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Instructor: Prof. Dr. Rainer Scheuring

# Assignment: Automation of Discrete Event Systems

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# 1 Task Description

- Implement this automaton using latches (flip flops):

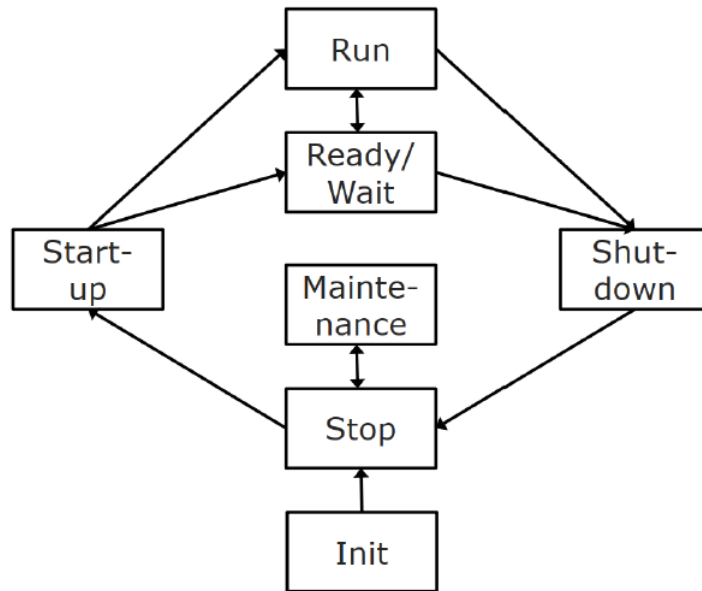


Figure 1: States Diagram

1. Add startup and shutdown
2. Use UniSim for implementation

## 2 Introduction

This task involves the implementation of an automaton which consists of 6 states using latches (flip flops). We did this implementation in two modes: manual and automatic. The setups below demonstrate these implementations.

### 3 The Unisim Setup

The Unisim setup consists of a tank, a heater, inlet and outlet valves and controllers. The inlet valves control the flow of liquid into the tank. The heater while running heats the content of the tank and afterwards, the outlet valve lets out the heated liquid. This setup is shown in Figure 2 below.

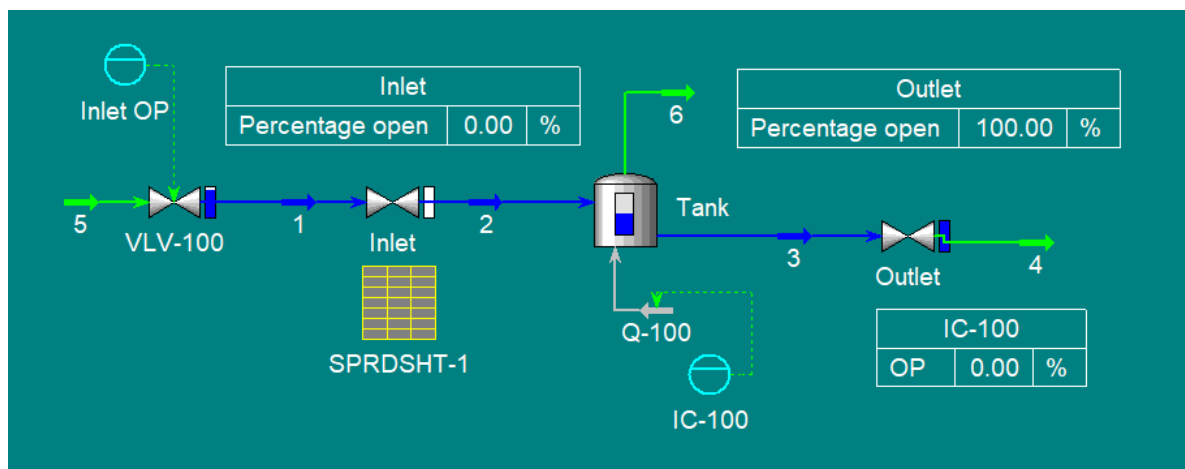


Figure 2: Unisim Setup

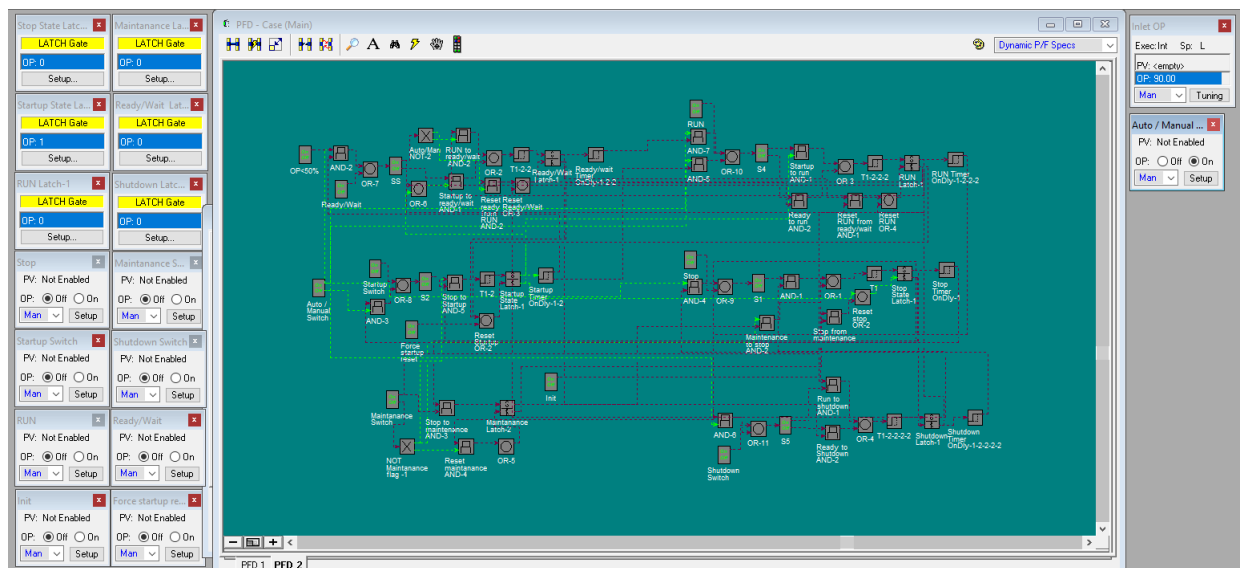


Figure 3: AutoMode

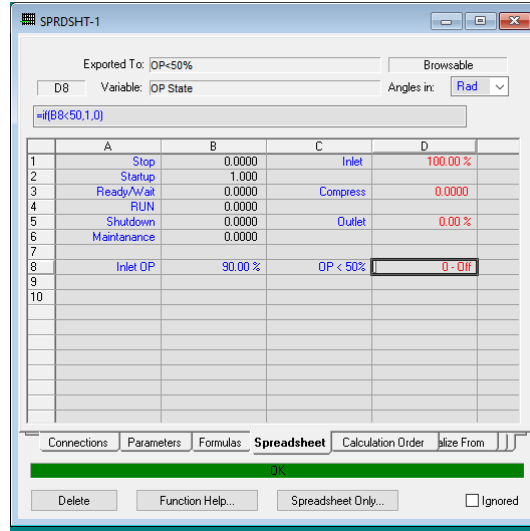


Figure 4: Spread Sheet

## 4 Simulation Model

The model is set up in such a way that the process remains in a state for 5secs before transitioning to another state. To avoid 2 different states being ON at the same time, we introduced timers before the states to allow the previous state to reset before the next state comes ON.

### 4.1 System Inputs

- Operation Modes: This system is designed to operate both in Auto and Manual modes. Each state can be selected by the operator using an Auto/Manual mode switch as shown in the figure below. The ON button allows the system to run in Auto mode while the OFF button allows the system to be operated manually.

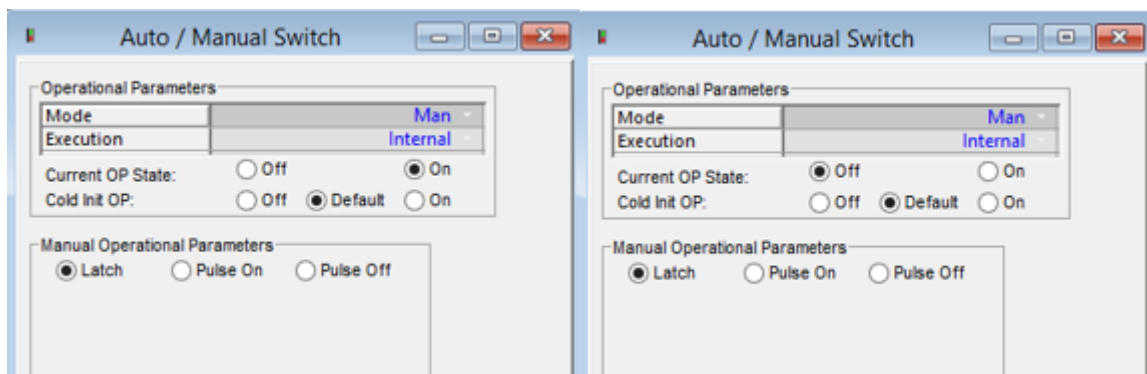


Figure 5: Auto/Manual Switch

- Inlet OP: This input is used to set the percentage of the inlet valve opening by the operator who may wish to let the liquid flow in a fast or slow manner. This is controlled by the Inlet valve controller. Further details about this setup is given in the transition from Startup state to either Read/Wait or Run states.

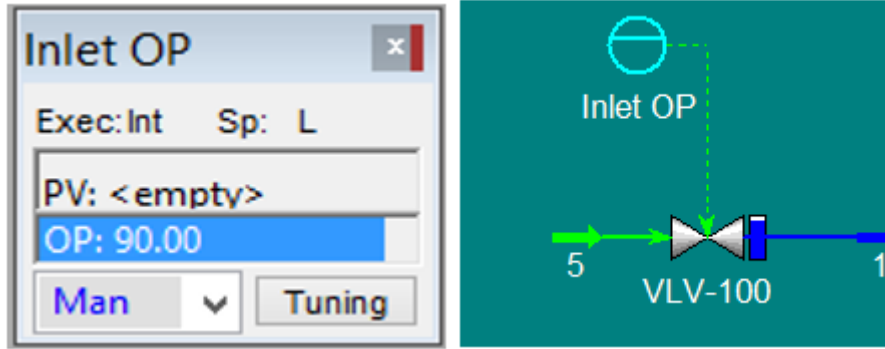


Figure 6: Inlet Valve Control

## 5 Auto Mode

As soon as the Auto mode is set using the Auto/Manual switch, an OP value is set and the Start button is turned ON, the system is initialized and first of all, enters the Stop State.

### 5.1 Stop State

In the Stop State, both the Inlet valve and outlet valves are closed, the heater is also off.

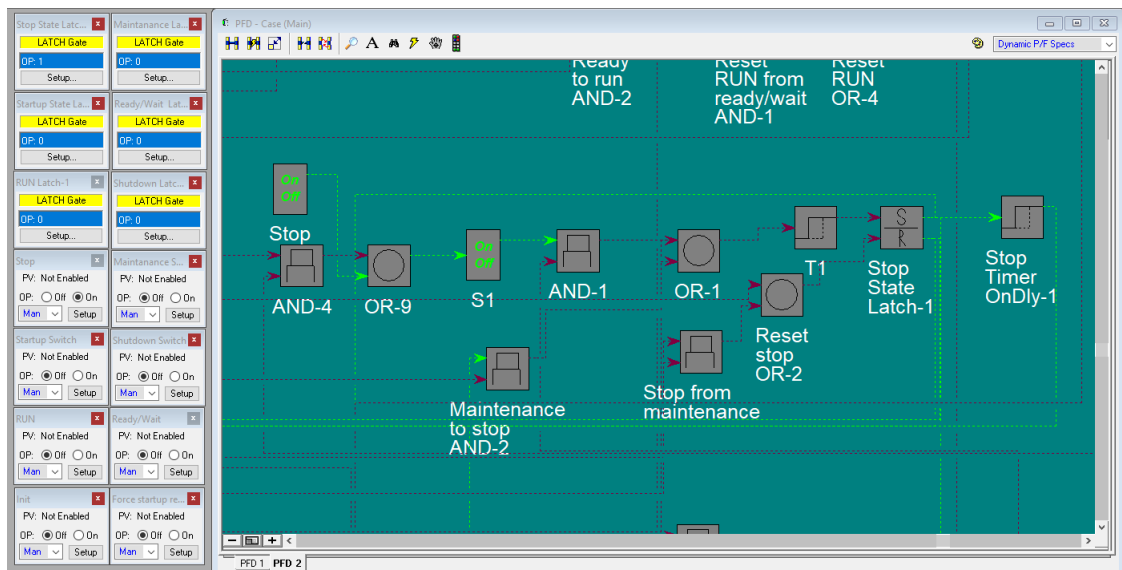


Figure 7: Stop State

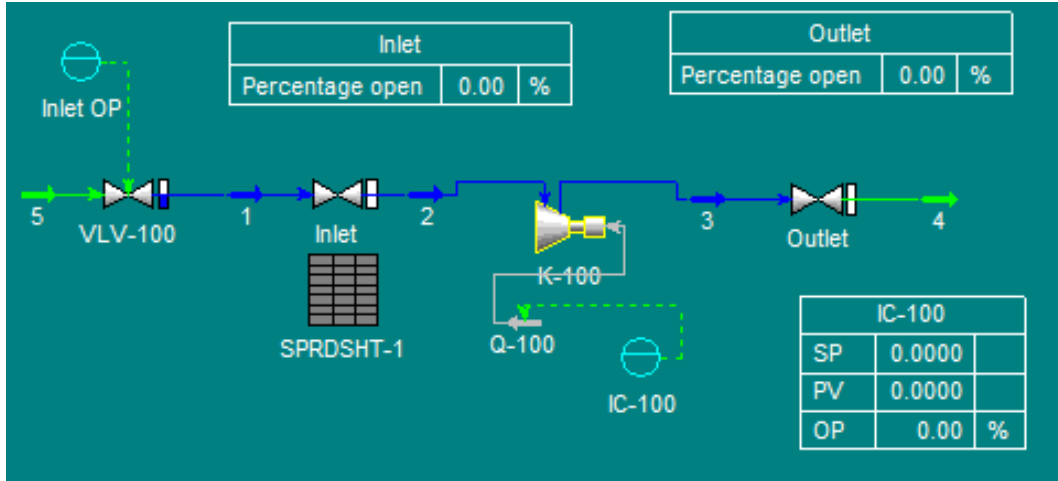


Figure 8: Operation in Stop State

- Transition from Stop State to Startup or Maintenance States: This model is setup in such a way that the process transitions to Startup State from the Stop State, assuming normal functional state. But in case of a fault that needs a maintenance, the maintenance latch is turned ON. Then, the system transitions from Stop State to Maintenance State and remains there as long as maintenance is carried out. After maintenance is completed, the latch is turned OFF, process transitions back to Stop State and the normal operation continues.

## 5.2 Maintenance State

In maintenance state, the inlet valve is closed, the outlet valve is closed and the heater is OFF.

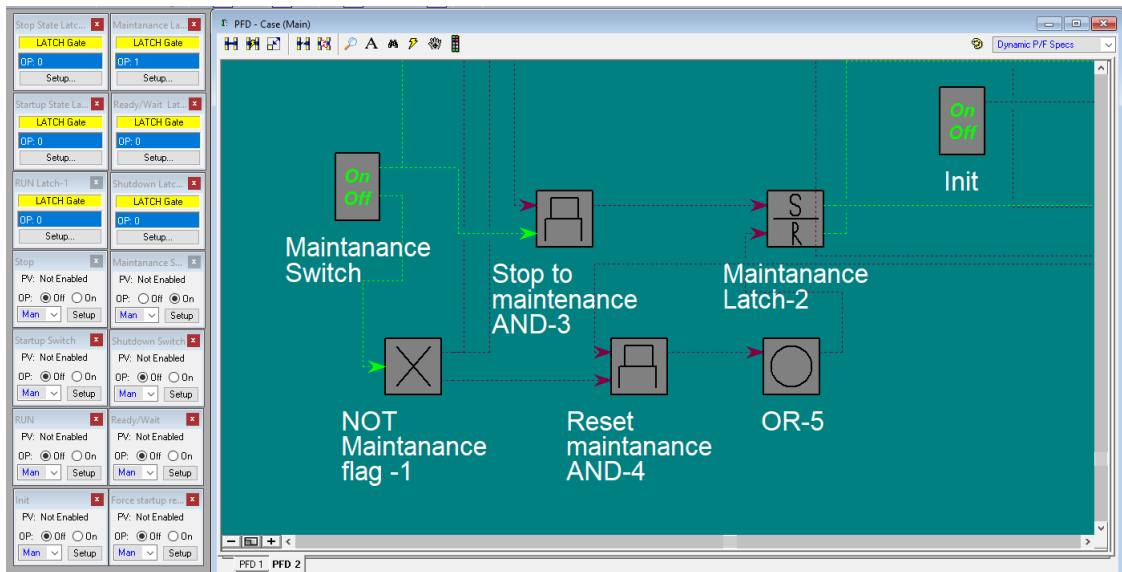


Figure 9: Maintenance State

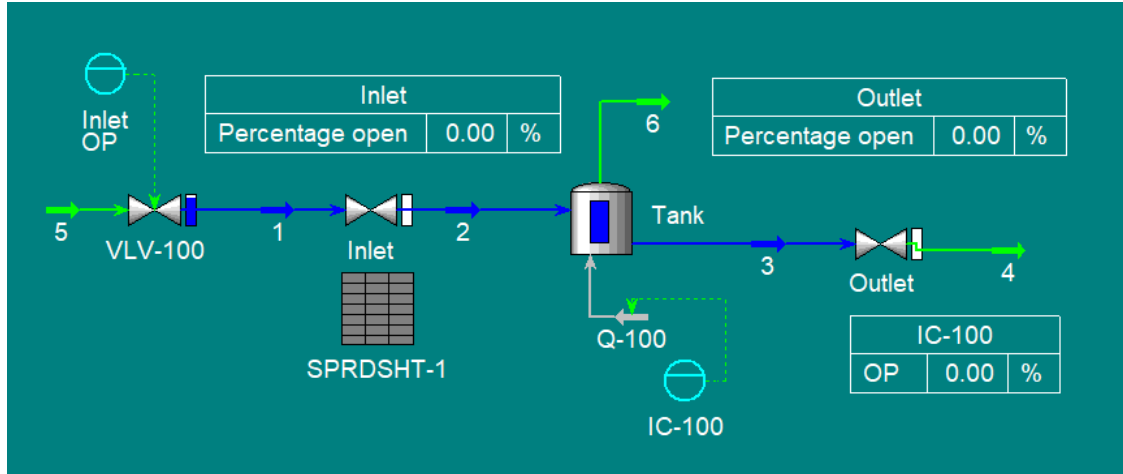


Figure 10: Operation in Maintenance State

### 5.3 Startup State

In this state, the inlet and outlet valves are closed and the heater is OFF.

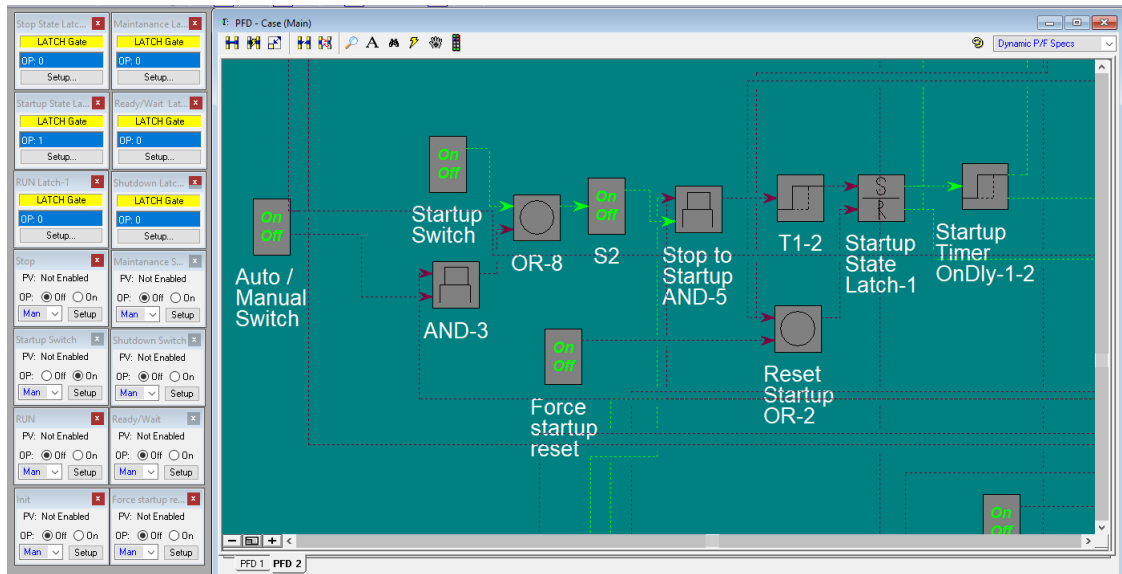


Figure 11: StartUp State

- Transition from Startup to Ready/Wait or Run States: The process can transition to either Ready/Wait or Run State depending on the amount of liquid in the heating tank. This model is structured in such a way that if the inlet OP is set to less than 50%, the process transitions to Ready/Wait State in order to allow more fluid into the tank. After a preset time(having sufficient liquid in the tank), it transitions to Run State. But if the inlet OP is set to greater than 50%, it means enough liquid flows immediately into the mixing tank, the process transitions to Run State from the Startup State.



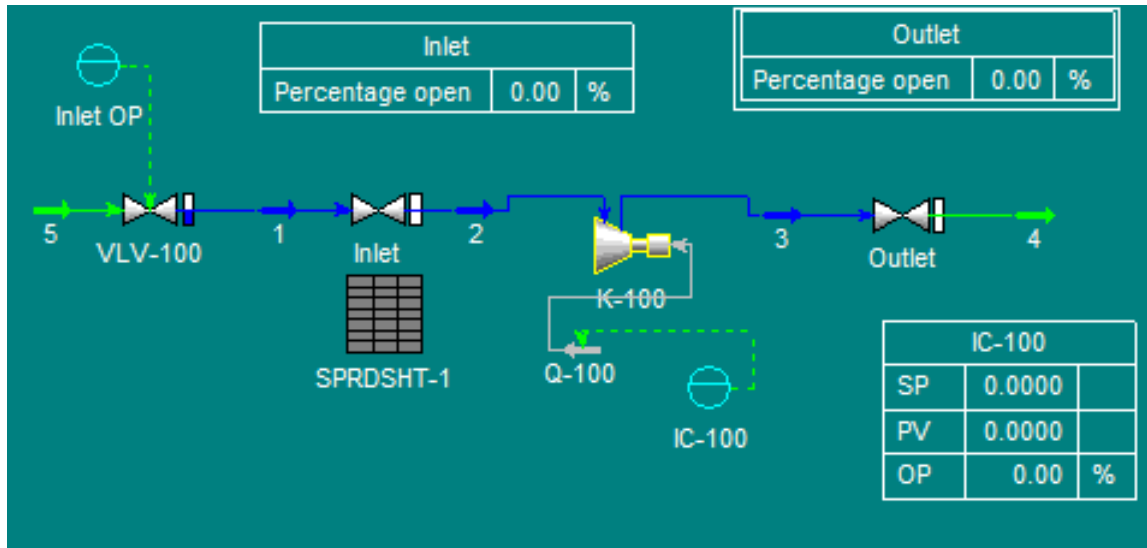


Figure 12: Operation in Startup State

## 5.4 Ready/Wait State

While in Ready/Wait State, the inlet valve is open to allow fluid into the tank but the outlet valve is closed so that nothing flows out yet. The heater is also not running yet.

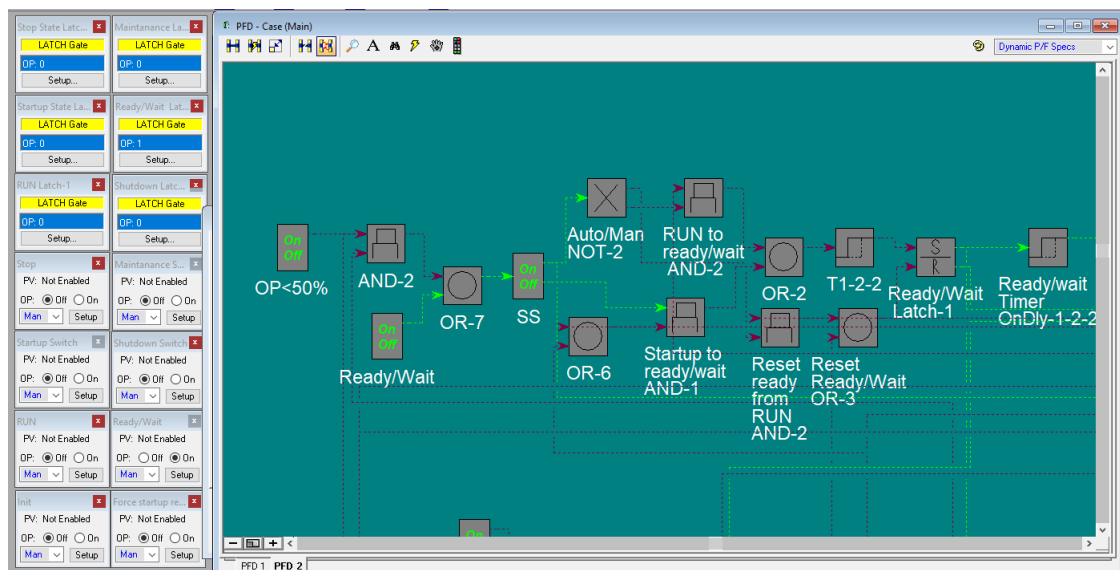


Figure 13: Ready/Wait State

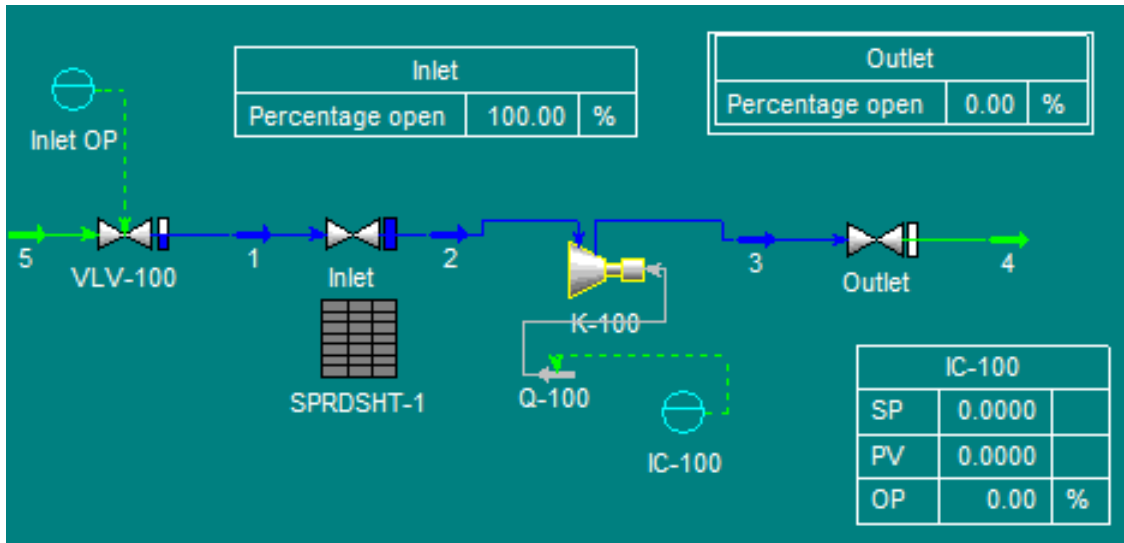


Figure 14: Operation in Ready/Wait State

## 5.5 Run State

In the Run State, the inlet valve is closed so that no more liquid flows in. The outlet valve is still closed and the heater is now running in order to heat the content of the tank. After the defined period, the process transitions to Shutdown State.

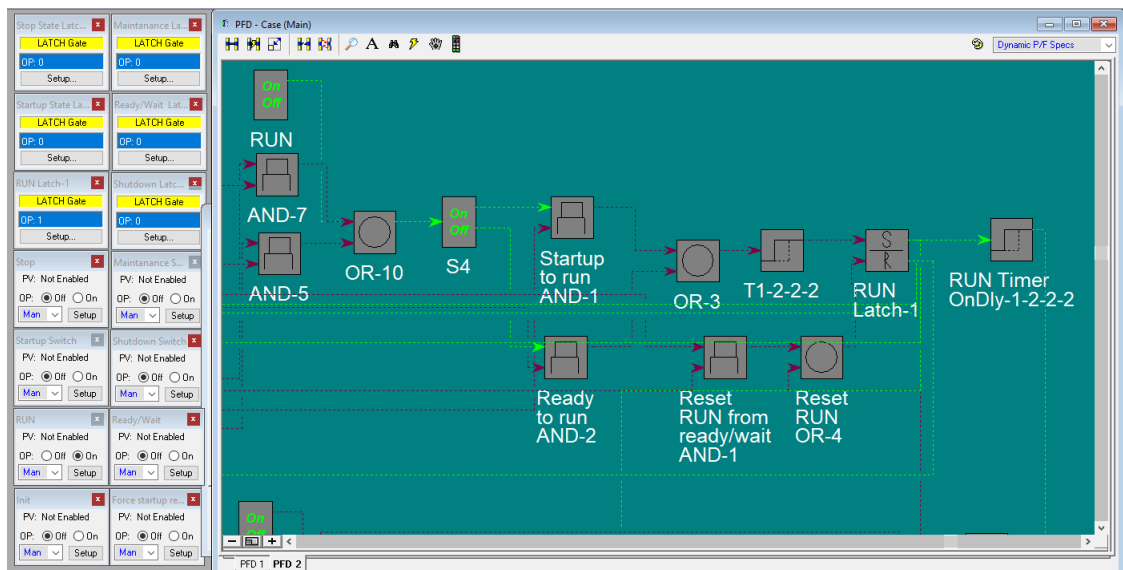


Figure 15: Run State

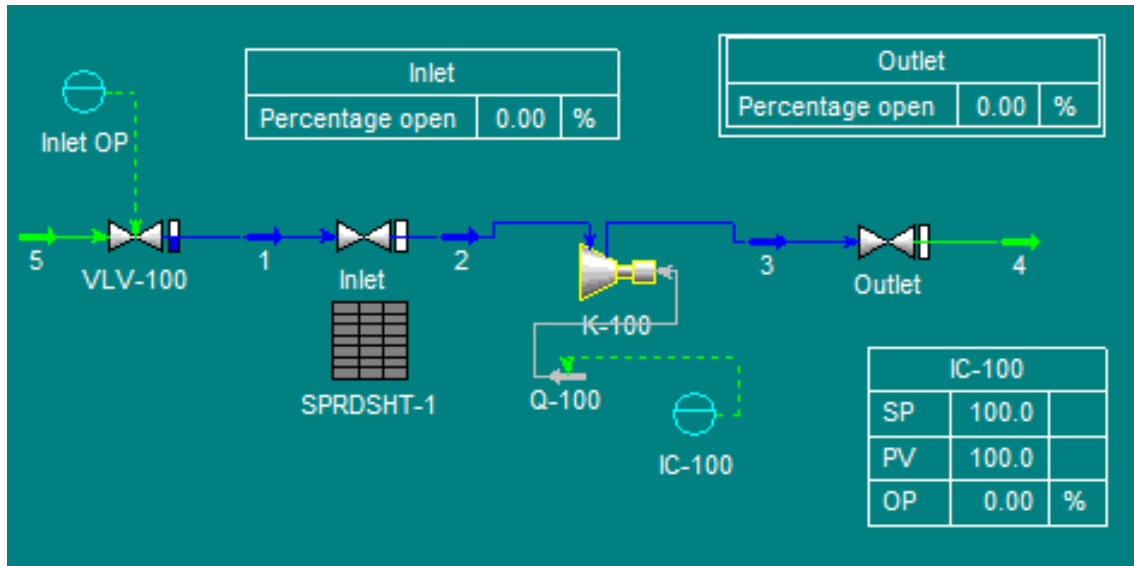


Figure 16: Operation in Run State

## 5.6 Shutdown State

In the Shutdown State, while the inlet valve is still closed, the heater stops running and the outlet valve opens to discharge the hot mixture into storage vessels. After discharge which takes a preset time, the process transitions to Stop State and the cycle repeats.

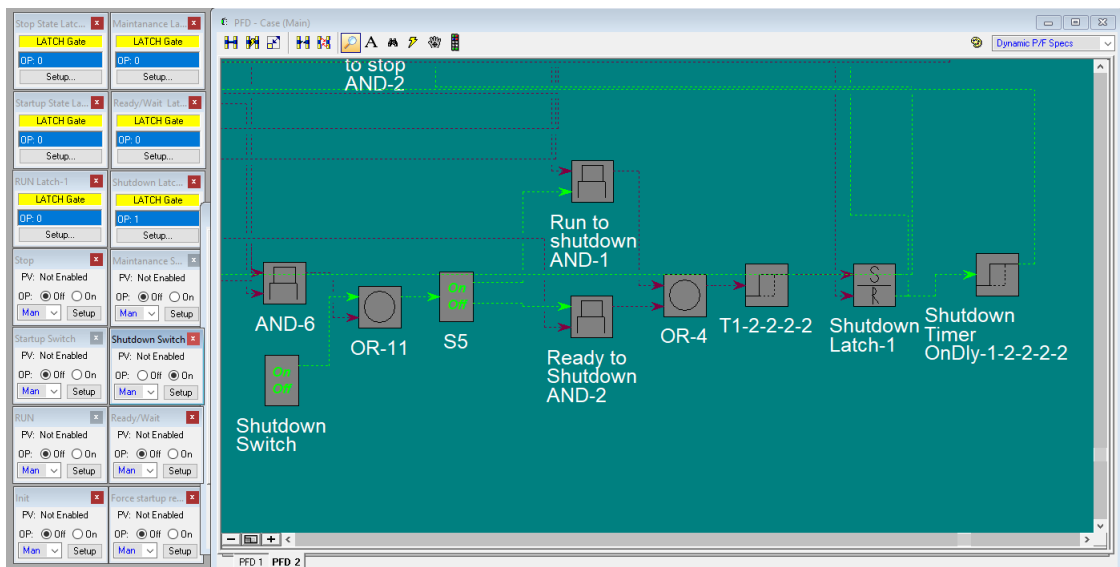


Figure 17: Shutdown State

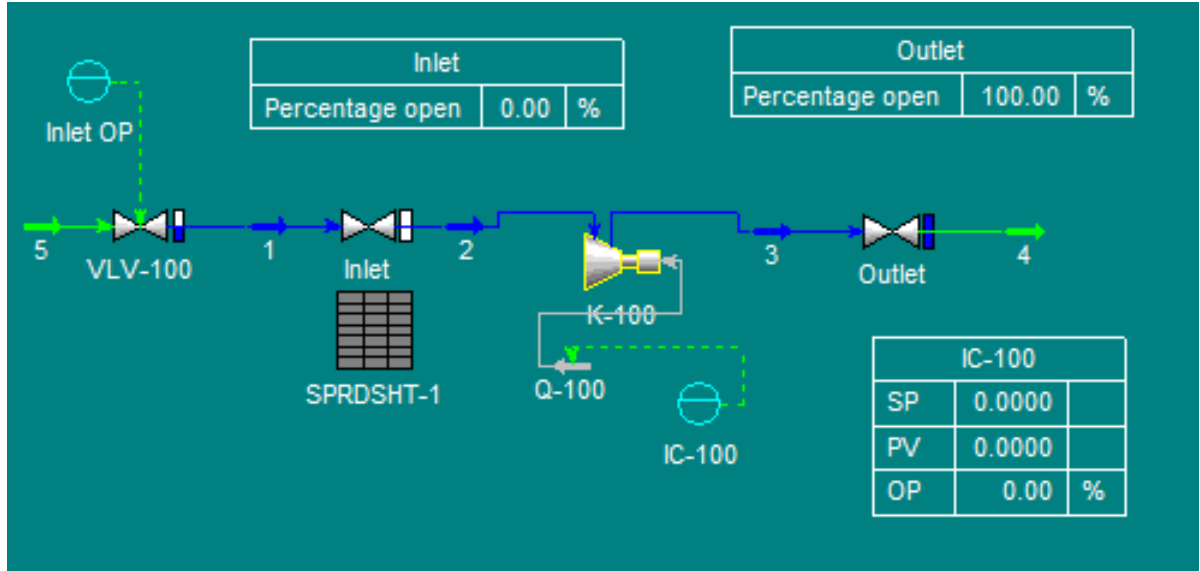


Figure 18: Operation in Shutdown State

## 6 Manual Mode

As mentioned in section 4.1 above, the process can also be run in manual mode. This mode is activated by simply turning the Auto/Manual Switch to OFF position. This gives the operator the opportunity to manually select a State of operation per time. This is usually important in industries in case the auto mode fails at some point.

## 7 Conclusion

We have demonstrated, using this experiment, how an Automaton with any number of states can be implemented. And of course, the more the number of states the more complex it should become since many more components and connections will be involved.