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# Automation of Endurance Testing Machine for C Arm of X Ray Scanner System using PLC

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**ABSTRACT:** Endurance is the capacity of something to last or to withstand wear and tear. Present work is to design and develop a PLC based automated Endurance testing machine to examine the endurance of C Arm of X Ray Scanner System. Initially a control panel is to be developed as per the design of endurance testing machine by proper selection of components. The C arm X-ray scanner system has the feature to rotate in various directions like orbital motion, wig wag motion, horizontal movement and c-rotation. The endurance testing machine helps in moving the C arm in all required directions and checks for the lasting power of the C Arm of X Ray Scanner System. Control system for the Endurance Testing Machine includes use of PLC interfaced with HMI, so that automation and sequential flow of the testing machine is achieved.

**KEYWORDS:** Endurance Testing, Automation, C Arm X Ray Scanner System, PLC and SCADA

## I. INTRODUCTION

Due to the rapid advances in technology, all industrial processing systems, factories, machinery, test facilities, etc. turned from mechanization to automation. A mechanization system needs human intervention to operate the manual operated machinery. As new and efficient control technologies evolved, computerized automation control is being driven by the need for high accuracy, quality, precision and performance of industrial processes. Automation of the endurance testing machine is also a part of these advances. This project helps us to check the endurance of the system. The programming can be done such that the system can be made to run in the required sequential order. The automated system needs a dedicated hardware and software for implementing control and monitoring systems, both are developed for proper functioning of the endurance testing machine.

A control panel for the endurance testing machine is developed to assure the quality of the C-Arm X Ray Scanner System. The endurance testing machine is designed such that it moves in horizontal direction, wig wag motion, C-rotation and orbital movement. The endurance testing machine fitted into the C-Arm of X Ray Scanner System, explained in methodology. The testing machine rotates the C-Arm in all the required directions and checks for proper functioning of the product. In this project, the endurance testing machine is automated by developing a control panel using PLC. The proposed block diagram representing the working of control panel with PLC is shown in further sections.

## II. LITERATURE REVIEW

Francesco Basile et.al [2], K. Gowri Shankar [3] describes about the industrial automation system using PLC. Industrial automation is largely based on PLC based control system event driven approach to improve the design of industrial control systems using commercial PLCs also explains about automation of boiler using PLC-SCADA.

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Wang Huiqiang et.al [5] showed the control system of belt grinder that included use of PLC and HMI. Similarly, for the automation of the endurance testing machine, PLC and HMI can be interfaced and programmed.

**Problem Formulation**

Since the control panel is being manufactured for the newly developed endurance testing machine, various concepts from various papers is referred. Details are as shown below;

- Endurance testing of products [1], the author described methods of ensuring quality of HVDC cables hence informing about the importance of endurance test for manufactured products in industries. In this project endurance testing is carried out for C Arm X Ray Scanner System.
- Implementation of industrial automation system using PLC [2]. The industrial automation is largely based on PLC based control system; event driven approach is used while designing the program. Similar concept is adopted in the project, the programming in the PLC is done as per the sequence of events i.e., event driven approach.
- Automation of manually operated boiler [3] by interfacing PLC-SCADA. The boiler operation is fully automated considering all the needs of industrial sector. Similarly, the endurance testing is completely automated by establishing interface between PLC and HMI.
- The use of multiple Input/Outputs in PLC [4], there are multiple inputs/outputs to be operated from/to endurance testing machine. Hence use of a multiple Input/Outputs PLC would be easier. The author showed the use of such PLC.
- For further ease of automation, PLC is interfaced with HMI in the control system. This concept is described in [5]. The author showed the control system of a belt grinder which is using PLC along with HMI.
- The endurance testing machine contains induction motor, and for proper operation the speed of the motor is to be varied, it can be achieved by using VFD fed 3 phase induction motor, since PLC is being used [6] gives a brief idea. PLC is being used for the automation and even induction motors are present in the machine and hence [8] helps us know about induction motor being controlled by PLC and VFD hence making it easy to manufacture control panel.

Considering all these concepts a control panel that includes a PLC to control all the control actions, a HMI to achieve interaction with outside world, VFD's fed to induction motors etc is to be developed.

## III. PROPOSED METHODOLOGY

This section shows the proposed methodology, control panel block diagram and the project implementation steps.
Fig 1 shows the endurance testing machine fitted into the C Arm of the X Ray Scanner System. The endurance testing machine is designed such that it moves in horizontal direction, wig wag motion, C-rotation and orbital movement. The endurance testing machine fitted into the C-Arm of X Ray Scanner System. The testing machine rotates the C-Arm in all the required directions and checks for proper functioning of the product. In this project, the endurance testing machine is automated by developing a control panel using PLC. The proposed block diagram representing the working of control panel with PLC is shown in fig 2.

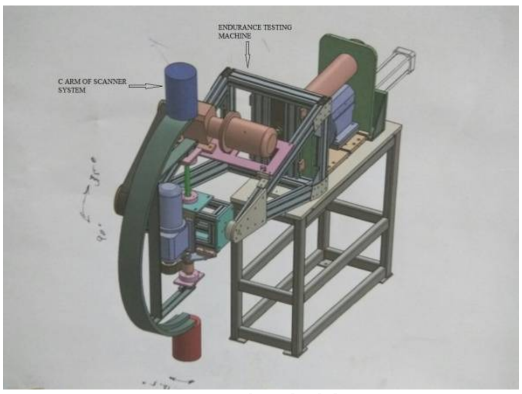


**Fig 1:** Proposed methodology

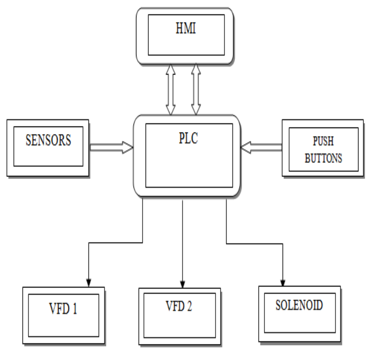


**Fig 2:** Control Panel Block Diagram

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Project Implementation Steps:
Steps involved in implementation of the project are as shown in fig 3;

- **Data Collection:** The required necessities for ease in operation is studied, data regarding it is collected, input/outputs to the system, required components for the system are collected.
- **Control System Design:** Involves the design of control panel, programming in PLC and HMI.
- **Testing and Modification:** After the control panel is interfaced with machine it is tested for proper functioning. If there is no satisfactory output, modifications in the program is done else commissioning is carried out normally.

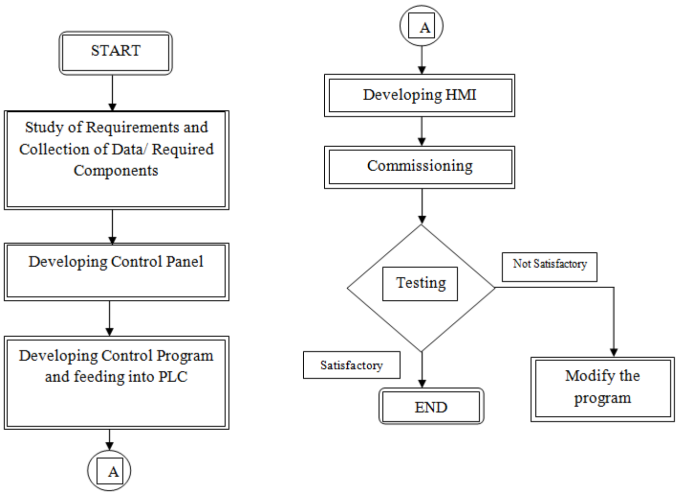


**Fig 3:** Implementation Steps of the Project

## IV. DESIGN OF CONTROL PANEL

Control panel being manufactured for the endurance testing machine mainly consists of Programmable Logic Controller (PLC), Variable Frequency Drive (VFD), Human Machine Interface (HMI), relay boards, SMPS etc. These components are wired and are further connected to the endurance testing machine. A brief block diagram showing the connection between the control panel and endurance testing machine is shown in fig.4. The block diagram just gives a brief idea about the connection between the endurance testing machine and the control panel that is to be manufactured. The proximity sensors are inputs to PLC. The position of different movements whether at home position or at end position is given to PLC through proximity sensors. As per the programming done, actuating output signals are given to VFD fed induction motors, which results in the movement of the C-Arm in the direction given by the operator i.e., on actuation of 0.75HP motor C rotation takes place where as on actuation of 1HP and 0.5HP motor orbital and wig wag motion takes place respectively. The interfacing between the PLC and HMI makes it easy to operate the C Arm in required directions manually or in auto mode.
Components with specifications used in control panel –
Control Panel 1 –
SMPS: Omron manufacture 24VDC, 2.1A.
PLC: Main Block I/O 8/6, Extension Block I/O 8/8.
MCB: 2Pole, 2A.
4 channel relay board
Contactors
8 channel relay board
Transformer: 440V/ 230V.
Control Panel 2 –
MCBs: 3pole, 10A.

Relays
VFD: INVT manufactured 0.75kW (1HP), 3ph, 415VAC VFD.
VFD 1- connects to 0.75HP motor, responsible for C rotation.
VFD 2- connects to 0.5HP and 1HP motors, responsible for wig wag and orbital motion respectively.
Fig 5 and 6 shows the developed control panel that contains the control panel components;

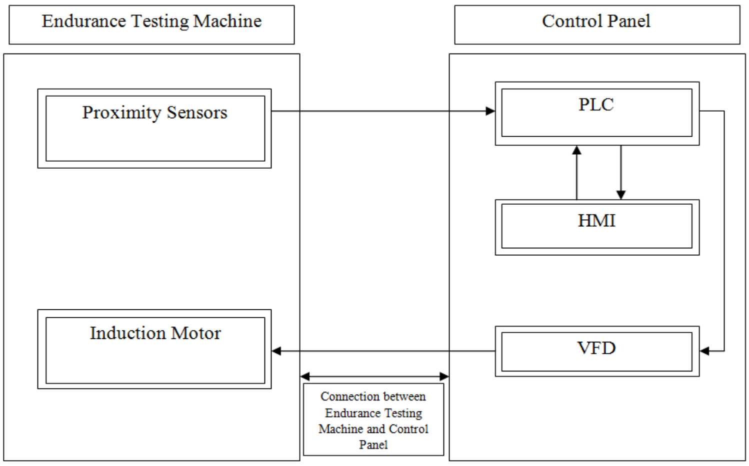


**Fig 4:** Brief Block Diagram showing connection between Endurance Testing Machine and Control Panel

**Fig 5:** Control Panel 1

**Fig 6:** Control Panel 2

**Program Flow –**
**Sequential Flow Chart**

Auto mode can also be called as sequential flow of operations. Here, the four movements of C Arm takes place one after the other in an order. Completion of these four movements is one cycle. The number of cycles that is to be run can be fed in HMI by operator. The number being fed is called to be set value (SV) and the number of cycles executed is present value (PV).Firstly, the PLC checks for all the sensors to be in their respective home positions. Horizontal movement comes first in the sequence, the machine moves horizontally forward followed by C-Rotation moving to 180 deg, -180 deg and then to 0 deg position, then orbital motion starts by C Arm moving to 90 deg then to 35 deg and 0 deg position followed by the wig wag movement, 12.5 deg to -12.5 deg and 0 deg position, the machine then moves in

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the reverse direction horizontally and returns to the home position. After the completion of one cycle the PLC checks for the present value and the set value, if both are equal then the machine stops, else the same cycle repeats and continues until the present and the set value becomes equal to each other.

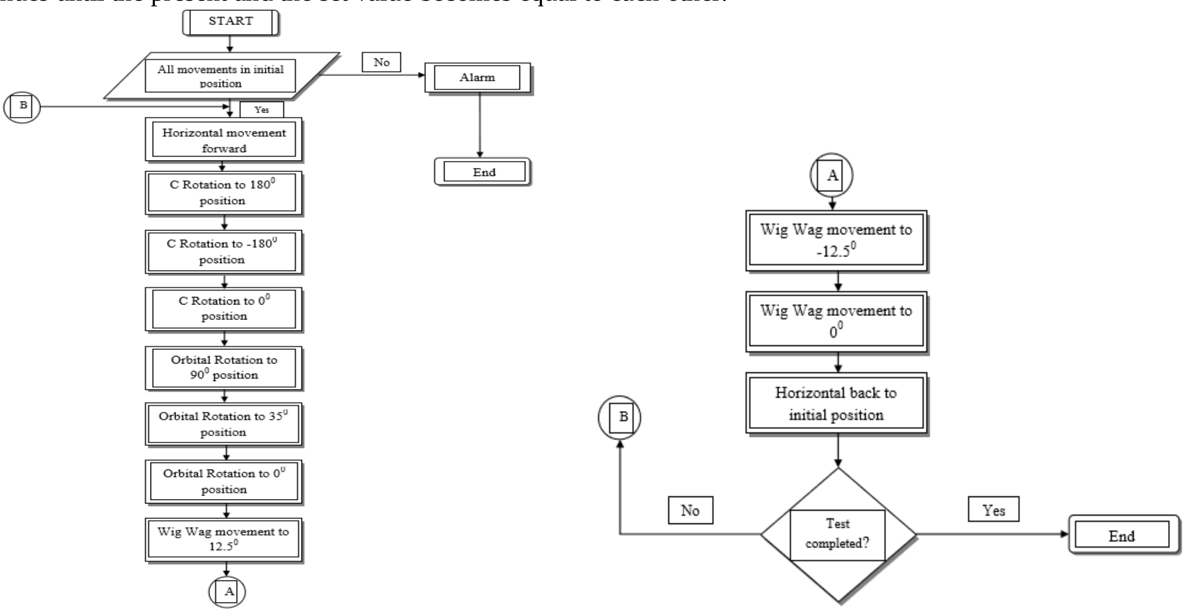


**Fig 7:** Sequential Flow Chart

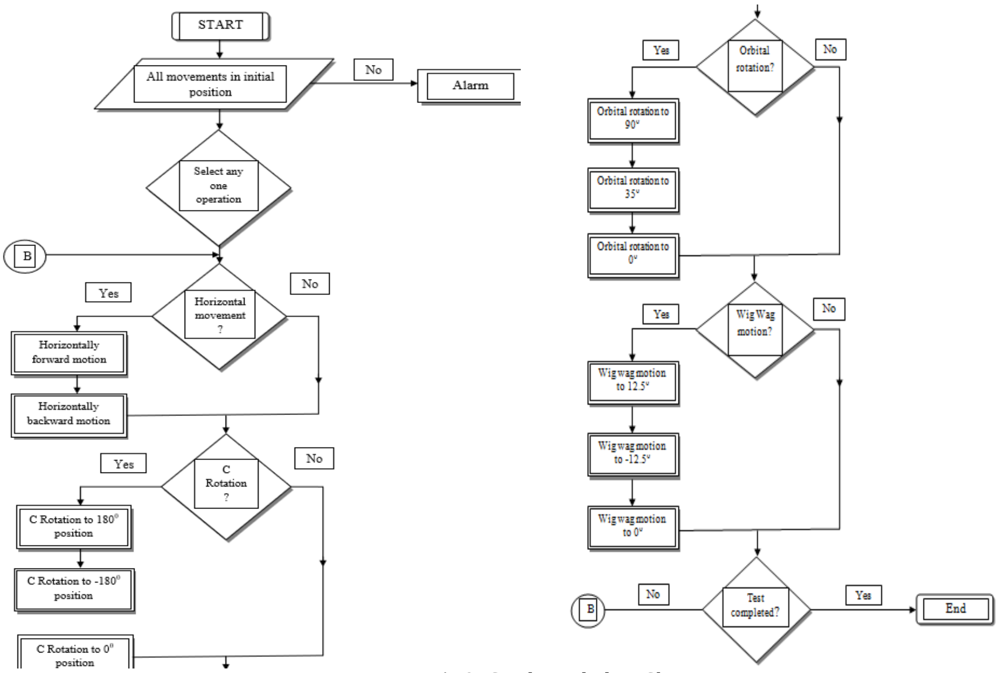


**Fig 8:** Conditional Flow Chart

## Conditional Flow Chart

Conditional flow is nothing but manual mode of operation. In this mode, the C Arm can be operated manually through HMI, the HMI screen displays respective movements on its touch screen, and any of the direction can be selected. Manual control can be done in two ways, in one option any particular movement can just be selected by clicking on the start option in HMI screen which makes the C arm execute the selected movement for example if orbital movement is


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to be operated then on the screen, the start option present besides the orbital movement is to be clicked which results in orbital movement of the C Arm, where as in the other option each movement is provided with a forward and reverse arrow such that on operating arrows the C Arm can be manually operated in forward or in reverse direction for example if C Rotation is to be manually controlled then the forward arrow present beside C Rotation if clicked moves the C Arm to 180 deg and stops, to bring back the C arm back to its original position the reverse arrow is to be clicked until the C Arm reaches home position or the 0 deg position.

## V. RESULTS AND DISCUSSIONS

Fig 9 shows the endurance testing machine been fitted into the C Arm of X Ray Scanner System. As explained in earlier chapters, the control panel manufactured to control the endurance testing machine is connected to the machine as shown. The endurance testing machine is automated with the help of PLC to rotate the C Arm of X Ray Scanner System in four directions as per the ladder diagram constructed.

**Developed HMI Screens:**

**HMI Screen 1**

When the machine is turned on the first screen that appears on HMI is shown in fig 10. Cycle count is total number of times the machine is to be run; one cycle is nothing but execution of all four movements. Set value (SV) is the number of times the operator wants the machine to run where as present value (PV) is the executed cycle number after the machine has started running. There is option for manual sequence, manual, alarms and I/O monitor. These icons when clicked, that particular screen appears which is explained in next sections.

**HMI Screen 2**

When manual sequence icon is clicked on HMI screen 1, the screen that appears is shown in fig 11. Here, each direction can be operated manually by clicking on the start and stop icons. For example, if the operator wants to operate wig wag motion then the number of cycles i.e. SV has to be fed, and the start icon should be clicked, on doing this the wig wag motion will run for specified set value and stop. The motion can be stopped if required by clicking on the stop icon. Same procedure is applied for remaining movements; each direction can be checked individually in this sequence. The home icon directs to HMI screen 1.


**Fig 9:** Project Set Up

**HMI Screen 3**

On clicking the manual icon on HMI screen 1 the screen that appears is shown in fig 12. Here, the movements can be controlled manually by just clicking on the arrows. There are no any set values to be given to the HMI. For example, if C Rotation is to be operated, for the movement of the C Arm from $0^0$ to $180^0$, forward arrow is to be clicked continuously until the C Arm reaches $180^0$ similarly to bring the C Arm back to home position reverse arrow is to be clicked until C Arm reaches $0^0$. Likewise all the other movements can be keenly assured by operating in this mode.

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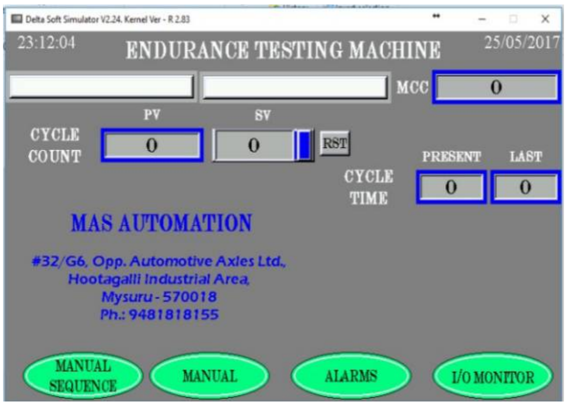


**Fig 10:** HMI Screen 1

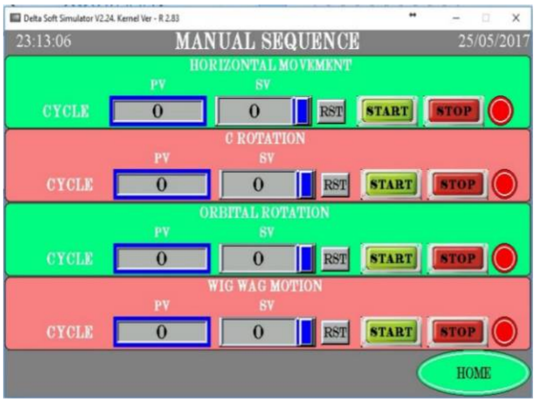


**Fig 11:** HMI Screen 2

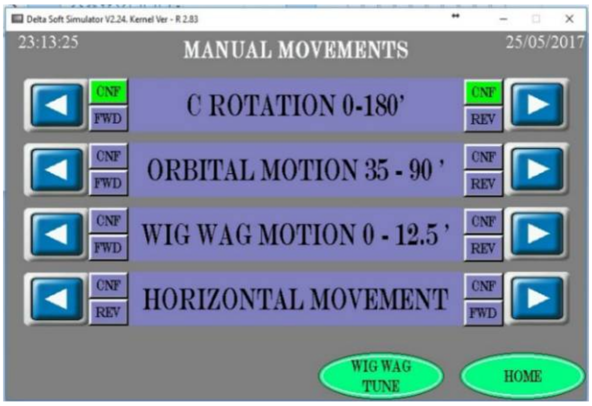


**Fig 12:** HMI Screen 3

## VI. CONCLUSION

C Arm of the X Ray Scanner System is flexible in nature and rotates in different directions like orbital motion, wig wag motion, C-rotation and horizontal motion for ease in imaging during surgeries. For checking the proper functioning of all the mentioned movements a developed endurance testing machine is automated considering all the movements of the C Arm. For ease and sequential functioning of the endurance testing machine a control panel is developed which includes PLC. The project mainly deals with the control panel being developed and automation done using PLC. Control panel is designed considering all the possible constrains, sequential and conditional flow of movements of the C Arm of X Ray Scanner System achieved by construction of ladder diagram in PLC, PLC and HMI interfaced with each other to achieve effortless communication with the endurance testing machine. The testing of the Scanner System is hence done successfully with the help of automated endurance testing machine.

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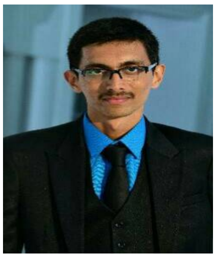

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