DEVELOPMENT OF PROCESS AUTOMATION SYSTEM FOR SERVICING OF ISRO SATELLITE LAUNCH VEHICLES DURING VEHICLE ASSEMBLY

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Abstract- The paper deals with development of PLC based process automation system for servicing of ISRO satellite launch vehicle during assembly of its stages. PLC based Process Automation System is realized and being used for PSLV and GSLV-mk2 launch variants. The existing automation system needs to be augmented to meet the requirements of Geosynchronous Satellite Launch Vehicle Mark III , which is a launch vehicle currently under development by the Indian Space Research Organization. De mineralized water filling into the water tank of liquid stage (L110) of Geo Synchronous Satellite Launch Vehicle Mark-III is one of the main servicing activity carried out during vehicle assembly. This paper deals with design and development of program and its associated Graphical User Interface for filling process.

Keywords- Programmable Logic Controller (PLC), SCADA (Supervisory Control and Data Acquisition), Flow Control Valve (FCV).

I. INTRODUCTION:

The GSLV-III or Geosynchronous Satellite Launch Vehicle Mark III is a launch vehicle currently under development by the Indian Space Research Organization. GSLV Mk III is conceived and designed in launching heavier communication satellites of INSAT-4 class, which weigh 4500 to 5000 kg. It is a three stage vehicle i.e., solid stage of 200 tones propellant (S200), liquid stage of 110 tones (L110) and cryo stage of 25tones.Servicing operations include carrying out leak checks of Liquid Stages to ensure its integrity prior to the final phase of countdown operations and DM water filling into the liquid stage which acts as a coolant and is required to run the turbo pumps of the liquid stage. In order to perform these safety critical activities PLC based Process Automation System is being realised with UnityPro as IDE.A SCADA mimic is developed to displav the state of filling process in Vijeo Citect client software.

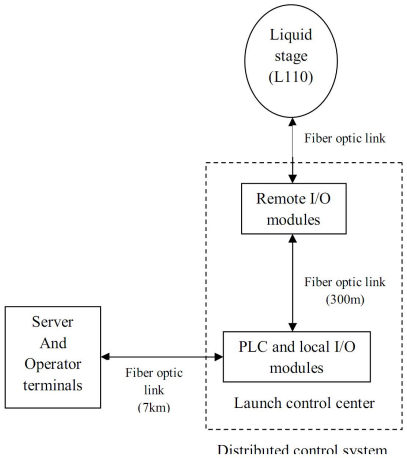


Figure1: Block diagram

Figure 1 describes the process of filling DM water into L110 stage. The stage water tank requires to be filled with 1700 ltrs of water. Initially the water tank will be filled above the siphon level and it will be trimmed to 1700 ltrs by doing forced over flow (O/F) operation after that the water tank will be pressurized to 1.3 bar. Filling is done in three phases. Phase I and Phase III have equal flow rates which is low when compared to PhaseII.Process elements like valves, liquid sensors (LS), turbine flow meter (TFM), pressure transmitters, level transmitters, FCV(which is used to obtain different flow rates required in three different phases of DM water) are used in the entire filling process.

The DM water is stored in road tanker initially and is filled into the L110 stage. Prior to the stage filling, priming (i.e.line filling is done from road tanker to the vehicle assembly building to prevent air locks. After priming uniform flow rate is obtained and stage filling is commenced. Line hose is the length of the pipe over which the path is established during stage filling. LS hose indicates the pipe length from admit valve to the fill and drain level sensors of the mobile launch pedestal. The required 1700 ltrs of DM water is filled into the water tanker of the L110 stage and then filling is completed. These process elements are interfaced with remote I/O modules like analog input module which receives stage pressure reading from pressure transmitters, analog output module for commanding FCV, digital input modules for getting liquid sensors status and digital output module to command valves. These remote I/O modules are interfaced with PLC which gets the required stage parameter values and processes them and provides the required output command. For the user to control the process remotely a mimic is developed which displays the state of the process. PLC communicates

with the operator terminals through servers. Fiber optic links are used for the entire connectivity of process for accuracy and at every level redundancy is maintained to prevent loss of data.

II. DESIGN COSIDERATIONS:

Initial constraints:

- Target quantity : 1700 ltrs
- Phase I quantity : 500 ltrs
- Phase II quantity : 1200 ltrs
- Phase III quantity : 1700ltrs
- LS1 hose quantity : 10 ltrs
- LS2 hose quantity : 10 ltrs
- Line hose quantity : 35 ltrs

Pressure requirements:

Storage tank :

- Min pressure: 6 bar
- Max pressure: 8 bar

Stage:

- L1 pressure: 1 bar
- L2 pressure: 0.9bar
- H1 pressure: 1.1bar
- H2 pressure: 1.3 bar

L1,L2-min pressure levels of the stage.L1 is the precise min pressure level to be maintained and L2 gives an alert message.

H1,H2-max pressure levels of the stage.H1 is the precise max pressure level to be maintained and H2 gives an alert message.

III. ALGORITHM OF PROCESS:

- Acquire Ground data from field sensors and Stage data from launch control center
- Check for initiation of L110 DM water tank filling.
- Check initial conditions for tank filling
- Wait for chief authorization for filling.
- Carry out line filling till fill and drain LS is detected.
- Start Filling by opening the required valves, FCV and ensure their open status.
- Monitor tank pressures continuously and filled quantity with necessary actions.
- Close all the related valves after target quantity is reached and ensure the close status of all valves.

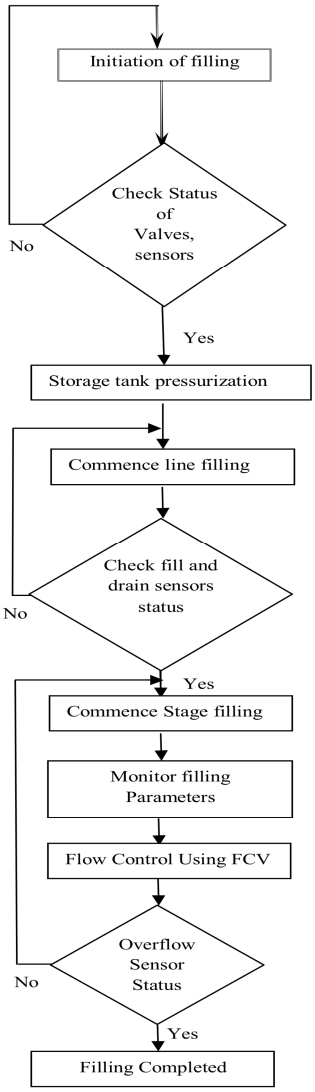


Figure 2: Flow chart

Figure 2 describes the flow of the sequential process. Once the initiation command is given for filling then closed status of valves and sensors is checked. Then if the status of process elements is closed then filling is authorized. If the pressure constraint of storage tank (8 bar) is satisfied then line filling is commenced. Once the fill and drain sensors sense the liquid flow then it is an indication to stop line filling and stage filling is commenced and is continuously monitored. If over flow sensor is on then it indicates the completion of filling.

IV. RESULTS:

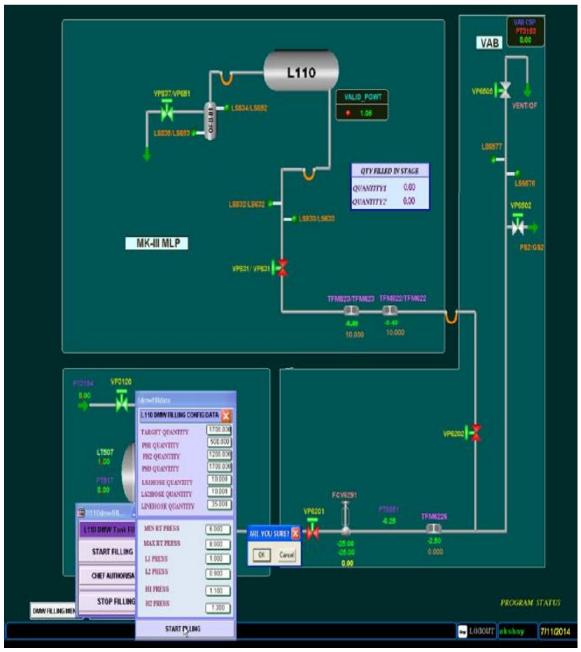


Figure 3: Start filling

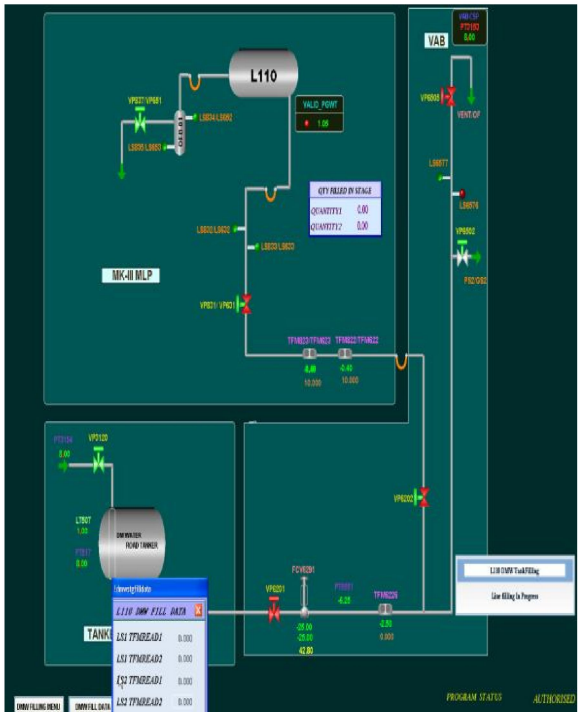


Figure 4:line filling

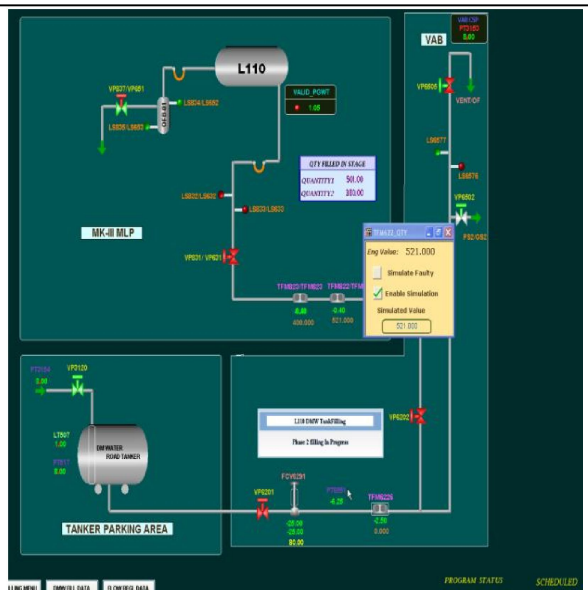


Figure 5: Phase2 filling

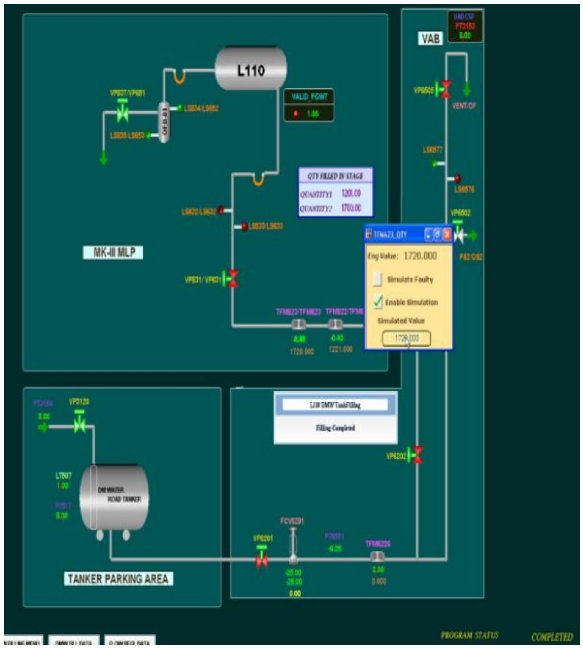


Figure 6:completion of filling

Figure 3 represents initiation of filling.To start filling a popup is generated which contains start filling command. On clicking start filling, all initial conditions like valves, sensors status is checked. If conditions are satisfied then we wait for chief authorization.

Figure 4 represents line filling through which air locks in the pipe lines are removed and regular flow rate is achieved. Storage tank outletvalve and fill and drain valve are opened to establish path from storage tank to the vehicle assembly building.

Figure 5 represents stage filling is commenced and phase 2 filling is under progress. In phase 2 filling a target quantity of 1200 ltrs is filled into water tank of L110 stage.

Figure 6 represents completion of filling and this is the 3rd phase of filling and a target quantity of 1700 ltrs is filled into the L110 stage.

CONCLUSION:

The control logic developed using programmable logic controller and the scada mimic developed meets the objective of filling DM water into the water tank of L110 stage of GSLV-MK111.The code is tested in lab with help of simulations and with suitable number of iterations and it is able to function correctly satisfying specified constraints.

The mimic developed gives the results of all stage parameters and the status of all process elements accurately. Also the paper brings out all the sequential interlocks and their execution in order to carry out the filling process error free and without any hazardous conditions. This automation system can be used in DM water filling of L110 stage in ISRO's Advanced launch vehicle GSLV-Mk III.

ACKNOWLEDGMENT:

Author likes to express their thanks to the management of JNTU-Kakinada and Department of ECE for their continuous support and encouragement during this work. Especially author likes to express their thanks to Dr.I.Shantiprabha, Professor, Dept. Of ECE, JNTU-Kakinada for her excellent guidance and support for the completion of this work.

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