PROCESS DRECRIPTION

CLASSIFICATION OF PROCESS ENGINEERING SYSTEMS

To effectively automate process engineering systems, structuring the system as well as describing its intended utilization is necessary. It is helpful in this case to subdivide the system into classes of process engineering plants that are similar regarding the requirements for automation engineering. According to [1], the number of fundamentally different products and the physical structure of the system can be used for classification.

If in principle the same product is manufactiured in a plant, it is called a ***single product plant***. If the environmental conditions change or the composition of the educts fluctuates, only the parameters of the process sequence or the settings are to be varied in these plants, in order to always get the same product.

In a ***multi-product plant***, on the other hand, different products are manufactured either according to different processes or according to the same process but with clearly different parameters.

From the view of automation, the ***single line plant*** represents the simplest physical structure of a plant. The intermediate steps of the product traverse the units in a fixed sequence. A ***multi line plant*** consists of several parallel single lines; however, no product transfer is intended between them. Only material quantities and finished product stores are used jointly by the single lines. A ***multi line-multi path plant*** also consists of single lines, but in contrast to the simple multi line plant, product exchange between lines is possible. Here, the paths can either be fixed, dynamic with a fixed connection, or dynamic with a flexible connection.

PLANT DESCRIPTION

In this instruction module, the laboratory plant shown in the adjacent Figure 1 is being automated.

The core of the plant consists of 2 reactors that are loaded with different educts. In the reactors, different products can be made at the same time. For that reason, the plant can be classified as ***multi-product plant*** and ***multi line-multi path plant***. It consists of several units that are permanently connected to each other. Depending on the production process, it is possible to wire the lines between the units dynamically. This requires complex automation. In the following chapters of this training module we will learn, however, that by taking into account a few simple principles and rules the complicated automation system can be assembled quite effectively and efficiently through combining existing blocks of the ***PCS7*** process control system.

Figure 1: Multi product and multi train-multi stream process cell at TU Dresden as play ground for modern process control engineering

The first unit provides the educts for the reactors. It consists of three educt containers. Their instrumentation is identical. To ascertain whether the container is empty or full, the level is monitored by two encoders. With a valve at the outlet and a pump, the educt can be dosed for the second unit. By means of a valve at the inlet, the educt is refilled.

The second unit consists of two reactors that have the same dimensions as the educt containers and are equipped with the automation resources. Each reactor is provided with an agitator and a heater. With an ultrasound sensor the level is measured continuously, and with a PT100 element the temperature. By means of the three valves at the inlet, the educts are drained into the reactor. With a pump at the outlet, the reaction product can either be transferred to the other reactor respectively, or drained into the third unit. An additional valve at the inlet allows for the reactor being cleaned with rinsing water from the fourth unit.

The third unit contains the finished products and consists of two containers with two encoders that display the minimum and the maximum level. While the reactors can be loadeded by all educt containers, the product containers are assigned exactly to one reactor. With a valve at the inlet of the product container, the path from the reactor to the product container is enabled. A valve each at the outlet of the product containers serves to remove the finished product from the plant.

The fourth unit consists of a rinse water container. It also is equipped with two encoders to indicate the minimum and maximum level. With a valve and a pump at the outlet, the rinse water can be transported to the reactors of the second unit, and by means of the valves at the inlet back again from the reactors.

PIPING AND INSTRUMENTATION DIAGRAM

Although a textual description of a plant explains the essential relationships, it is not very suitable to communicate the joint tasks of process engineering, electrotechnical engineering and automation engineering, because a textual description is prone to misunderstandings even where small plants are concerned, but above all in the case of large plants with hundreds of devices and several tens of thousands of measurung points.

In the course of time, the Piping & Instrumentation Diagram (P&ID) has developed into a central planning tool for that reason. The P&I diagram documents the structure and function of the process system for process as well as automation engineering. Figure 2 shows the P&I diagram of the automated experimentation plant that is to be automated in this instruction module.

Containers, valves and pumps as well as process control engineering functional requirements are represented by standardized symbols. The piping between the elements is indicated as solid lines, information flow as dashed lines. For the sake of clarity, in Figure 2 all units are shown in a P&I diagram.

A container or a process control function is associated with a certain unit by means of an identification system This identification system provides for clarity for humans as well as the computer. As long as people work closely together, they can easily distinguish between educt container B001 and the product tank B001 based on the context. This becomes more difficult if communication takes place over several departments, employees are processing many projects simultaneously and computers are involved. The complete designation for the first educt container B001 is therefore ***=SCE.A1.T1-B001***. Thus, tank ***B001*** in factory ***SCE***, unit ***A1***, subunit ***T1*** can be clearly distinguished from a similar plant part in another factory, or in another unit.

SAFETY INTERLOCK AND PROTECTION FUNCTIONS

The P&I diagram is not sufficient to specify all requirements for process control engineering. To ensure safe plant operation, the controller has to do the following: monitor process intervention and if needed, suppress user input, switch actuators on or off, mutually lock functions and/or take the plant to a safe state. For the plant described above that -according to Figure 2- is equipped with meters, the following monitoring and locking functions are required and, within the instruction modules, implemented step by step with ***PCS7***:

– Actuators must be switched only if the main switch of the plant is switched on and the Emergency Off switch is enabled.

– Containers must not overflow; that means there is either an encoder that signals the maximum level, or the maxmum level (here: 1000ml) is known numerically and is evaluated by means of the measured level.

– Pumps must not take in air; that means there is either an encoder that signals the minimum level, or the minimum level (here: 50ml) is known numerically and is evaluated by means of the measured level.

– Pumps must not attempt to take in liquid when a valve is closed, or pump liquid against a closed valve.

– The temperature in the two reactors must not exceed 60°C.

– The heaters of the two reactors must only be operated if they are covered with liquid (here: a minimum of 200ml in the reactor).

– The agitators of the two reactors should be operated only if they are in contact with liquid (here: a minimum of 300ml in the reactor).

RECIPE

According to [1], a recipe is a specification for manufacturing a product according to a procedure. It describes what is needed to carry out a procedure. To the plant described above, the following recipe applies which is implemented within this instruction module with ***PCS7***:

1. First, 350ml are to be drained from educt tank =SCE.A1.T1-B003 into the reactor =SCE.A1.T2-R001 and at the same time 200ml from educt tank =SCE.A1.T1-B002 into the reactor =SCE.A1.T2-R002.
2. When reactor =SCE.A1.T2-R001 is filled, the liquid is to be heated 25°C with the agitator switched on.
3. When reactor =SCE.A1.T2-R002 is filled, 150ml of Educt A fom Educt Tank =SCE.A1.T1-B001 is to be added to reactor =SCE.A1.T2-R002. When this is completed, 10s later the agitator of reactor =SCE.A1.T2-R002 is to be switched on.
4. If the temperature of the liquid in reactor =SCE.A1.T2-R001 has reached 25°C, the mixture is to be pumped from reactor =SCE.A1.T2-R002 to reactor =SCE.A1.T2-R001.
5. Now, the mixture in reactor =SCE.A1.T2-R001 is to be heated to 28°C and then be drained into product tank =SCE.A1.T3-B001.

LITERATURE

[1] DIN EN 61512-1 (Status 2000-01): Batch Oriented Operation.

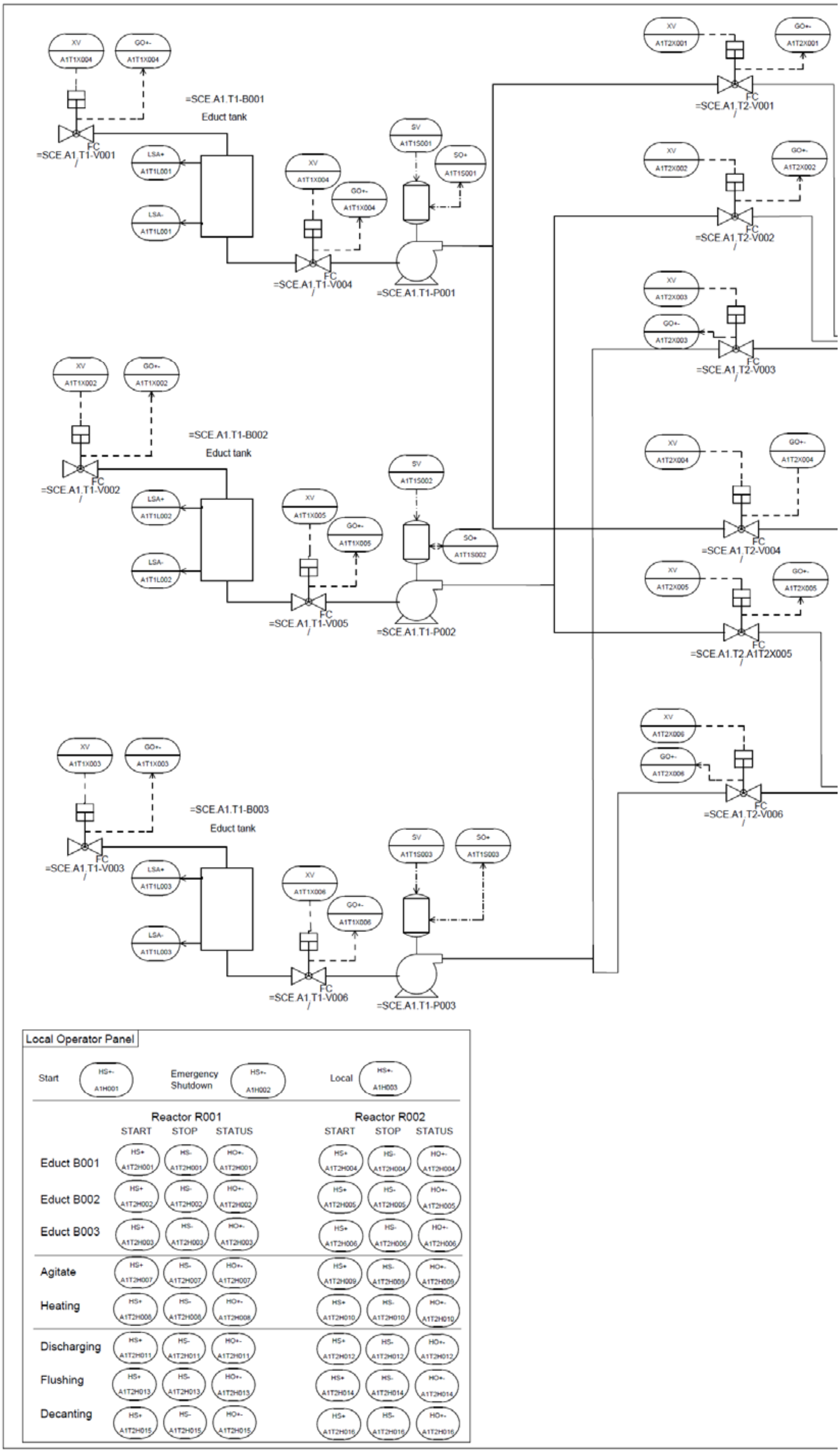

Figure 2: Developed Process Cell (Part 1)

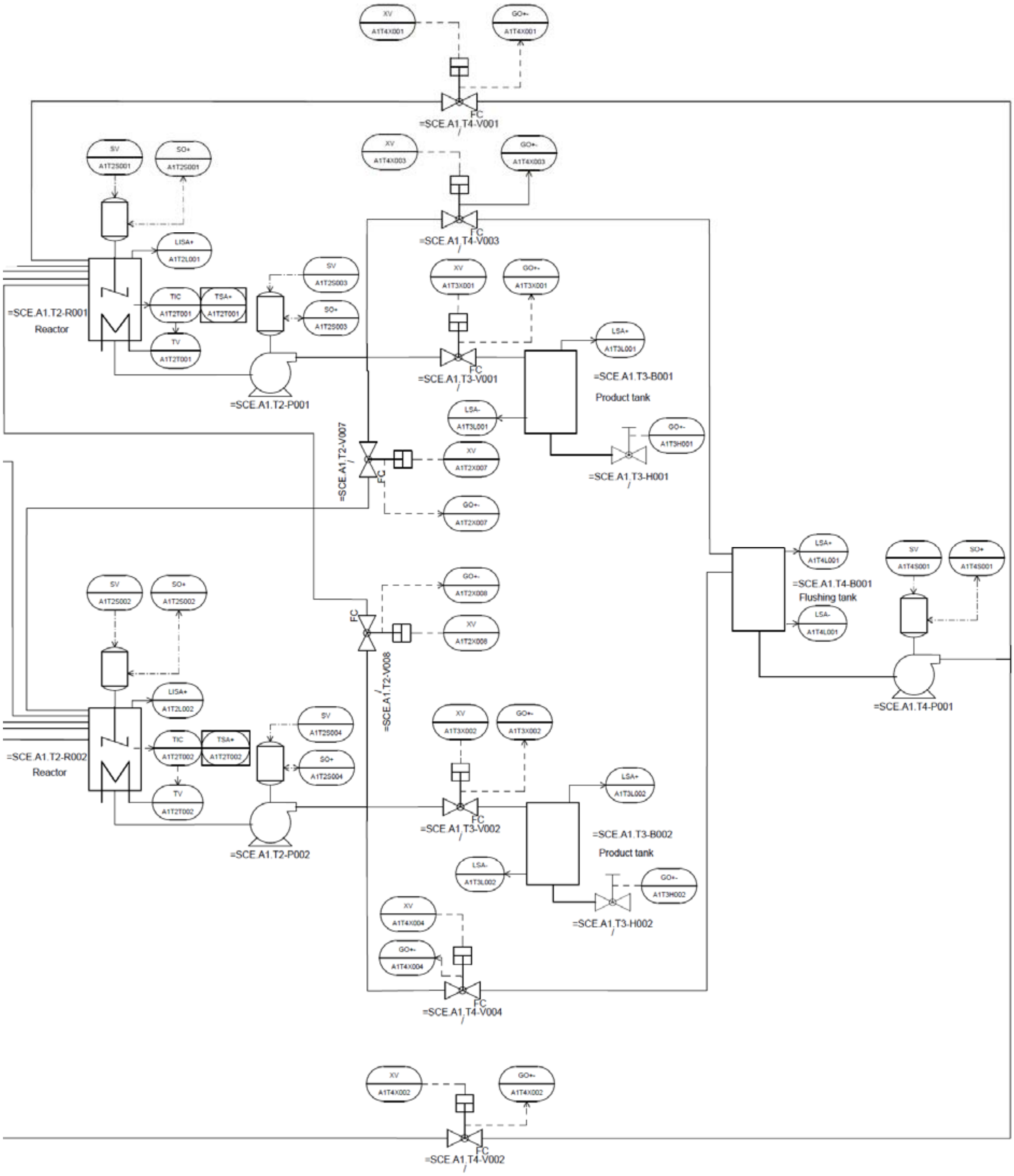

Figure 2: Developed Process Cell (Part 2)