

IMPLEMENTATION AND PROCESS CONTROL OF A CRICKET FILTER

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Abstract. The present article describes the steps and functions needed to configure a sequence control system in Honeywell Experion PKS, following guidelines and modifying the Human Machine Interface (HMI), so that the operators can understand and control the process better.

Keywords: Cricket Filter, Process Control, Human Machine Interface (HMI), Configuration Studio, Pressure Filtration, Experion PKS.

1. INTRODUCTION

Pressure filtration, a method used for separating solids from liquids, has a long history dating back to ancient times. The concept of using pressure to drive liquids through a porous medium to separate solids can be traced back to the Egyptians, who used rudimentary methods to filter water for drinking purposes.

However, pressure filtration as a systematic process began to evolve during the Industrial Revolution in the 18th and 19th centuries. The development of the first filter press is attributed to Sir Charles Barry in 1853. However, it was Sir Richard Tangye who patented the design and introduced it commercially in 1858. The early filter press consisted of a series of cloth-covered frames arranged between two heavy plates. Pressure was applied manually to force the liquid through the cloth, leaving behind a filter cake.

One significant development in pressure filtration occurred in the early 20th century with the invention of the filter press by Charles Pack. The filter press utilized a series of plates with filter cloths to separate solids from liquids under pressure. This invention revolutionized industrial filtration processes, particularly in industries such as mining, chemical processing, and wastewater treatment.

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In the following decades, various improvements and innovations were made to pressure filtration systems, including the introduction of automatic and continuous filtration processes. These advancements increased efficiency and productivity in industries reliant on filtration, further cementing pressure filtration as a crucial technology [1].

The process of pressure filtration can be summoned up into 7 parts, which are as follows:

- **Preparation of Slurry:** The process begins with the preparation of a slurry or suspension containing a liquid and solid particle. This mixture could be obtained from various industrial processes such as mining, chemical manufacturing, or wastewater treatment.
- **Filling the Filter Press:** The slurry is pumped into the filter press, a specialized apparatus consisting of a series of chambers formed by plates and frames. Each chamber is lined with a filter medium.
- **Application of Pressure:** The plates of the filter press are pressed together, applying mechanical force to the slurry. This pressure forces the liquid component through the filter medium, leaving the solid particles behind to form a filter cake.
- **Filtration and Cake Formation:** As the liquid passes through the filter medium, solid particles are retained, and a filter cake accumulates in each chamber. The cake's thickness depends on the characteristics of the slurry and the filtration requirements.
- **Cake Washing (Optional):** In some applications, an additional step involves washing the filter cake with water or other suitable liquids to remove any remaining impurities or residual mother liquor.
- **Drying (Optional):** Depending on the intended use of the filtered solids, a drying step may be employed to reduce the moisture content of the filter cake.
- **Cake Discharge:** Once the filtration process is complete, the filter cake is discharged from the filter press. The now clarified liquid, free from most solid particles, is collected for further processing or disposal [1].

2. FILTRATION THEORY

Scientific approaches to understanding filtration date back to the 1850's, when Darcy noted the proportional relation between pressure drop Δp and liquid flow Q through a packed bed of solids (1). Physically arguing, the solid-liquid suspension passes through channels that form in the bed. Friction losses, depending on viscosity and flow regime, occur when the medium passes over a

surface. Larger particles will start to accumulate on the upstream side of the cake, which therefore grows over time. Smaller particles gradually adhere to walls and cavities while passing through the channel-matrix. Pressure losses across the cake are thus linked to the depth of the permeated media, which furthermore influences the quality of a separation. However, characteristics such as particle size distribution, shape and morphology, surface charge, and pH will determine the pressure gradient throughout the bed (Tarleton and Willmer (1997)) [1, 2, 3, 4]. It is convenient to express the flow pressure drop relation by means of a cake resistance α :

$$Q = \frac{A\Delta p}{\mu L\alpha}. \quad (1)$$

Here, L denotes the measure for the depth of the bed, A the cross-sectional area and μ viscosity. In reality α is not constant throughout the cake, as nearly all filter cakes exhibit compressibility – meaning that permeability properties in the cake are not constant. For a limited range of pressures, an empirical approximation is given by:

$$\alpha(\Delta p, n) = \alpha_0 \Delta p^n, \quad (2)$$

where n is a compressibility index (0 denoting a noncompressible material) and α_0 a reference resistance. If a more convenient expression is desired, one finds a remedy in averaging over the cake depth, as documented e.g. in Tien (2006) [1], which then yields:

$$\bar{\alpha} = (1 - n)\alpha_0 \Delta p^n. \quad (3)$$

In order to extend the descriptiveness of equation (1) to an entire filtration cycle, the relationship between cake growth and time must be established. If the concentration of accumulation particles on the top-layer ($\bar{c}$) and likewise the cake's structural integrity are sufficiently constant,

$$L = \frac{\bar{c} \int Q dt}{A} = \frac{\bar{c} V}{A}. \quad (4)$$

Yields the desired equivalence, in which V denotes the amount of processed filtrate. Thus, equation (1) and (4) and ultimately (3) yield the necessary link between time and filtration, processed filtrate, and pressure drop:

$$\frac{dt}{dV} = \bar{\alpha} \mu \bar{c} \frac{V}{A^2 \delta p} + \frac{\mu R_m}{A \delta p}. \quad (5)$$

In (5), a second term has been included to account for the medium resistance across the membrane (R_m). It is a common assumption to view R_m as constant, furthermore is the cake resistance typically larger by several orders of magnitude. Reliable first principal models are scarce and complex; thus it should be regarded as best practice to determine any α , c , or R_m experimentally in lab- or ideally pilot scale experiments. However, one should keep in mind that even, cross-scale validity is usually an issue, as discussed in Tarleton and Hancock (1997) [1, 2, 3, 4].

3. CRICKET FILTER

The Cricket filter, which is shown in Fig. 1 and is created by the amafilter® Filtration group®, was successfully launched in 1990 and has since been installed in over 1,000 industrial and food applications globally. It has become a well-established pressure filter, developed to combine the advantages of pressure leaf filters and cartridge/candle filters whilst avoiding their drawbacks. It is especially suited for separating fine solids from fluids, widely deployed in applications such as edible oil, gelatine, cocoa butter, sugar, sweeteners, oleo chemicals, mining and amine cleaning.

The Cricket filter offers versatility for a wide range of applications while providing confidence in critical environments. It is available as a standard in stainless steel 316L. Carbon steel and other special alloy materials, design pressures/temperatures and design codes can be provided upon request. For the discharge of the cake, the carriage with the filter leaves is moved outside the filter tank with either an electric or a hydraulic system, which also operates the bayonet closure. The cake is then discharged by a pneumatic vibrator [5].

3.1. Features and benefits

- Up to 40% larger filtration area than traditional pulse tube filter systems.
- Large filtration area within a small footprint.
- Hermetically closed system and can be fully automated.
- Suitable for direct cloth filtration or precoat/body-aid filtration.
- High filtrate quality.
- The Cricket filter is simple to clean. It uses air or gas pulses for cleaning the elements section by section, without requiring a vibrator.
- Low maintenance.
- Suitable for a wide range of applications.

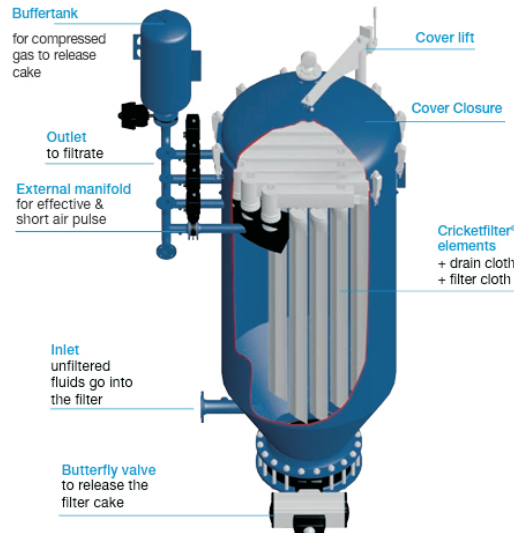


Fig. 1. Cricket Filter

- The Cricket filter can be used with filter cloths of various pore sizes and materials. This reduces and at times eliminates the amount of extra pre-coating needed, making filtration more economical.
- Cricket filter automation. It is possible to automate, therefore ensuring low necessary maintenance [5].

3.2. Implementation and execution

The previously mentioned cricket filter has been implemented in the KPO refinery in Kazakhstan. The Karachaganak Petroleum Operating B.V. (KPO) is a joint venture between Royal Dutch Shell (29.25%), Eni (29.25%), Chevron (18%), LUKOIL (13.5%) and KazMunaiGas (10%). KPO oversees the expansion and development of the Karachaganak field – one of the world's largest oil and gas condensate fields. Located in northwest Kazakhstan it covers an area of over 280 square kilometers and holds estimated hydrocarbons initially in place (HIIP) of 9 billion barrels of condensate and 48 trillion cubic feet (tcf) of gas, with estimated gross reserves of over 2.4 billion barrels of condensate and 16 tcf of gas [6].

The control strategy for the cricket filter is done in the Honeywell Experion Process Knowledge System (PKS), which is a modern distributed control system with an integrated modern process automation platform [7, 8]. Programming and configuration of control strategies in the system is done through

the Control Builder software package (Fig. 2). It provides a graphical interface for building process control strategies.

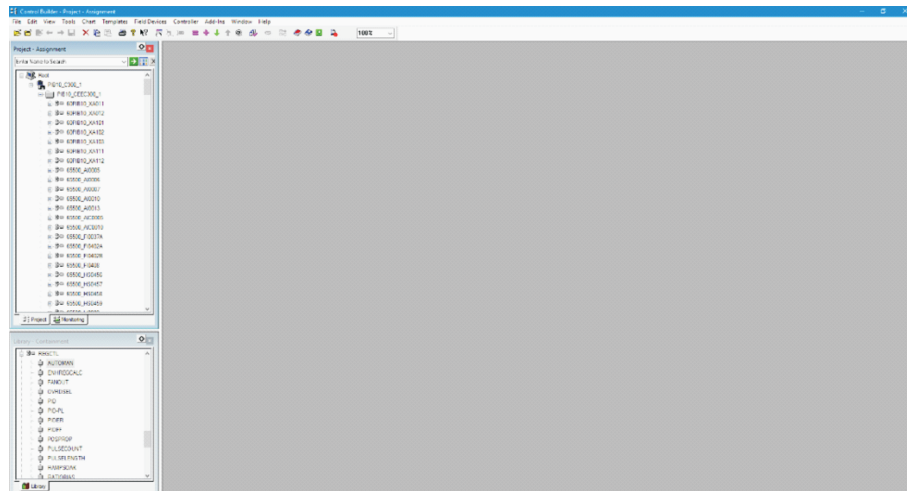


Fig. 2. Control Builder

The control builder allows the user to create logic or process control strategies with the help of specific blocks, which can be found in the system library. For the cricket filter system, due to the number of steps which had to be executed it was made with a sequential control module (Fig. 3).

In Experion, Sequential Control Modules execute sequential control and Recipe Control Modules execute procedural control. The Sequential Control Modules and related function blocks are included in the standard Experion system [7, 8].

The Sequential Control Module (SCM) and the Recipe Control Module (RCM) are containers composed of one or more Handlers. Each SCM handler can contain transition, step, and/or synchronization blocks. Each RCM Handler can contain phase, transition, step, and/or synchronization blocks.

The SCM commands can be executed only if the valves or pumps in this scenario are in program mode. If they are not in program mode then the program spots and activates the ABORT/RESTART handler.

After creating the process control strategy, the next step involves creating a display, from which the operators can see what is happening with the cricket filter in real time. This is done in the HMI Display Builder.

This package was used to create the cricket filter control display. HMI Display Builder is part of the Experion Process Knowledge System and is a graphical tool for creating user displays using WebBased functions.

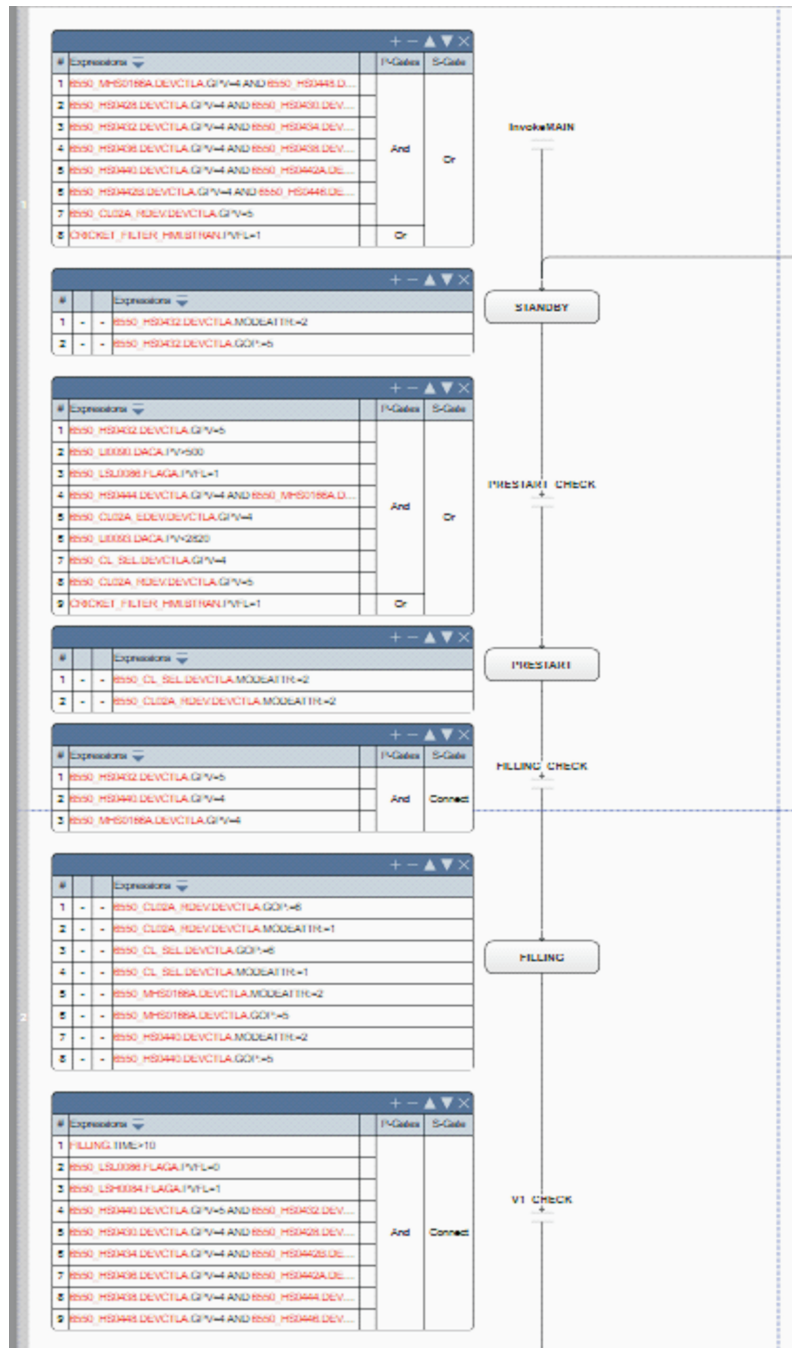


Fig. 3. Sequential control module

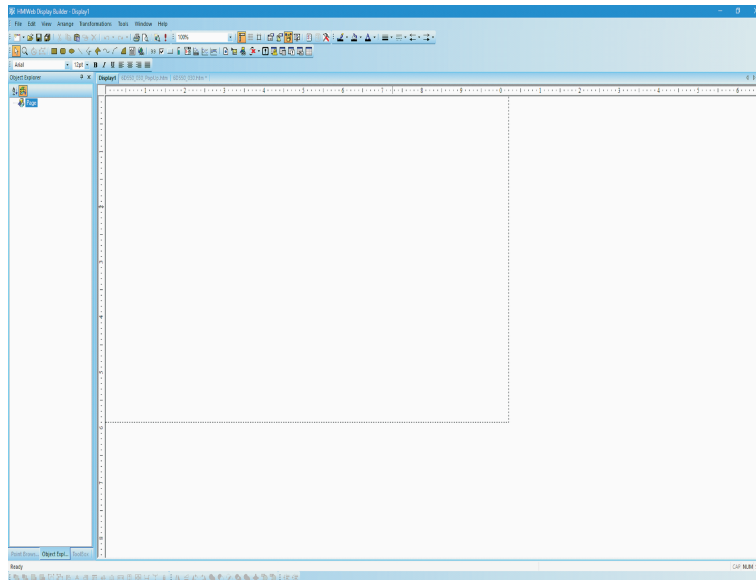


Fig. 4. HMI Display Builder

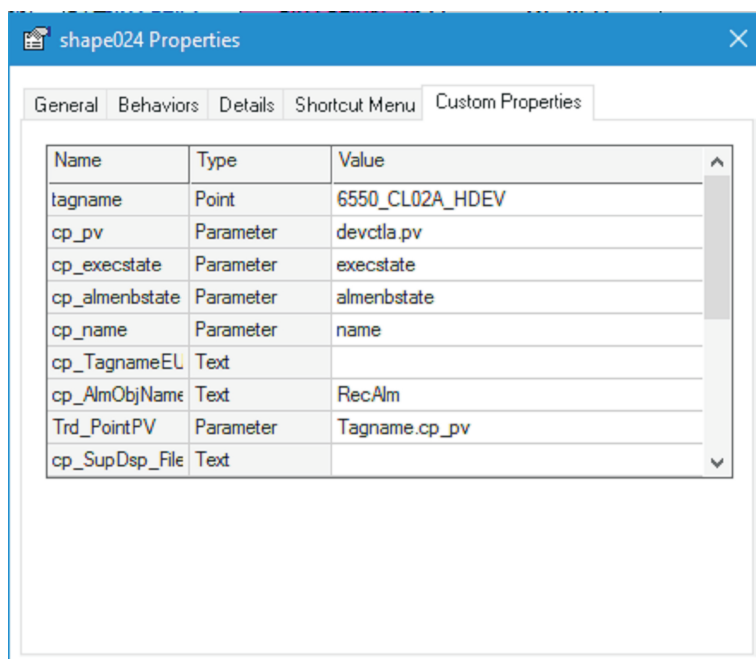


Fig. 5. Necessary parameters for configuring a graphical object

C:\ProgramData\Honeywell\Experion PKS\Client\Abstract\KPO_CNU\60550_SEQ6.htm

Number	STEP	CL-02A		CL-02B	
Step 1	STAND BY	☐	0	☐	0
Step 2	PRE START	☐	0	☐	0
Step 3	FILLING	☐	0	☐	0
Step 4	VENTING	☐	0	☐	0
Step 5	CLOTH WASHING	☐	0	☐	0
Step 6	REFILL	☐	0	☐	0
Step 7	VENTING 2	☐	0	☐	0
Step 8	CLARIFICATION 1	☐	0	☐	0
Step 9	CLARIFICATION 2	☐	0	☐	0
Step 10	FILTRATION	☐	0	☐	0
Step 11	CIRCULATION	☐	0	☐	0
Step 12	EMPTYING	☐	0	☐	0
Step 13	VENTING 3	☐	0	☐	0
Step 14	OPEN CAKEDOOR	☐	0	☐	0
Step 15	CAKE DISCHARGE	☐	0	☐	0
Step 16	PULSE	☐	0	☐	0
Step 17	VALVE CLOSE	☐	0	☐	0
Step 18	CAKE DISCHARGE READY	☐	0	☐	0
Step 19	CLOSE CAKEDOOR	☐	0	☐	0

Fig. 7. Cricket filter steps

are executed during the step. From here the operator can easily understand the process and can determine if a certain condition hasn't been fulfilled and from here, he can decide if it's necessary to override it or not, without needing to open the configuration studio. This representation is definitely an improvement over the current active depiction of the filtration process, which is active on site.

4. CONCLUSION

This paper explains how it is possible to implement and control a cricket filter with dry cake discharge produced by amafilter®Filtration group®using the Honeywell Experion PKS environment. By enhancing the sequence control and thanks to the HMI Display builder it is easier for the users to understand the system and thus increase productivity. The Sequence control

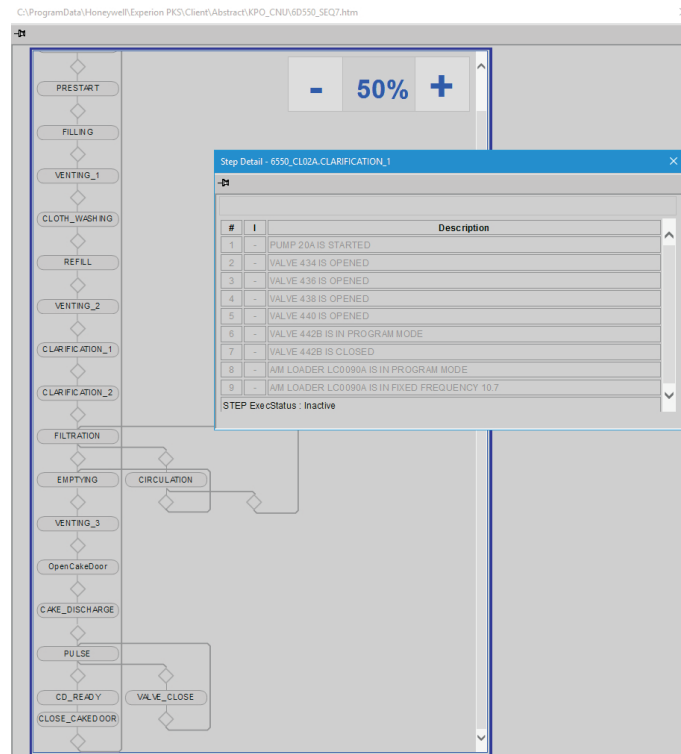


Fig. 8. SCM shape

module (SCM) allows the users to see in real time what is happening with the system and using the different handlers, which are provided by the SCM, any possible scenario can be controlled.

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