PLC based High Speed Steam Sterilizer

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ABSTRACT
Sterilizer is an instrument that maintains saturated steam for a period of time at high temperature and under pressure. It is used to sterilize medical equipments and lab equipment by destroying potentially infectious agents. An effective autoclave or sterilizer must contain dry saturated steam. In order to achieve this air must be removed from both the load and the chamber. This can be accomplished number of ways. Existing method of sterilization comprises, Pre-vacuum, water level inside the boiler are carried out by operator. Other process like Pre-Vacuum, injection of jacket steam inside the chamber, drying is manually done by the operator through multiport operating valve situated at the top of the unit. Pressure inside the jacket and chamber are displayed on Bourdon type pressure gauges and temperature on analogue meter. These all process are carried out manually resulting human errors and time consuming. To overcome this problem we designed sterilization process with the help of Programmable Logic Controller (PLC).

Keywords: Steam sterilizer, PLC, High Temperature

1. INTRODUCTION
Medical equipments and surgical instruments are examples of devices that are essential to the care of patients; however, because they typically are designed for reuse, they also can transmit pathogens if any of the steps involved in reprocessing, cleaning, disinfection, or sterilization are inadequate or experience failures. Because the vast majority of pathogens are present in organic matter, e.g. visible soil, the first step in reprocessing, cleaning, is the most important. Any failure to remove soil at this point creates the potential for transmission of infection as the efficacy of subsequent disinfection or sterilization will be compromised. Decontamination is the process by which microorganisms are removed or destroyed in order to render an object safe. It includes Cleaning, Disinfection, and Sterilization. All hospitals and health care facilities should have a decontamination policy and help staff to decide what decontamination process should be used for which item of equipment. Steam is produced by evaporation of water, which is a cheap and plentiful commodity in most parts of the world. Its temperature can be adjusted very accurately by the controls of its pressure using simple valves. It carries relatively large amount of energy in a small mass, and when it is encouraged to condensate back to water, high rate of energy flow (into the material being heated) are obtained. Thus steam is most economical, flexible and versatile tool for industry whenever heating is required.

2. CONVENTIONAL STERILIZATION METHOD
In this method all the sterilization procedure are carried out manually i.e. vacuum, heater on/off, sterilization time, evacuating time with the help of operating valve situated on the equipment, resulting following disadvantages. These are Errors due to manual controlling of all the procedure, Power loss and monitoring of all parameters manually as well as Efficiency is low.To overcome above, we have designed PLC based fully automatic high speed rectangular sterilization technique, which will Control all the procedure automatically. The unit has sterilization chamber, made up of 304 grade stainless steel. For controlling sterilization cycle a two way valve –made of brass is provided. It has built in water level controller, door locking mechanism, thermostat for safety and pressure relief valve (PRV),temperature indicator cum controller (TIC) having PT-100 sensor and built in pressure gauge.

3. PROGRAMMABLE LOGIC CONTROLLER
A programmable logic controller (PLC) is an industrially hardened computer-based unit that performs discrete or continuous control functions in a variety of processing plant and factory environments. Originally intended as relay replacement equipment for the automotive industry.

4. HIGH SPEED STERILIZATION PROCESS
1. Turn on unit by keeping mains ON/OFF switch to ‘ON position.
2. System will ensure the water level inside the water storage tank, if sufficient level detected by level sensor sensed by the PLC, heater will be turned ON.
3. Load the sterilizer material inside the sterilization chamber and close the door firmly, it will activate the door limit switch SW1,from NO to NC,recognized by PLC and further procedure will start
4. Water boosting pump will start functioning and water will be sprayed through nozzle as fine droplets in main stream generation unit and it will be admitted in the sterilization chamber.
5. After reaching steam pressure at 121 °C and 15 PSI(1.5 bar), PLC will recognized the required temperature has been reached through TIC, for this NC contact of TIC has been used, and then heater will turned OFF.

6. Exposure cycle will start and hold the steam inside the chamber for 15 minute
7. After completion of exposure cycle period, evacuation cycle will start-for 2 minute, by putting ON the SV2 solenoid valve; it will create positive pressure inside the chamber by admitting fresh air
8. After evacuation cycle process END indicator will illuminate, it means that sterilization has been completed successfully, and thermal biological indicator changed its colour

4.1 Interlocks for the system

a) Water level inside the tank.

b) Sterilization chamber door locking limit switch

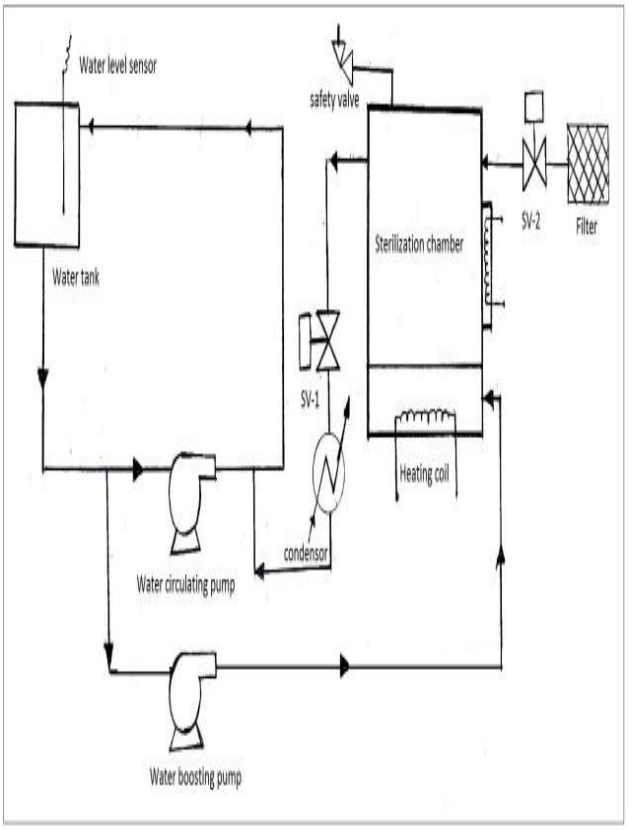

Fig.1: Process flow diagram of High speed steam sterilizer

4.2 Safety provisions

1. Pressure relief valve (PRV) to release the pressure inside the chamber if exceed over 4 bar.
2. Thermostat, if chamber temperature exceeds beyond 150 °C it will cut off the mains supply of the unit.
3. Emergency STOP switch has been provided to abort the cycle in case of emergency or in abnormal condition,

4.3 Front control panelIndicators

1. Process start- It will illuminate when process will start,
2. Heater ON- It will illuminate when heating process functioning,
3. Process END- It will illuminate when process completed.

4.4Visual display

1. For on-line temperature-To show the instantaneous temperature inside the chamber through Pt-100 sensor.
2. Steam pressure- It will show the pressure inside the sterilization chamber by pressure guage in PSI.
3. Water level indicator- To show the level and quantity of water inside the tank in litre.For this glass tube is calibrated accordingly.
4. Switch**:**
   ON/OFF switch – To start the unit to turn ON.

4.5 Unit details

1. Sterilization chamber size:width-200mm,Height-210mm,Depth-400mm
2. Power supply-230 VAC/50 Hz.
3. Operating temperature-121 °C

5. PROCESS FLOW CHART FOR HIGH SPEED STERILIZER

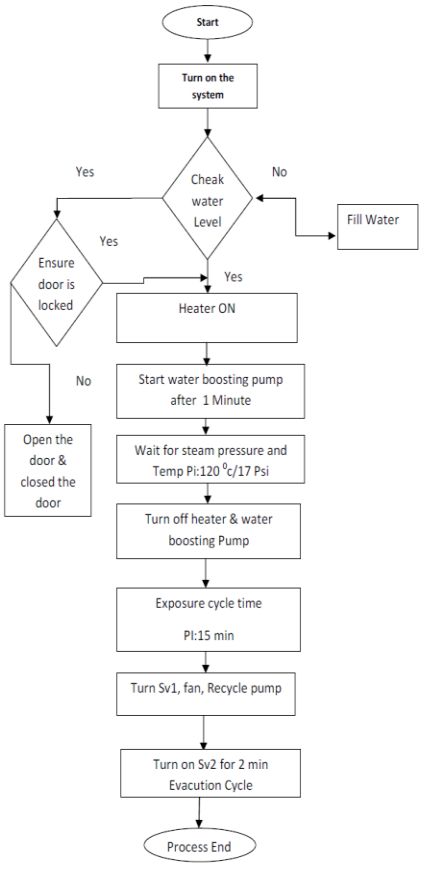

Fig.2: Process flow chart for High speed steam sterilizer

Table 1.Selection of components

Description of component	Specification
Temperature sensor	0-800°C Pt-100
TIC	0-160°C with one NO and NC contact
Solenoid valve	0-4 bar with brass material
Contactor	3-pole/16A,230VAC operated coil
Thermostat	0-300°C
Water level sensor	Single point, copper material
Heating coil (steam generator)	1.4KW
Surface heating coil element	500W
Pilot lamps	Panel mounted,230 VAC operated
Pressure gauge	0-5 bar panel mounted (45mm x45mm)

6. LIST OF INPUTS AND OUTPUTS DEVICES

INPUTS

1. Start button :X000
2. Emergency stop :X001
3. Door switch:X002
4. Water level sensor :X003
5. Temperature sensor:X004

OUTPUTS

6. Heater coil: Y000
7. Water boosting pump: Y001
8. Process ON indicator: Y002
9. Process END indicator: Y003
10. S.V.1, Water circulating pump: Y004
11. S.V.2:Y005

7. SPECIFICATIONS OF PLC

1. Scan time-22-40 ms,
2. LED indicator-for I/P,O/P, run mode, error, power ON
3. Power supply-230 VAC/50Hz,
4. Outputs –Relay output 24 VDC (Input switching)
5. Timer counter- Unlimited
6. NO/NC- Auxiliary relay unlimited,
7. Programming communication port-8 pin mini DIP type RS 232,
8. Input- discrete,
9. Output-Discrete,
10. Software platform-medoc s/f windows 95/DOS,
11. Scan time-22-40 ms,
12. LED indicator-for I/P,O/P, run mode, error, power ON

8. INTERFACING WITH-MITSUBISHI PLC

Figure below shows the wiring diagram for the developed model with PLC-MITSUBISHI FX ON MELSEC 24 MR-ES.

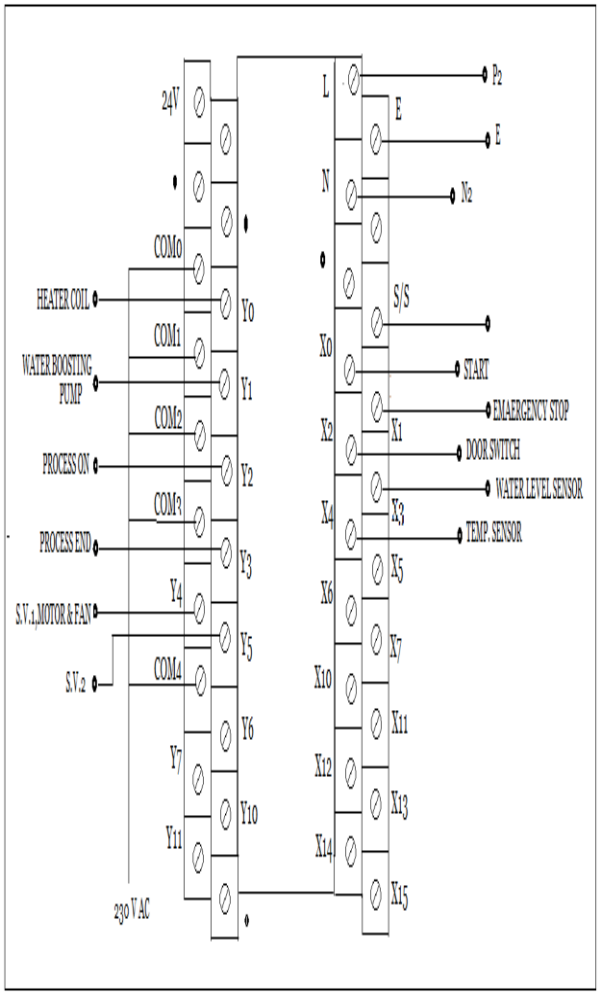

Fig.3: Interfacing with-MITSUBISHI PLC

9. SIMULATION MODEL

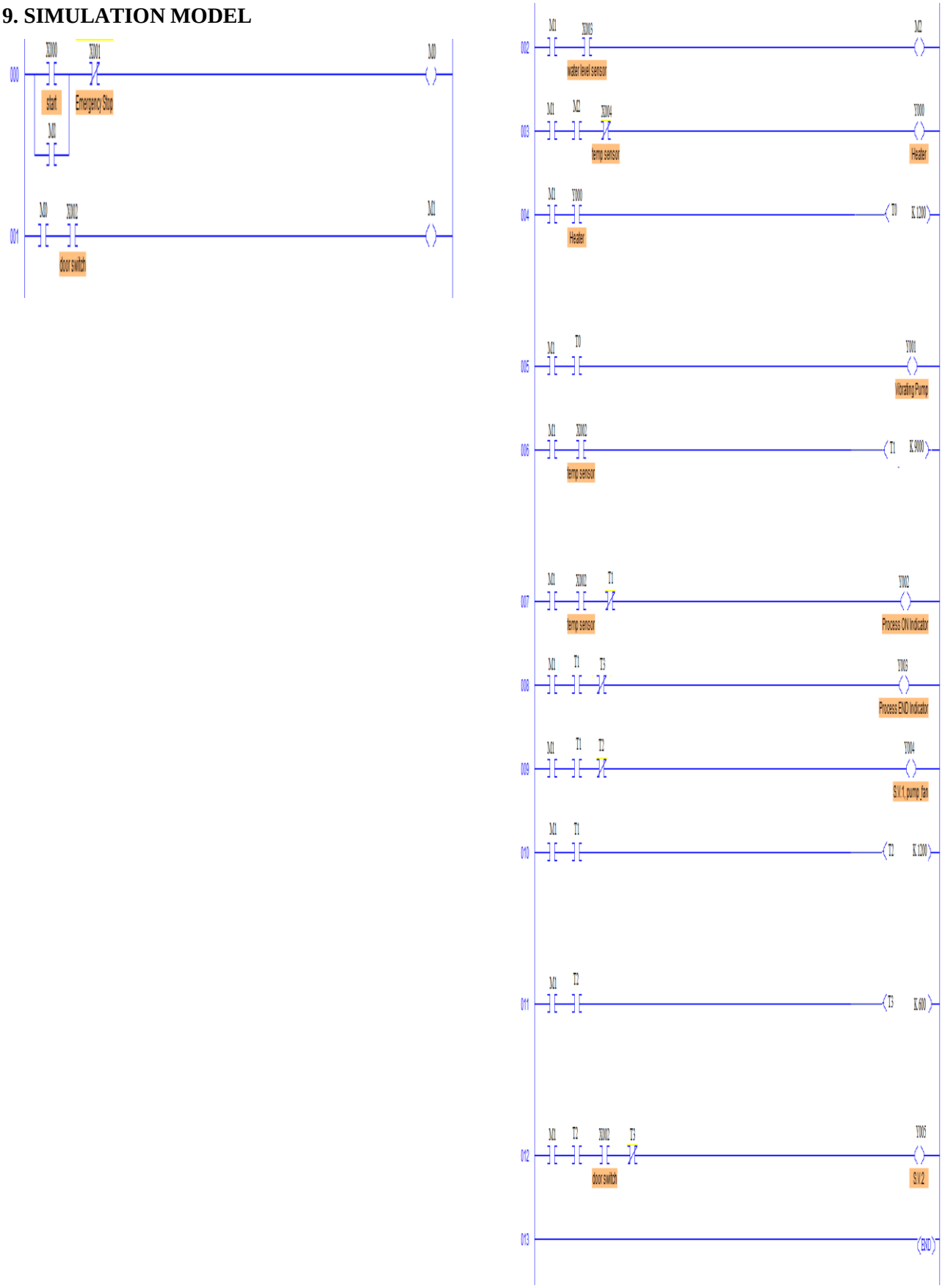

Fig.4Simulation Model of Process

10. RESULTS

Table 2. Reading based on testing of the developed model of HSSS

Temperature (°c)	Pressure (bar)	RTD resistance (ohm)
40	-	117.5
50	0.3	121.2
60	0.6	123.0
70	0.7	125.5
80	0.9	127.7
90	1.0	130.7
100	1.1	133.5
105	1.1	134.0
110	1.2	137.3
115	1.3	138.2
120	1.5	139.0
121	1.5	139.6

11. DEVELOPED PROJECT MODEL OF HIGH SPEED STERILIZER

Fig.5: Developed Project Model of High Speed steam

12. CONCLUSION

As compare to manual sterilization process automatic high speed sterilization method using PLC will be more suitable for controlling parameters like temperature, pressure and level.It also minimizes the sterilization process time with high accuracy.It is user friendly and high quality of sterilization of equipments used in Hospital (sterilization of surgical instruments and consumables) ,biotechnology and pharmaceutical industry can be done

13. FUTURE SCOPE

Presently we designed for only one cycle for 121 °C, in future it can be upgraded for cycle 134°C and various preset-able sterilization cycle times and can be interfaced MMI/HMI for easy user friendly

14. REFERENCES

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