REVIEW OF THE IMPLEMENTATION OF SUPERVISORY SISITEMA IN A PRESSURE FILTER

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Abstract. *The use of systems that allow automation and monitoring of industrial equipment in real time is present in different environments and leads to the development of systems called SCADA (Supervisory Control & Data Acquisition Systems). In industrial processes involving chemical reactions this methodology is widely used not only in order to economic factors but also the issues of worker safety. This paper aims to propose architecture to implement a supervisory system in a pressure filter on the handling of liquefied minerals in sulfuric and fluoride acids. As results, the implementation schemes, the economic factors and the advantages of automation equipment operating in areas of risk in industrial plants will be demonstrated.*

Keywords*: Supervisory system, pressure filter, automation, PLC, mining*

1. INTRODUCTION

With the price decrease of computer equipments and the raise of availability of development tools in the market combined with flexible frameworks that can be adapted to various processes and in some cases, these frameworks can be downloaded free on the Internet, the industry has opted for the automation of your plant via computer.

This automation is usually done by special equipment called Programmable Logic Controller (PLC). As there is not usually an interface between PLC and the operator of the process, a computer with specific software for this communication is used. Nowadays it is possible to implement supervisory in all segments of commerce and industry as alarm systems, schools, hospitals, department stores, air conditioning of offices, laboratories, small factories and in many industrial processes.

The initiative to automate any process must be based on careful evaluation of cost of implementation and maintenance of the system and benefits, such as the flexibility of the process, increase of productivity, reduce of costs and the increase of the safety of people and equipment.

According Shikari (2004), in addition to analysis based on the operational point of view, the implementation of the automation process involves a detailed study of the steps that comprise a maintenance policy to be considered with the flowchart as shown in Figure 1.

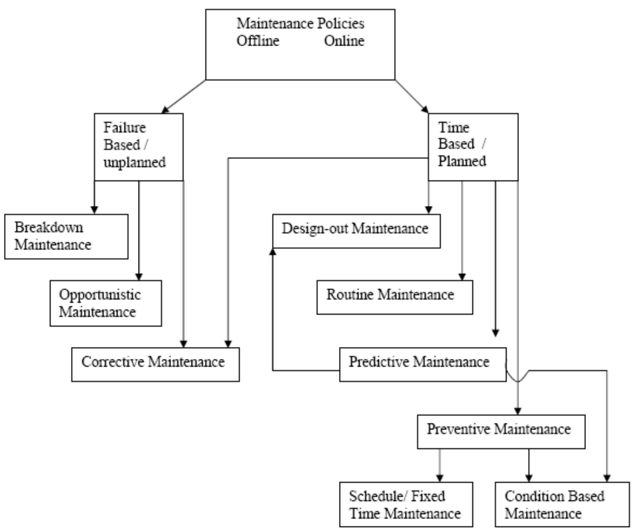

Figure 1. Maintenance policy flowchart

Along with the technological demand, there was an increase in demand for minerals applied to the chemical industry and electronics, requiring greater investment in the mining and extraction to increase productivity, ensuring quality, delivery times and prices.

According DNPM (2009), the strong demand in the global market for commodities processed metal used in electronics, automotive, metallurgical and construction industry has been stimulated in recent years by the current growth of China. Brazil has a favorable position because it is considered one of the largest mineral producers, and for some specific minerals, Brazil has about 98% of world production.

Some of these substances are found in rocks and minerals, and the extraction process is initiated by a chemical process called digestion. Digestion is the acid leaching of the raw materials using hydrofluoric acid (HF) or sulfuric acid (H_2SO_4). The process is done in batches, under discontinuous and transient regime. The pulp resulting from this process is directed to the pressure filter, where the solid, called sludge, is separated from the liquid material that is rich in the substance that want to extract.

The filtration process is the main bottleneck of the production, because in the industry under study, activation of all commands is performed by an operator in an electric control panel. The current system has low operational reliability and exposes the operator for a very long period the highly toxic fumes and gases becoming a potential risk to his health.

In mining processes, advanced methods of control and automation have been developed and reported excellent results (Townsend, 2003). However, this development is concentrated in the milling process, digestion and flotation. Very little effort has been placed on the development and control in the filtering process.

1.1. Supervisory systems

A few decades ago, the process of mechanization was limited to the operator and the machine. However, the need for amplification of industrial processes began to seek devices that could, upon receiving information from the environment, process them. Thus emerged the automation of processes and machines based on the reduced dependence of sensory and decision capacity of the operator, replacing human action control.

The supervisory systems are defined as systems that supervise or monitor processes running in an industrial plant, through visualization of variables of the plant that is being automated as well as actions taken by the automation system. They are also employed in order to recognize likely failures in plant components before they actually occur (Melendez et al., 2001).

The modern industrial automation systems needs to model their facilities in order to be able to market competitiveness, so in a modeling environment it is necessary to plan the system architecture, this being perhaps the most important aspect. The supervisory enables the operation and allows its viewing through graphic screens developed for any industrial process or commercial, regardless of the size of your plant.

1.2. Basic diagram of the system

In principal, the basic scheme of the supervisory system consists by the inclusion of a microcomputer control system already in place or not, that in most cases is formed by a PLC and its peripherals. The communication between the computer and the control system typically follows the same protocol, however, with the help of interfaces and/or gateways it is possible to establish intercommunication on various protocols. This ensures the implementation of all supervisory control systems (Maia, 1998a).

The communication bus is composed of several protocols, which are commonly used RS232C or RS485 in the communication between PLC-Master and PLC-Slave, RS232C or TCP/IP connection between PLC-Master and computer. There is communication also in digital signals, or "loops" of current between PLCs, electrical panel and field elements. There are currently various network protocols for the connection between PLCs and field elements.

As shown in Fig. 2, the supervisor will oversee all elements of the bus, but in most cases, the supervisory restricts its access only to the CLP-Master, which prepares a status table of the process and delivers it to the supervisory which may or may not promote an interference on the progress of the process, changing the control parameters (LCSLINK, 2002).

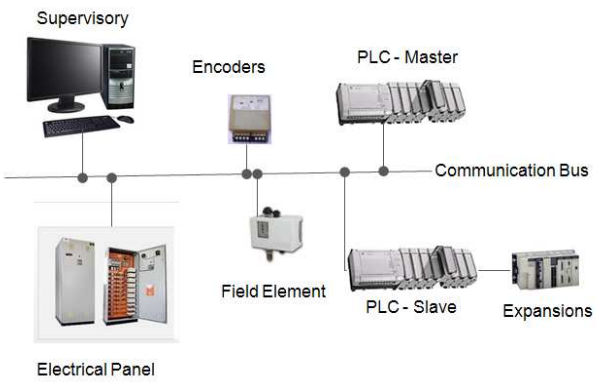

Figure 2. Scheme of an automation system

To enable the exchange of information between supervisory systems and PLCs, communication drivers were developed, because manufacturers of PLCs and supervisory software may not be the same. The manufacturers of automation products structure their products according to international standard IEC 61131-3 and communication OLE for Process Control (OPC), providing a standard framework for control and data exchange (Diniz and Paula, 2008).

One of the most common tasks of supervisory control is the statistical process, which, by processing variables, can plot graphics and point out trends. The system operator will have available a graphic display representing part or all of the process, its parameters (set points) and the actual values of the field. In the representation of Fig. 2 comprises a Master-Slave network-type between the two PLCs and it is their task to interlock and control the field elements (sensors, valves, relays, etc) via a logic program that runs on each PLC. It is also the task of the PLC to inform the supervisory system on the process variables (Maia, 1998b).

2. PRESSURE FILTER

The pressure filter is an equipment used in chemical, food, sanitation, and mining industries. Its function is to separate materials and according to the final product application, can be liquid or solid. In this particular case, the pressure filter is in a chemical industry used in mineral processing to extract the liquid part of the compound produced by the digestion stage.

Figure 3 illustrates a horizontal pressure filter similar to the one used in this work. In Fig. 4 we have illustrated in a simplified way the pressure filter. This equipment consists of several plates, lined with filter cloth, which are compressed by a hydraulic cylinder. Between each plate chambers are formed where will be accumulated solids.

Figure 3. Photo illustration of the pressure filter

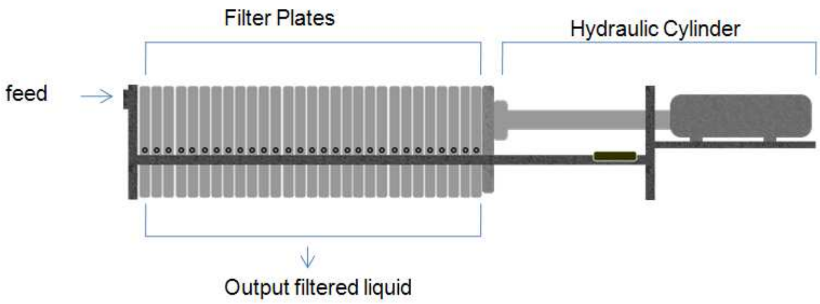

Figure 4. Basic diagram of the pressure filter

Within each plate, there is a diaphragm that is pressurized, increasing the compression of the solid material, extracting the maximum liquid substance.

The liquid material removed from the pressure filter is directed to special ponds where they will be processed in a later stage.

2.1. Filtration processes

The pressure filter is a machine that works on cycles, comprising the steps represented in Fig. 5. It is noteworthy that during the cycle, some steps may occur more than once depending on the nature of the product to be filtered and the final material of interest (liquid or solid).

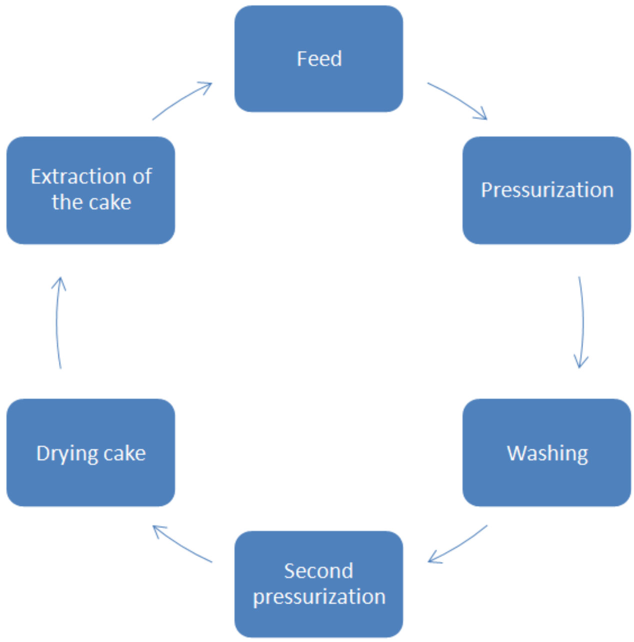

Figure 5. Representation of the filtration cycle of a pressure filter

The first step is the feed. With the pressure filter closed, the material to be filtered is pumped to the pressure filter, forcing the material to pass through the filters plates. The solid material is retained in the filter, extracting only the liquid. The increase of solid material retained on the filter increases the pressure of the feed system until a threshold called the set point. Upon reaching the maximum pressure, the feed is interrupted, leaving the system available for performing the next step called pressurization.

In pressurization step, we use compressed air to dilate the diaphragm located inside of each plate, increasing the compression on the cake retained on the filter cloth. In this step is taken the maximum amount of liquid substance.

The washing step is only used when the product is of interest to the process is the liquid material. In the case of this study, the substance to be extracted is liquefied, so the washing is essential to reduce the need to pass the rejected material again by the digestion process.

After washing, the second pressurization is accomplished in the same way as the first, but the objective is to remove the water used to wash the cake in the previous step.

Drying is accomplished by blowing compressed air into the cake. This step is important to dry the material as most as possible, facilitating the removal and handling of the cake.

The last filtering procedure is the extraction of the cake. This step is performed with the pressure filter cylinder recessed and the pickup tray opened. An automatic displacement of plates is used that will separate the plates. The dry cake will fall by gravity into storage of the slurry. The sludge will be analyzed in the laboratory and if they do not meet the minimum standards of concentration, it will be recycled by the digestion process, resulting in increased operating expenses

3. DEPLOYMENT OF AUTOMATION SYSTEM

In this chapter we will present the computational tools used to develop the system, the control algorithm, the fault detection module and interface with other systems.

3.1. Computational Tools

The pressure filter of the company under study was initially designed to operate automatically, but due to a deficiency in the absence of a control and supervisory system, the execution of each step of the filtration process is initiated by the operator in an electrical panel. This equipment has a hydraulic unit, actuated valves and sensors connected to the PLC MicroLogix 1500 from Rockwell Automation.

To the development of PLC control program, the language used was Ladder, implemented in the Rockwell's environment: RSLogix 500 was used to create the control program in ladder logic, RSLinx was used to perform the communication between PC and PLC, Logix 500 Emulator was used to simulate the environment of the PLC in a microcomputer.

To the development of supervisory was used free software SharpDevelop 4.0. The SharpDevelop is an Integrated Development Environment for C # and VB.NET using the. NET Framework 4.0 from Microsoft. The decision to use free software is due to the high cost of investment in the acquisition of proprietary software licenses to generating supervisory programs.

The database used was Microsoft SQL Server 2005 Express Edition. This software is a free database from Microsoft.

3.2. Graphic displays and control algorithms

The pressure filter in study was designed to work automatically, but due to the absence of a supervisory system for monitoring and control of the process, the beginning of each operation was initiated manually by the operator via an electric control panel. Another common problem was the difficulty in detecting the causes of failures because the operator and maintainer didn't had access to PLC variables.

The diagram in Fig. 6 corresponds to the proposed structure of control, defining each module and its interfaces. The lower module schema matches the Pressure filter equipment, and using the sensors and actuators accomplish the communication of the physical environment, represented by the pressure filter, and the operational logical, represented by the Allen Bradley MicroLogix PLC. The sensors that represent the input of the system are: inductive position sensors and mechanical (rollers), pressure switches, pressure transducers, sensors, valves and state contactors. On the Output of the system, the actuators are: hydraulic and pneumatic valves, contactors and motor of the hydraulic units.

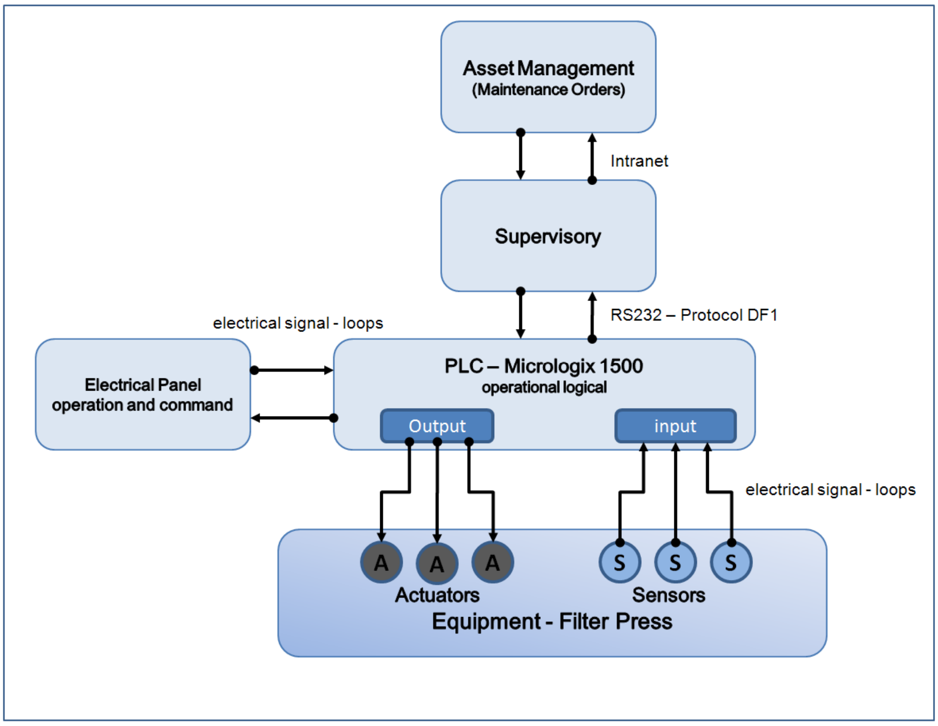

Figure 6. Representation of system structure

The PLC contains all the operational logic of the system, having two different operating modes: manual and automatic. The manual mode keeps the original features of the system, where the beginning of each stage is triggered by the operator at the control panel or by the supervisory. The manual mode was kept as a contingency action in case of failure or maintenance operation, which makes it impossible to follow the sequence in the operation.

The automatic mode works by following the sequence established by the engineer responsible for the production process. The operation sequence is represented in the flowchart of Fig. 7. The steps have conditions that must be met before starting the next steps. The control variables can be an internal timer, pressure indicated by pressure switches or mechanical or inductive positioning sensors. Set points are configured on each step and can be changed by the operator in supervisory.

At each stage, whether in manual or automatic mode, there are interlocking routines that check the status of the pressure filter for, when performing a task, does not exposed the operator to safety risks and equipment to break downs. If any requested task is not executed, the failure detection module is triggered.

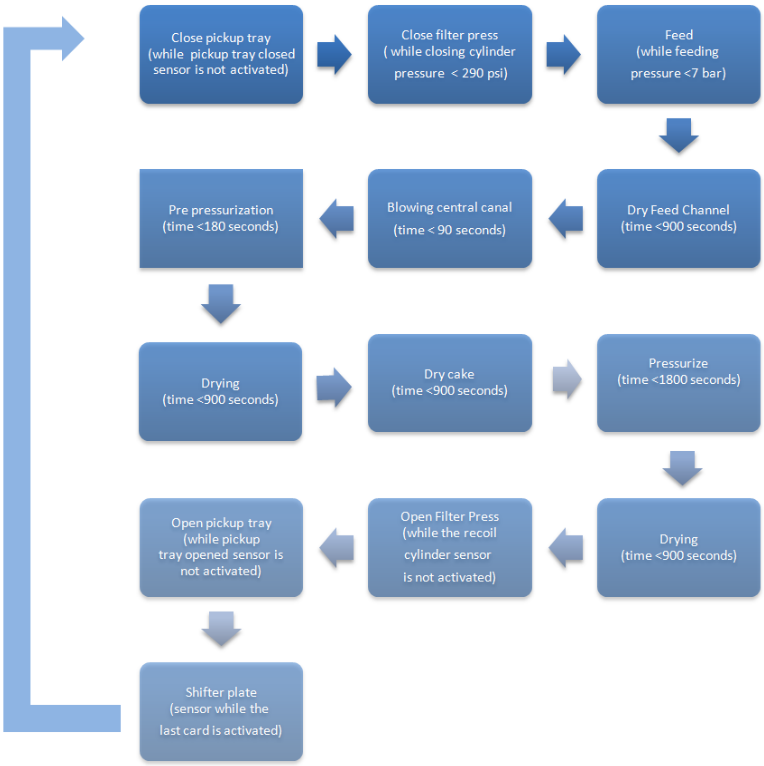

Figure 7. Sequence of operation of the pressure filter

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The fault detection module is responsible for identifying the occurrence of a failure, to classify the failure mode and to indicate the possible corrective actions to be taken by the operator or maintenance staff. Figure 8 is showing the flow of information during the execution of all stages of filtering.

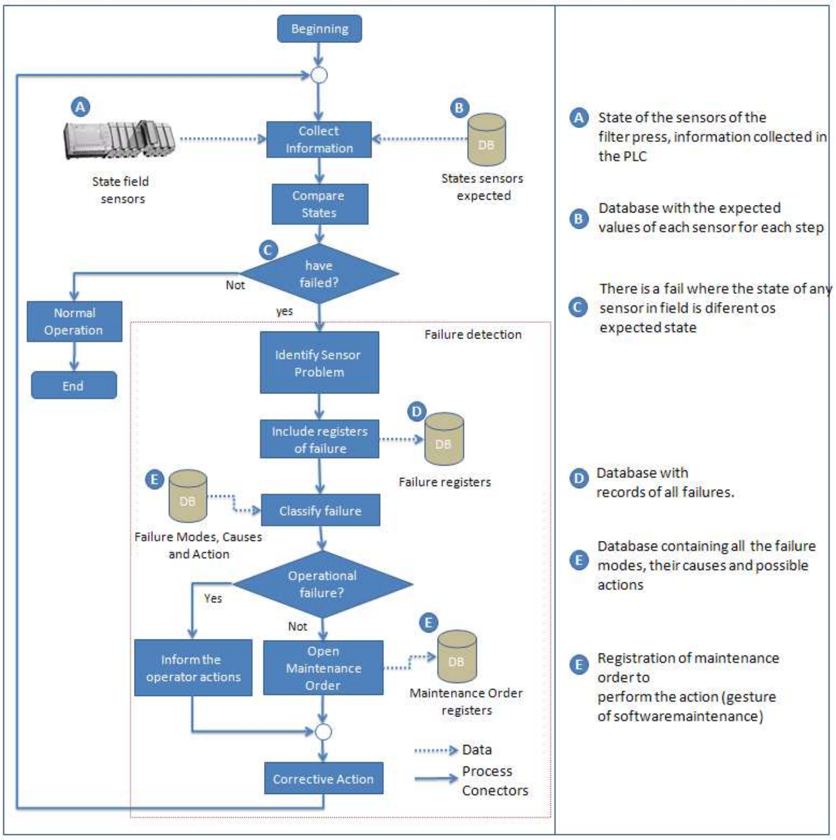

Figure 8. Flowchart of fault detection

When prompted to run any event, both in automatic or manual mode, if the event does not start, or is stopped during execution, the supervision system will identify the physical states of the sensors involved and compare them with the Expected State Sensors recorded in the table. For sensors that are in different state than expected, a failure registry will be created that will present the causes and possible corrective actions. First, if the action is operational, it will indicate to the operator on the screen of the supervisory and action to be taken. For maintenance actions, the supervisory system will automatically open a Maintenance Order in the Maintenance Management Software for the action to be taken.

The Fault Log contains all fault history where you can generate statistical reports of the events. With these reports it is possible to propose improvement actions that minimize the impact of failures. Figure 9 represent Main screen of the supervisory system.

The planned maintenance based on time or condition, are managed by the Maintenance Management Software of the equipments, which makes it unnecessary to be controlled by the supervisory software.

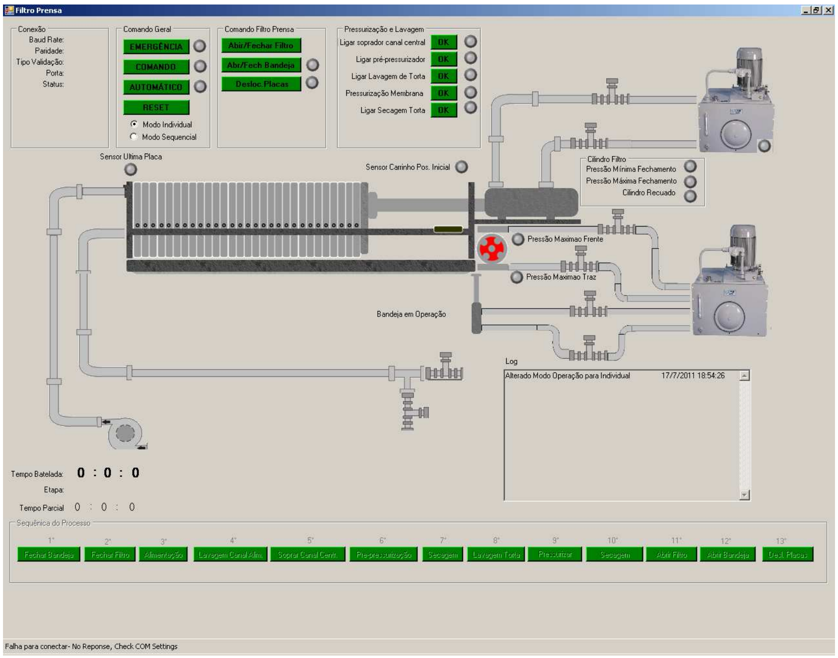

Figure 9. Main screen of the supervisory system

4. RESULT

The implementation of the supervisory system enabled process improvement and it is evidenced in three indicators.

The first indicator is related to productivity, it is the average number of batches days and the number of batches was reduced from 7 to 8, it increase 15% of production in the automatic mode. It was related in the non-necessity of operator intervention to initiate each step of a cycle.

The second indicator is related to rework, it is the index of the sludge reprocessing and it was reduced from 10% to 4%. With this reduction, it was possible to reduce the cost of inputs used during the digestion process: electricity, steam, hydrogen fluoride (HF) and sulfuric acid (H_2SO_4). The reduction of sludge reprocessing is due to the correct execution of the right sequence steps of the filtration cycle, where it is extracted as much material liquefied of the sludge.

The third indicator was related to the availability of equipment, it reduced the mean time to repair (MTTR) from 3 hours to 40 minutes. This accentuated reduction in repair time is related to the failure detection time. Before the implementation of supervisory systems, the maintainers did not have access to the control variables of the PLC, the maintainers were obliged to perform various tests on various sensors, switches and actuators of the equipment. With the failure detection module, the condition that was not fulfilled is displayed to the maintainers, so the supervisory shows what sensor that has failed and what action was not executed. The system shows to the maintenance technicians what they have to do and which equipment part that really requires maintenance.

Tabela 1 – Comparative results

Indicators	Before	After
Average number of batches daily	7	8
Index reprocessing sludge	10%	4%
Mean time to repear (MTTR)	3 hours	40 minutes

In addition to the tangible gains that were represented by the three indicators in Tab. 1 it was possible to reduce the time of exposure of operators to environment with acid fumes, because there is no need to the operator to start each stage. With the process running more efficient, the resulting cake is dry and is completely extracted by the process of displacement of the plate, falling by gravity directly into the collection reservoir.

5. CONCLUSION

With the implementation of the new automated control and supervision system, the time that the operator was exposed to the area next to the pressure filter with high acid fumes generated was reduced, increasing the operator safety. It was possible to increase the productivity since the downtime was reduced between each step, because the sequence is initiated automatically without the need of human intervention between each process step.

Another important factor was the creation of a database, where it is possible to obtain operational data such as total number of batches during the day, time of each cycle and run stages. With this information, together with the laboratory results of the reject slug in the process, it is possible to study improvements of operations aimed at increasing productivity, reducing time and therefore energy consumption.

The maintenance downtime greatly reduced through the implementation of fault detection module, where you can identify the cause of failure through known failure modes and existing in the database or, in cases of failure modes not identified, include in your bank data these new causes of failure with the possible actions already undertaken.

The development of the system in platform VB.NET provided the reduction of expenditure on dedicated software licenses, more robustness of the system and the ease of integration with the supervisory system for maintenance management, enabling opening of maintenance orders automatically, increasing efficiency planning and implementation of preventive and corrective actions.

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