Water level regulation

1 Working Principle

The system is based on the water level regulation system of a tank studied in the thesis redacted by Vincent Cocquempot *"Contribution à la surveillance des systèmes industriels complexes"*. Some liberty has been taken with regard to the model developed by Mr. Cocquempot.

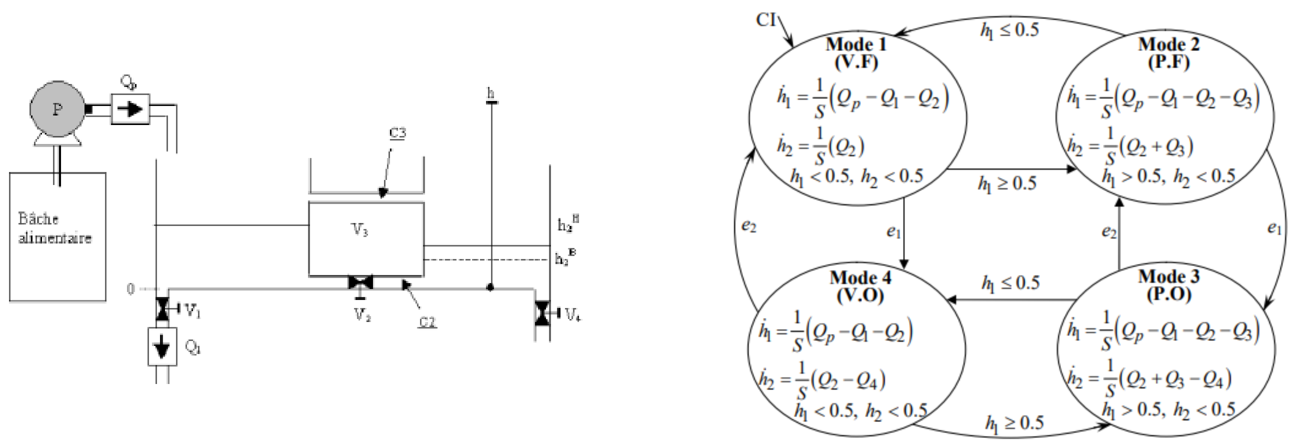

Figure 1: Schema of the system and its hybrid system modelisation (taken from Mr. Cocquempot's memoir)

The objective of the pomp is to maintain the water level of second tank between the height of the canal C_2 and C_3. The pomp will supply or not the first tank depending on the water level state and its speed in the second tank. After a while, the valve V4 is activated for a few minutes. The state of the models are mainly defined by the water level of the first tank and the state of the valve V4.

2 Model

Figure 1 shows the modeling the physical system, the states are defined in the following way:

- **State 1**: The water level in the first tank h_1 is between the height of the conduits C_3 and C_2. The valve V_4 is closed.
- **State 2**: The water level in the first tank h_1 is higher than the height of the conduit C_3. The valve V_4 is closed.
- **State 3**: Same situation as State 2 except the valve V_4 is open.
- **State 4**: Same situation as State 1 except the valve V_4 is open.

Thus the transitions between the State 1 and 2 and between 3 and 4 are done by comparing the water level in the first tank with the height of the conduit C_3. The transition between the State 1 and 4 and between State 2 and 3 are done during the opening of the Valve V_4. This transition will be modeled by a timed guard.

In the model, the opening and the closing of the valve V_4 are modeled respectively by the vents e_1 and e_2. However Stateflow fave difficulties when it comes to generate and read rising edges. Thus e_1 and e_2 are modeled by a Boolean whose value will be 1 if the valve is open, 0 otherwise.

Q_p represents the flow of the water supply. Its value will be null or not depending on the evolution of the water level in the second tank.

In order to establish the equations, we consider the flow is incompressible, stationary and perfect. Thanks to those hypothesis, the Bernoulli theorem can be used to establish the following relationships :

$$Q_1 = \alpha\sqrt{h_1}$$

$$Q_2 = \alpha\, sign(h_1 - h_2)\sqrt{|h_1 - h_2|}$$
$$Q_3 = \alpha\sqrt{h_1 - 0.5}$$
$$Q_4 = \alpha\sqrt{h_2}$$

- Q_1 is the liquid flow in the canal at the bottom of the first tank
- Q_2 is the liquid flow through the canal C_2
- Q_3 is the liquid flow through the canal C_3
- Q_4 is the liquid flow through the valve V_4
- α is a constant obtained by calculating $\frac{\sqrt{2g}}{S}$ the section surface being the same for all canals

We inject those relations in the relation between the water level and the flow rates to establish the differential equations.