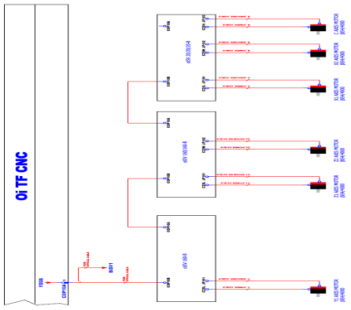

Fig 6: servo configuration with CNC controller.

A. Servo Amplifier:

The servo amplifier is the device which controls the servo drive with reference to feedback signal, and it is a closed loop system. The servo amplifier consists of combination of rectifier and inverter is shown in Fig 7. The rectifier converts AC signal to DC signal, which is further converted into required frequency AC signal by an inverter with the help of PWM (pulse width modulation) technique. The PWM technique helps in precise frequency control which intern helps in precise position and speed control, the relations of N, F and P are given in the equation [1]. Whereas N is speed of motor, F is frequency of supply & P is number of magnetic poles.

N=120F/P…… [1]

In the gantry system the servo drive is monitored through CNC controller, hence CNC is the master controller and servo drive or amplifier is slave controller.

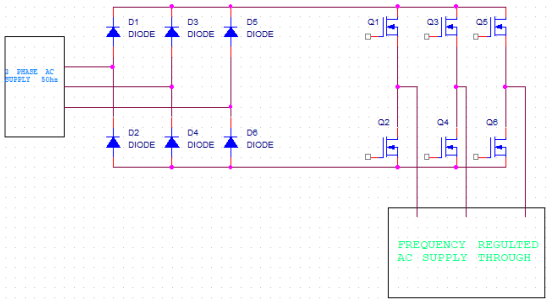

Fig 7: servo amplifier.

B. Configuration of Servo in CNC

In gantry system there will be many servo axis, this servo axis is configured in CNC by setting the speed, acceleration, torque, travel limit and axis position etc. In order to achieve above configuration in CNC there will be certain pre-defined parameter numbers, this parameter number change as per the model & manufacturer. The system use Fanuc oi-tf model CNC and its parameters are shown in table 2.

Table 2: Parameter number and description

Description	Parameter
Total no of Axis	987
Set the path Number to which axis belongs	981
Axis Type 0: Linear 1: rotary	1006
Control Axis Name	1020
Plane Selection	1022
Sequence of servo Axis	1023
Enable servo setting screen display	3111
Enable Spindle setting screen Display	3111
H/W Over travel Bypass	3004
Servo Loop Gain	1825
In Position width	1826
Position Deviation at running	1828
Position Deviation at stop	1829

Dry run Federate	1410
Maximum Rapid rate in Program	1420
Maximum Feed limit in all axis	1422
Maximum feed Rate at cutting	1430
Maximum Feed rate in Jog	1423
Maximum Rapid rate in Jog	1424
Reference return feed rate	1425
Rapid Acc/Dec time constant	1620
Feed Acc/Dec time constant	1622
Jog Feed Acc/Dec time constant	1624
ZERO REFERENCING	1815
Axis Interlock Disable	3003
Axis Interlock Disable	3003
Axis Interlock Disable	3003
DFS	14476
DGP	2000

V. GANTRY AUTOMATION:

Gantry automation system is incorporated with many stations, In order to achieve synchronise operation between servo axis and automated stations, CNC is used as a control unit for entire gantry automated system and it is shown in Fig 8.

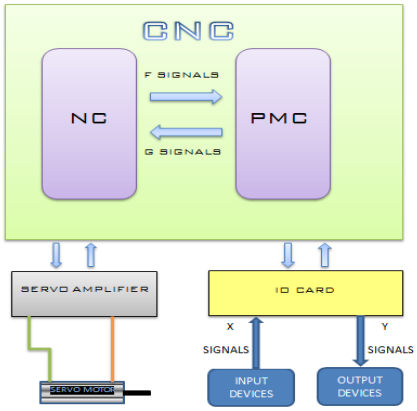

Fig 8: Schematic Representation of CNC Controller.

In NC programming, sequence of instruction is entered; this defines sequence of operation of the gantry system. The sequence of instructions also defines speed, interpolation and checks for logical interlocks. PMC is used to build logic for machine operations. It uses the ladder language for logic development and there is continuous communication through PMC and NC control. The logic for each station is built in PMC; the operation of each station is operated with respect to feed back of sensor signal and logic built in PMC.

VI. GANTRY SYSTEM PROGRAMMING.

The programming of gantry takes place in two sections, one is PMC programming and NC programming.

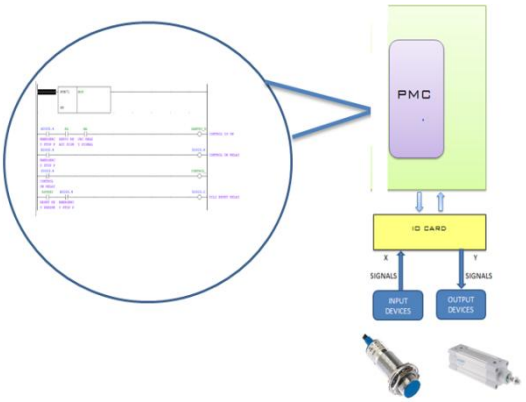

Fig 9: Schematic Representation of PMC Programming.

A. PMC Programming:

The PMC programming is used to communicate external hardware components to the CNC Controller, the Schematic representation as shown in Fig 9.This external hardware signals helps to build machine logic, by using ladder logic. PMC ladder logic is similar to PLC ladder logic, unless there is some special signals bits called g signals, f signals, position switches and macros. This special signals help in building ladder logic with respect to system parameter. M-Codes are used to activate external hardware signals, G signals are used to activate system outputs of control and F signals are system feedback signals. these signals are having dedicated address for dedicated function.

B. Position switches:

In Fanuc CNC system there is pre-defined 16 position switches per channel of CNC. The Fig 10. shows the ladder logic for axis interlocking, where F70.0- F71 is 16 position switches for defining the range of position. The ranges are used as AND logic.

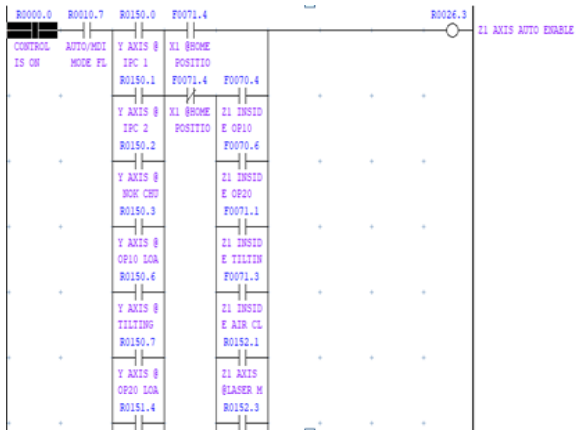

Fig 10: ladder logic for axis interlock.

C. NC Programming:

NC program is a technique where the sequence of operation is to be entered. In numerical program the sequence is divided into fragments m1 loading and m2 unloading etc. Then this fragmented sub programs are called in sequence of main program, this calling of sub program will only execute if pre-defined conditions is satisfied.

There are also some special sub programs involved such as home recovery program, empty cycle program and teach value programs. Fig 11 shows flow chart of NC- sub program sequence.

The designed gantry for compressor housing has been implemented at tested at customer site the total production rate one part requires 62.5 seconds and which is 30% less the earlier cycle time.

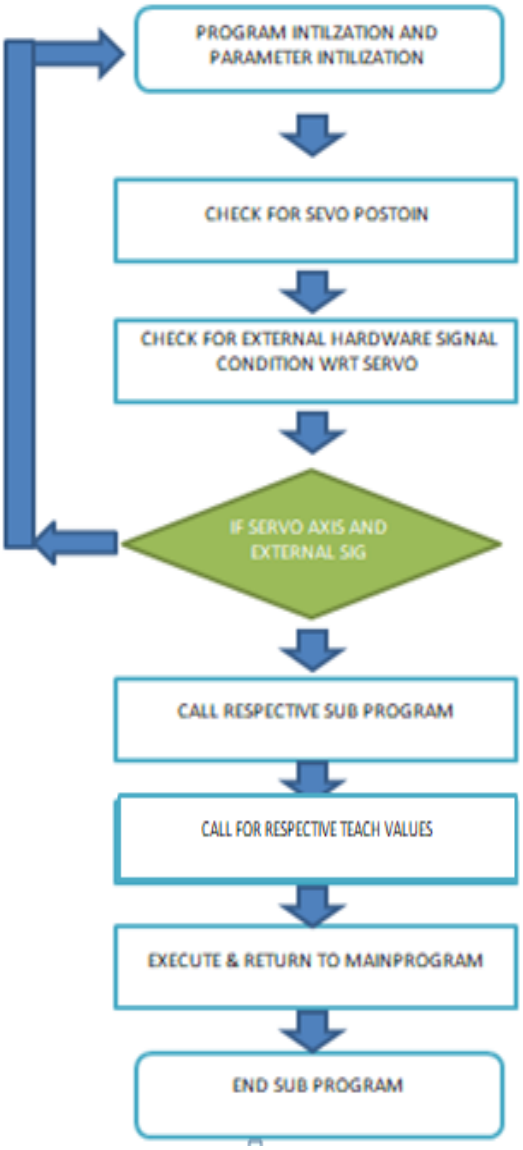

Fig 11: Flow charts of NC sub program sequence

VII. CONCLUSION

The objective of work is reduce the fatigue in handling heavier components for further processes in manufacturing production lines, in this an attempt has been made to design of gantry for transferring component of compressor housing in manufacturing and machining line of continuous discrete manufacturing industry, the results improved the production rate. The un-interrupted production rate is 62.5 sec per part,actually for one production cycle it takes 125 sec with 2 parts at time as finished product. This resulted in increase in 30% of the production rate. The gantry automation also provides provision for manual inspection with the help of SPC. The gantry is also designed with suitable electrical safety circuit in order to provide safety for machine peripherals and human machine interface

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