Design and simulate a SCADA system for wine production line integrated with power supply

Pham Thai Long
Hoang Khac Anh
Nguyen Tuan Vu
Nguyen Trung Duong

University of Technology of Ho Chi Minh City

August 2011

Abstract

This document presents the working principle of our system. Taking into consideration every technical concern related to power supply is far beyond our goal, as we do not have many practical experiences in this sector. Instead, while building the system, we intend to focus on modeling the operating procedure of two modules: first, the wine production line and second, the power distribution and generators blocks. In the first section, we introduce four stages of the wine production line. The second section describes a subsystem that supplies power for the wine production line.

Contents

1 Wine Production Line

This section describes the sequence that take places in our line. Four main stages make up the wine production line: weigh and clean, mill and ferment, press and filtrate, bottle and package. We present these stages in the subsections belows.

1.1 Weigh and Clean stage

When we press the Start button (Figure 1 and 2), Motor I starts and drives a conveyor belt that loads raw grapes into the weighing tank. Meanwhile, water is pumped into the water tank. Once the grapes' weight attains the preset value, the conveyor belt stops. And, if the water tank is full, piston Number 1 pushes the grapes from the weighing tank to the water tank. Then Motor II does its job: cleaning. After a preset time, Motor II stops, and the water used to clean the grapes drains off. When the tank runs out of water, piston Number 2 shifts the cleaned grapes to the second stage of the production line: mill and ferment (Subsection 1.2).

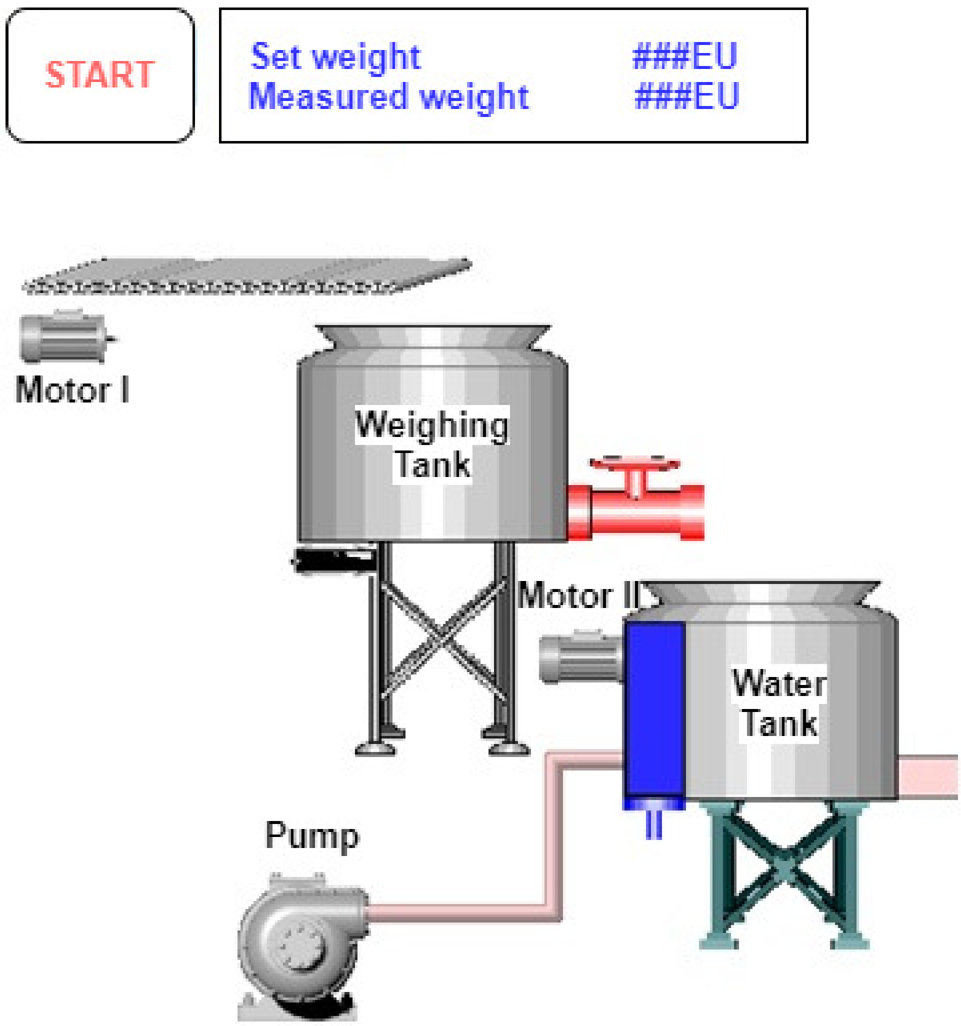

Figure 1: Weigh and Clean stage (Vijeo Citect).

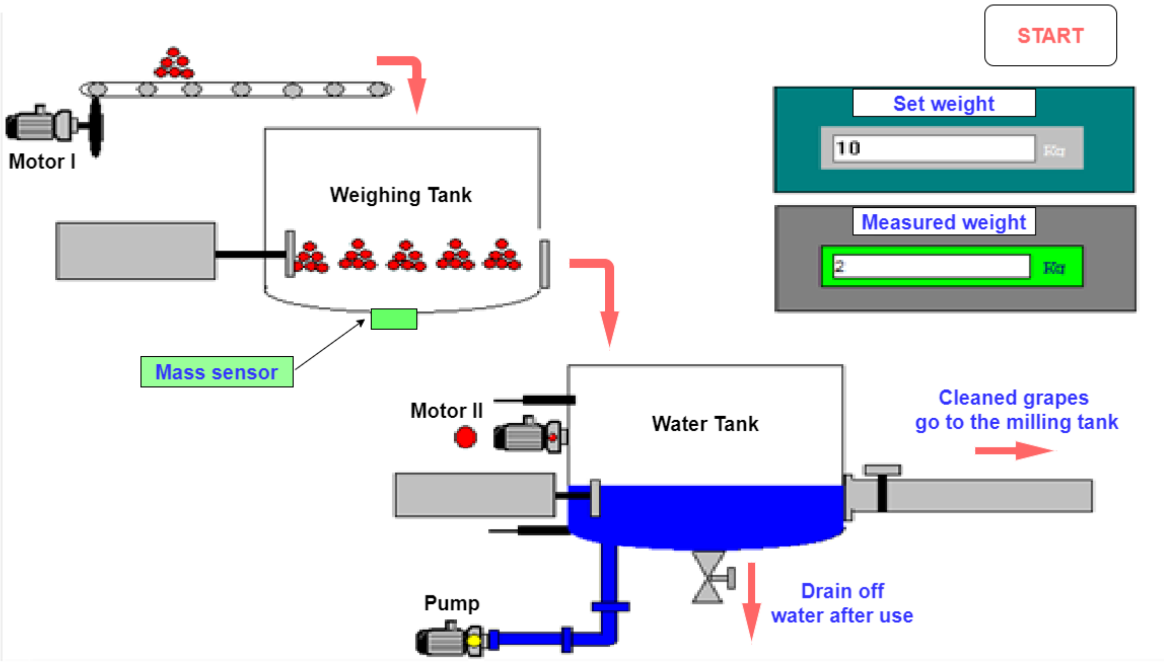

Figure 2: Weigh and Clean Stage (Unity Pro).

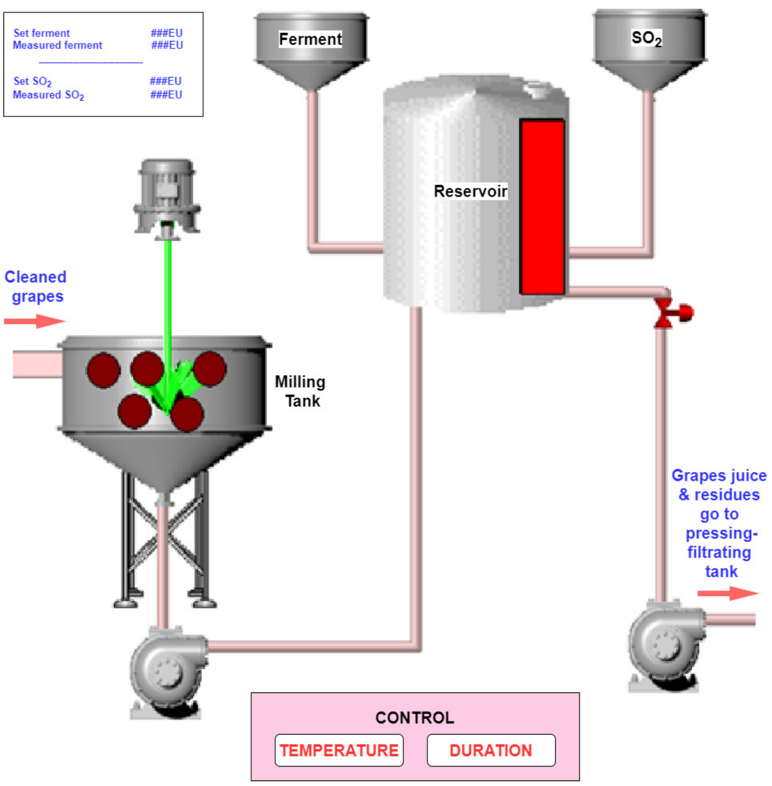

Figure 3: Mill and Ferment Stage (Vijeo Citect).

1.2 Mill and Ferment stage

Piston Number 2 transports the cleaned grapes to the milling tank (Figure 3). When the milling process finishes, the milled grapes are shifted to a reservoir, where we add ferments alcoholic and gas SO_2 to transform the grape juice into alcohol. Using a control panel (that displays the pop-up windows - see Figure 4), we can set the temperature and the duration of the fermenting process. At the end of the stage, grape juice (which has became alcohol) and the insoluble residues are carried to the pressing-filtrating tank, where the stage of press and filtrate starts (Subsection 1.3).

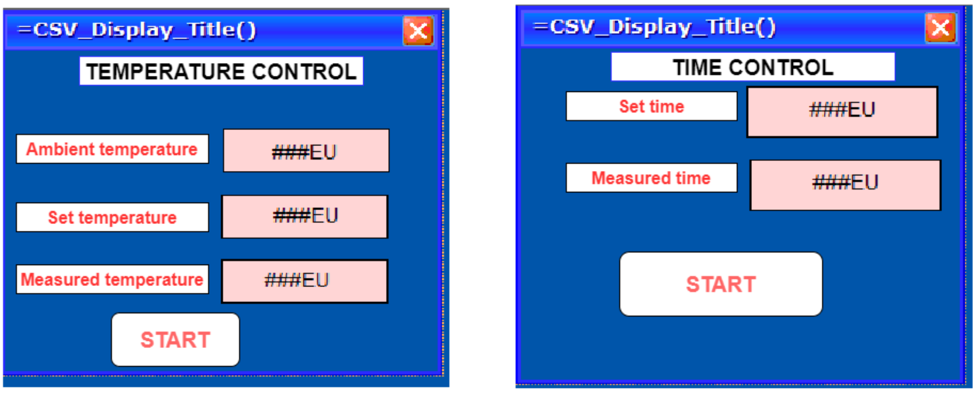

Figure 4: Temperature Control (Left) and Time Control (Right) pop-up windows.

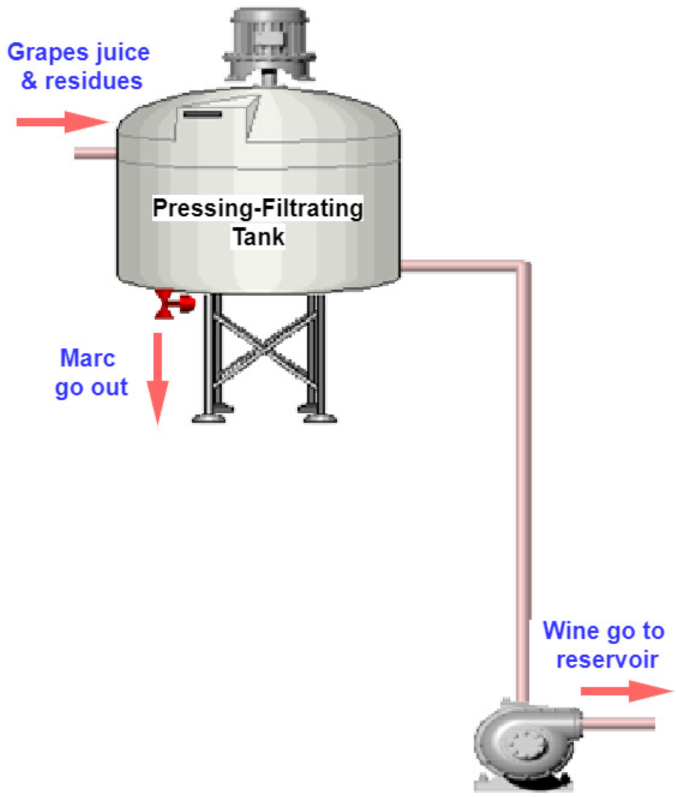

Figure 5: Press and Filtrate Stage (Vijeo Citect).

1.3 Press and Filtrate stage

First, the pressing-filtrating tank (Figure 5) squeezes the mixture of alcohol and insoluble residues to separate them. Next, the liquid part (the wine) is filtered and pumped to the wine reservoir, while the solid part (the marc) is removed from the tank. Now, we arrive at the final stage of the wine production line: bottle and package (Subsection 1.4).

1.4 Bottle and Package stage

In this stage, the reservoir pours wine into each bottle (Figure 6). Then, eight bottles of wine are packed every time. In each production batch, the system manufactures three packages of wine bottle.

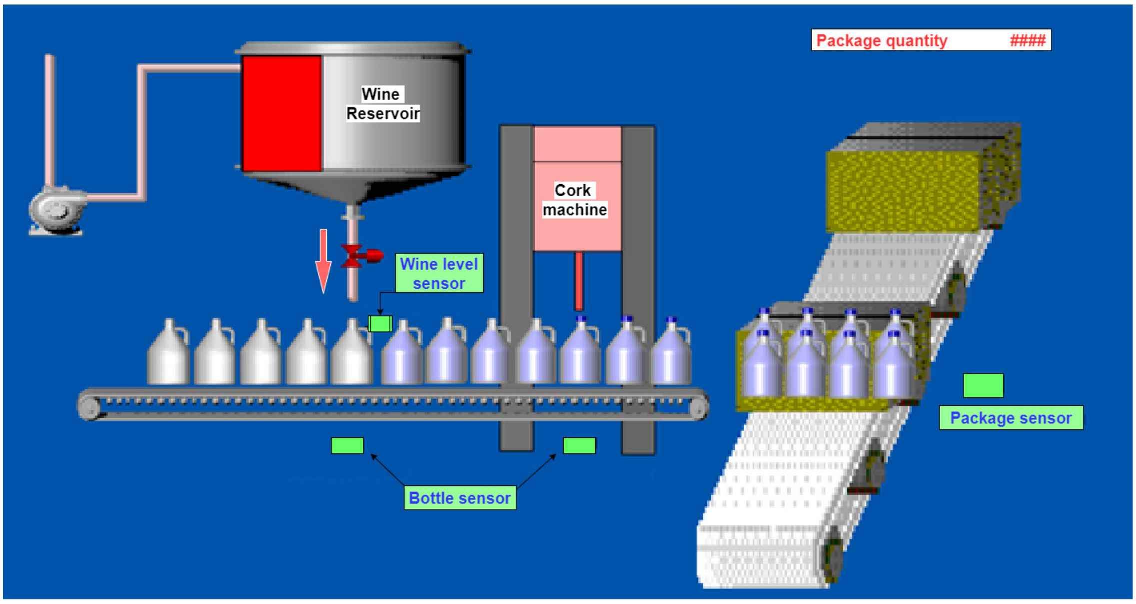

Figure 6: Bottle and Package Stage (Vijeo Citect).

Next, we come to the integrated power supply system. Section 2 presents the components making up this system.

2 Power Supply System

In our model, the power supply system combines two specific blocks. The first block includes two transformers and multiple circuit breakers (see Subsection 2.1). The second block comprises two generators and the subsidiary devices to supply cooling water and fuel for these generators (see Subsection 2.2).

2.1 Transformers and circuit breakers

To power the factory, we load the electricity from the 15 kV grid to two transformers, Transformer I and Transformer II, through two main circuit breakers (CB) called SWBT1 and SWBT2. The Transformer I has three outputs: T/O_1, T/O_2, T/O_3. The Transformer II has one output: T/O_4 (Figure 7).

The outputs of the transformers connect to seven CBs (1st-grade CBs). We divide these seven CBs into three groups: A (CTA1, CTA2), B (CTB1, CTB2, CTB3), and C (CTC1, CTC2). As we can see in Figure 8, these CBs connect to either the transformers' outputs T/O_1, T/O_2, T/O_4 or the generators' outputs G/O_1, G/O_2.

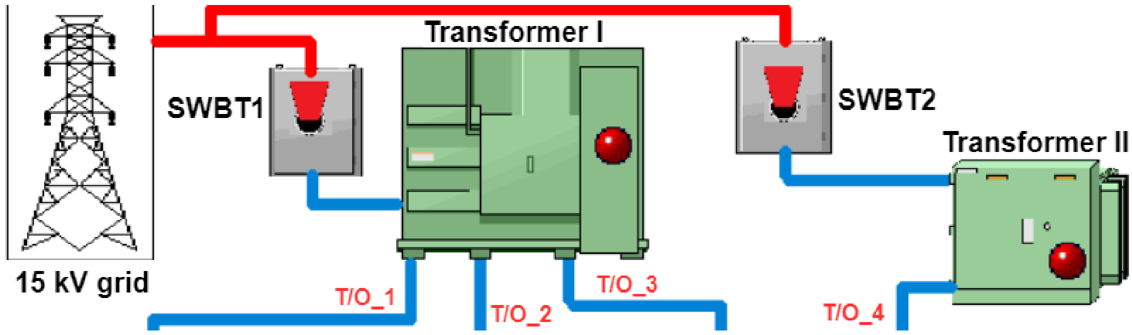

Figure 7: Two transformers are wired to the electrical grid.

Underneath the first-grade CBs is the second-grade ones which include three groups: (SW1_1, SW1_2, and SW1_3), (SW2_1, SW2_2, and SW2_3), and (SW3_1, SW3_2, and SW3_3). The CBs in the first two groups connect respectively to the first-grade CBs of group A and group B above. And, the CBs SW3_1, SW3_2, and SW3_3 wire, respectively, to a transformer's output (T/O_3 of Transformer I), the first-grade CBs (CTC1, CTC2), and a generator's output (G/O_3 of Generator II).

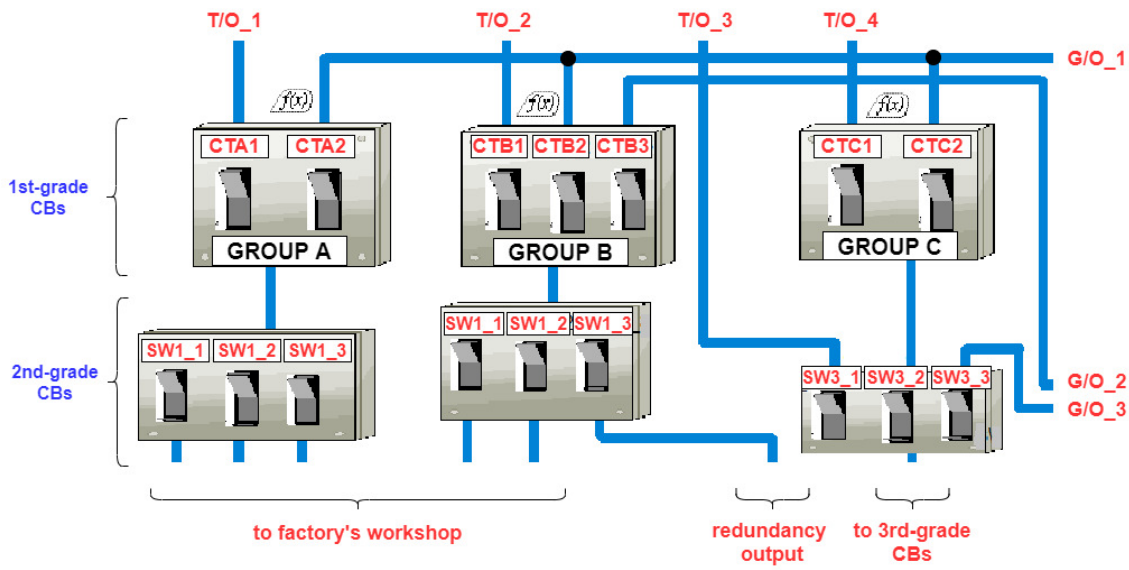

Figure 8: 1st-grade and 2nd-grade CBs distribute power from the transformers' outputs.

Among these second-grade CBs, the group (SW 3_1, SW 3_2, SW3_3) connect subsequently to the panel of third-grade CBs that transmit power straight to different stages of the wine production line presented in Section 1. The CBs from SW1_1 to SW2_2 conduct electricity to other factory's workshops, while SW2_3 is used as redundancy output.

The third-grade CBs (Figure 9) comprise CB F1, F2, F3, F4, and F5. As we just stated, the role of the CBs from F1 to F4 is to turn on/off power for the wine production process. The CB F5 is the power switch of the office building.

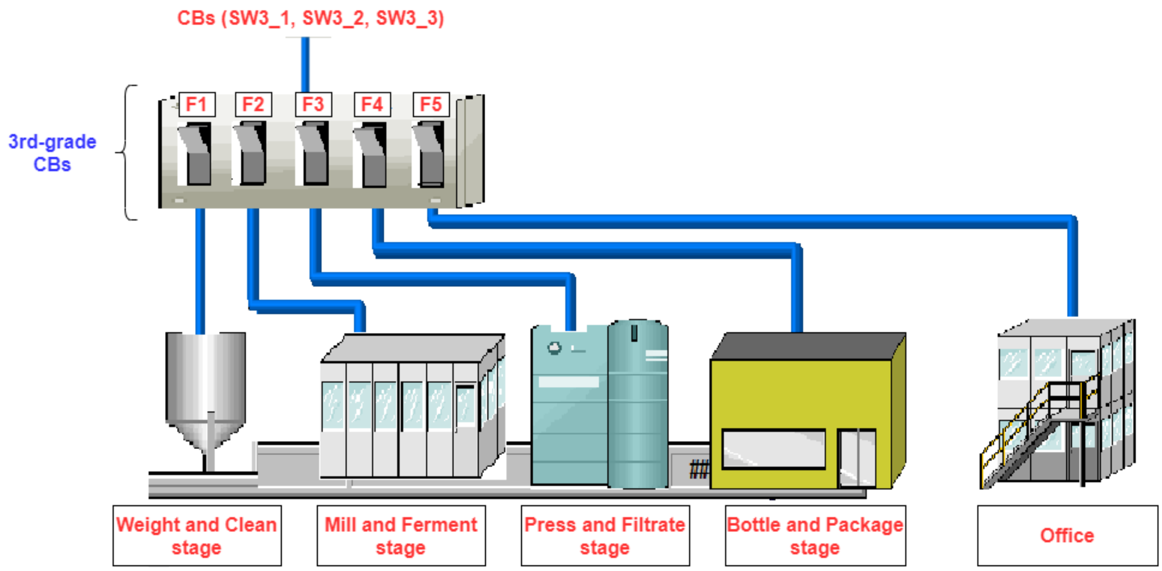

Figure 9: Third-grade CBs power the wine production phases.

In the next subsection, we describe the functioning of the block of generators and fuel & cooling water supply. For a power supply system operating in industrial plant, this block is indispensable.

2.2 Generators and fuel & cooling water supply system

Whenever an over-voltage (the voltage on the grid exceeds 16 kV) or an under-voltage (the voltage on the grid drops under 14kV) incident happens in the grid, the two transformers disconnect automatically, and the two generators (Generator I and Generator II in Figure 10) operate immediately. In this way, we can ensure the power supply for the entire factory. The unique output of Generator I (G/O_1) is wired to the input of the first-grade circuit breakers: CTA1, CTB2, and CTC2. Generator II has two outputs, denoted as G/O_2 and G/O_3, that connect to CTB3 and SW3_3, respectively.

The generator, while running, creates too much heat. Thus, a cooling process is imperative. Five seconds after the generators operate, a closed cycle of heat dissipation takes place. Specifically, a pump continuously pushes the water in a tank flowing through the generator engine, where it absorbs the heat and becomes hot water. Then, hot water is conducted to the fan that blows the heat to cool down it before returning to the tank. And from here, cool water is again pumped to cool down the generator engine.

When the problem on the grid is fixed (the voltage goes back within the range 14 to 16 kV), the two transformers are reconnected to the grid automatically. Meanwhile, the two generators continue to work for five more seconds before completely stopping. This stage, called synchronization, is to guarantee a stable power supply for the factory.

During the cooling process for the generator, the water gradually runs out. If the water volume in the water tank falls under 50 l, the water valve switches on automatically to let cool water from an external reservoir go into the tank. When the water volume in the tank is beyond 900 l, the valve automatically switches off.

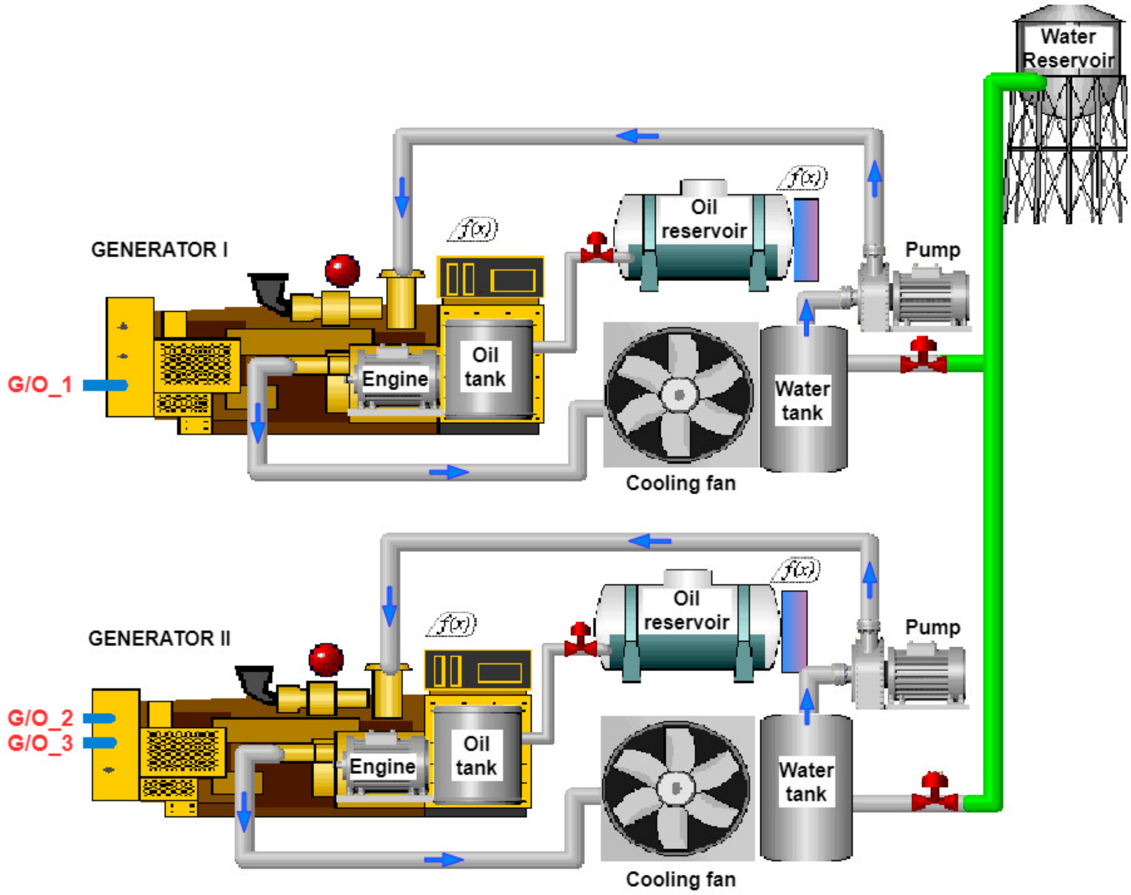

Figure 10: Generators and fuel & cooling water supply system.

The generator consumes oil reserved in his built-in tank. While the generator is running, the fuel level inside the tank decreases. Once the oil volume in the tank is less than 20 l, the valve of an external oil reservoir opens automatically to provide additional fuel for the generator's built-in tank. When the oil volume in the tank exceeds 450 l, the oil valve automatically closes.

In addition, besides the automatic mode, our system also allows the technician to turn on/off manually the generators, the water valves, and the oil valves.