DISTRIBUTED CONTROL SYSTEM FOR AN INDUSTRIAL ELECTRON BEAM ACCELERATOR

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Abstract

A PCVM type 3MeV DC Electron beam accelerator has been developed at Electron Beam Centre, BARC, Mumbai, India. A PLC based distributed control system has been incorporated for the control of the accelerator. A touch screen user interface (HMI) has been provides for single point control of the entire accelerator. The accelerator operation/fault related data is stored in the memory Flash card of the HMI. The Accelerator has many subsystems such as scan magnet supply to scan the electron beam, Chiller unit to supply the chilled water to the accelerator for cooling, vacuum system to maintain the vacuum inside the beam tube, high voltage unit to generate the EHV for electron acceleration and other support system. All the above subsystems have to be controlled from the central location in order to operate the accelerator safely. Each of the subsystem has been controlled by an independent PLC controller with all the safety features and control flow controlled by the program logic algorithm written into the PLC. After each of the subsystem has been tested separately all the PLCs are connected to the central PLC on Modbus TCP-IP. The main central PLC has been programmed to fetch the processed data from the individual subsystems PLCs and provides control and monitoring of the accelerator. In auto mode of operation setting the accelerator parameters operates all the subsystems automatically.

INTRODUCTION

The electron beam accelerator has various subsystems. All the subsystems have to work together in a defined sequence to generate the desired accelerated electron beam from the accelerator. All the subsystem such as vacuum system, sweep scan magnet unit, high voltage unit, chiller water unit, air circulation unit, search-secure, safety, interlock unit, steering/focussing magnet unit has to be controlled. Each group of similar units has been provided with a PLC controller in order to perform the fully automatic operation of that its subsystem. Finally all the PLCs are connected together on Modbus TCP-IP network to achieve a single point control of the accelerator. A touch screen panel has been provided at the control panel as an institutive user interface.

SYSTEM OPERATION

The 3 MeV electron beam accelerator is an industrial accelerator developed for the various industrial electron beam processing applications. The accelerator control system has been designed using industrial PLC in such a way that an operator with short duration training can operate the accelerator. The control system has been equipped with the self diagnostic features for quick finding of faults in the failed subsystem. This feature reduces the down time of the accelerator by giving type and location of fault hence helps in quick recovery of the accelerator.

All the PLCs of the various subsystems are connected to the main PLC. All the subsystem PLCs, operate their subsystems in the desired sequence in the pre-defined control flow. All the operate/control trip limits are set by the operator. Each of the subsystem PLC reports about the current state of operation to the main PLC. The main Master PLC initiates the inter-PLC operation based on its program to start the next subsystem operation when the previous stage operation gets over. For example after the desired vacuum has been achieved in the system the electron gun can be started. All these operations are performed automatically by the control system. The failure of any subsystem is reported on the control panel for the notice of the operator.

The control panel has three levels of control privileges as ‘Engineer’, ‘Supervisor’ and ‘Operator’ in their decreasing order of privileges. There are three login password based on the type of privileges. Log-in as an ‘Engineers’ allows the user to access/modify all the information related to each of the subsystem. Engineer also has the freedom to operate all the subsystem in manual mode instead of predefined sequence. This operator (Engineer) also has the privilege to bypass certain soft interlocks. This helps him in modifying the process or debugs the system fault. Login as supervisor allows him to access all the information related to accelerator operation, fault timings, system fault locations etc but he cannot modify the process or bypass any interlock. Operator login has only one mode of operation ‘AUTO MODE’. The Auto mode is also called as ‘operator mode’ of operation. This is the simplest mode of operation designed for the regular operation of the accelerator. In auto mode operation, the operator has to set the desired accelerating voltage and current and press start button. The control system starts the mains stabilizer to energize all the power supplies. Switches ON the electron gun filament then waits for it to heat up. Starts the HVDC supply and set the accelerating voltage to the set value by making incremental changes in the HVDC. When the set accelerating voltage is reached, the ‘Accelerator Ready’ is displayed’ on the HMI. During the automatic operation when any type of severe fault occurs say high voltage arc fault or over heating fault occurs, the accelerator high voltage is tripped automatically besides displaying and

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ISBN 978-3-95450-125-0

logging the type and time of fault. The operator has to restore the fault and press the reset button to acknowledge the fault.

CONCLUSION

The control system has been commissioned and it is working satisfactorily. Operation of the accelerator has been done on trial basis. In radiation environment, high-cost paper insulated Lead sheathed (PILCA) cables make the control wiring an expensive item, but the use of this distributed control has reduced the wiring length and its maintenance cost besides increasing the reliability of the accelerator.

ACKNOWLEDGMENT

We gratefully acknowledge the technical support offered by the vacuum, high Voltage and other auxiliary system groups in making their process understand. This has helped us a lot in the development, commissioning and operation of the control system.

ISBN 978-3-95450-125-0