ELECTRONIC VISION

Analisis of waste water treatment plant processes (WWTP) "sedimentation"

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Abstract

Sedimentation of wastewater is a process that takes place in a Wastewater Treatment Plants (WWTP) and its importance lies in the life cycle of all the components of the plant, since the passage of sediment valves, hoppers, and other sensors can cause damage or malfunction, also becoming very costly for the recovery of such vital fluid. For this reason, the main objective of this article is to clearly illustrate the sedimentation process, considering the variables involved in it as well as highlighting the importance of the required thorough calculations, which must comply with national and international regulations in order to obtain accurate and reliable data. These data serve as the foundation for the subsequent design of automation, instrumentation and control processes intended to optimize the treatment of wastewater.

Key words

Wastewater tanks, sedimentation, plant, fluids, OPC, Unisim, RSLogix 5000, automation.

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1. Introduction

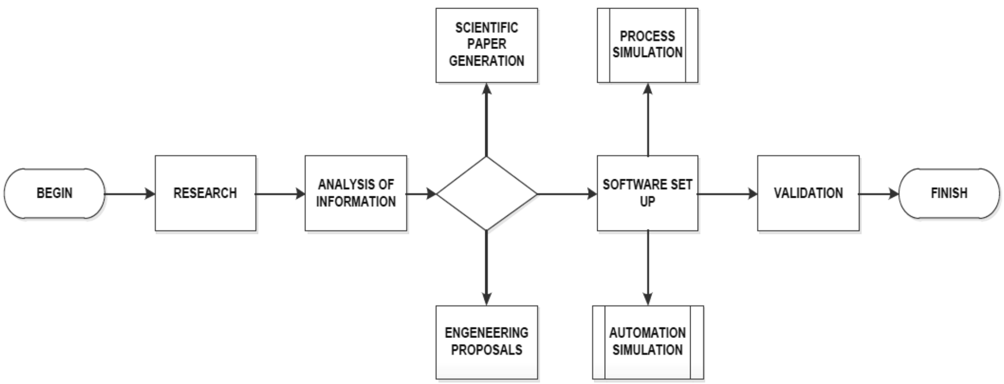
This paper is the first of several scientific articles that are to be presented as a research product. The present research has been conducted as part of a thesis within an electronic control engineering project called "Analysis of processes on wastewater treatment plants (WWTP) and simulation of automation process implementing first-class software at industrial level." The main idea of the project was to build a comprehensive and detailed database of knowledge that enables professionals (interested in the topic of reuse of water resources) to develop strategies for efficient design in terms of automation and control processes.

In this presentation, the curious reader will find relevant information on sedimentation techniques applied to the first stage of wastewater treatment, namely primary treatment [1]. Furthermore, this article contains the description of the technologies needed to carry out the process of sedimentation in order to develop appropriate proposals for instrumentation and automation processes. These technologies were subsequently validated in a high-level simulation platform involving Unisim Honeywell software version 430 [2] (specialized software that allows representing the physical and chemical characteristics of a process) and Rockwell RS LOGIX 5000 Alenbradley [3] software, which allows observing automation and control processes via OPC (Ole process control) when dealing with the simulation of a chemical process conducted using Unisim.

It is worth noting that the final product and most important part of the thesis project is the simulation of the entire plant in operation, as it is something that has never been done in Colombia and so it is good that professionals begin to adopt practices like the simulation of designs before installing equipment. These types of simulations are important since they validate systems without compromising the project's budget and also allow making corrections and improvements before the actual implementation of the whole system, preventing production downtimes and unnecessary losses in terms of financial assets.

Figure 1 presents de flow diagram of the overall project in order to describe its main purpose.

Figure 1. Project Flow diagram



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The following is an explanation of every stage appearing in the previous flow diagram.

- **Research phase**

In this phase, the team focused on gathering all possible information from libraries, electronic data basses and wastewater-treatment-process related institutions at a conceptual level as well as all complementary documentation obtained from government regulatory bodies.

- **Analysis of information.**

In this phase, the team explored and evaluated all the information from the previous phase in order to understand all aspects of wastewater treatment processes in detail. Also, the team acquired knowledge about the government regulatory bodies and the regulatory organizations. When the reading, analysis, and evaluation phase was over, the team was able to generate scientific papers for publication so that the idea of a proper context regarding the processes was made available to the society. Meanwhile, automation and instrumentation proposals were generated based on the process theory and the national government policies.

- **Software set up**

In this phase, the equipment to be used is configured, that is, software installation in every workstation begins and the project integrates a training program.

- **Process simulation sub-phase**

At this level, the group of the project is able to begin the simulation of the physical and chemical sub-process that were selected from the overall wastewater treatment process, using HONEYWELL, PROCESS SOFTWARE called Unisim, version 430.

- **Automation simulation sub-phase**

At this point, all the engineering proposals about automation and instrumentation were simulated using RS-LOGIX 5000 ROCKWELL Alenbradley SOFTWARE.

- **Validation phase**

This was the final stage of the project. Here, the team assembled the intercommunication components of the process and the automation simulations. Once communication is up and running, engineers can evaluate the proper operation of both simulations and therefore validate the results according to the research and the analysis of the wastewater treatment process conducted throughout all previous phases.

The body of work of this article is divided in five parts: Sedimentation; Types of sedimentation tanks; Primary sedimentation tanks and upward flow tanks for small wastewater treatment plants; Process variables; Basic control philosophy.

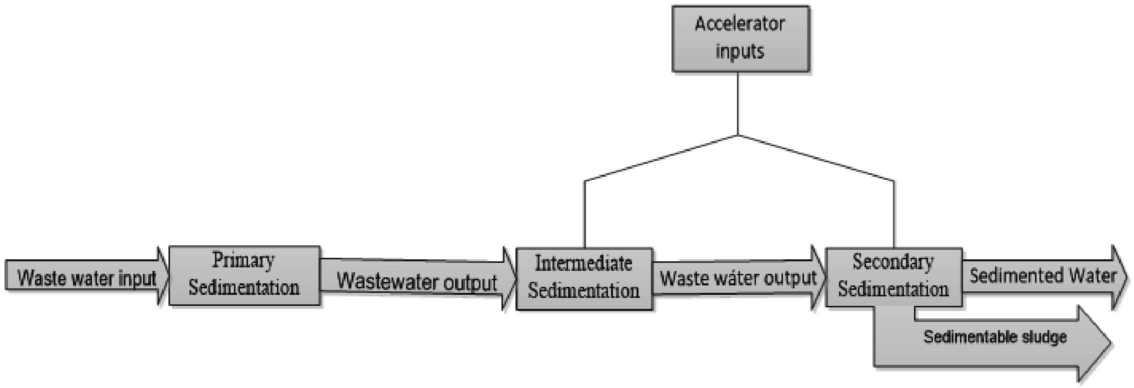
Each of the subsections provides detailed information and focuses on providing the necessary concepts for future engineering designs.

2. Sedimentation

The sedimentation technique is applied to industrial wastewater to separate components of water in a macroscopic and microscopic scale. In this technique, it is vital to contemplate all the variables that have an impact on the sedimentation process, such as the geometry of tanks, the addition of coagulant materials to increase the removal of suspended solids, the concentration of phosphorus and BOD (biological oxygen demand). To this end, the Colombian standard, namely RAS 2000, recommended charts for BOD removal rates [4] in order to optimize the process. To obtain a complete understanding of the sedimentation process, it is imperative to segment this stage since there is more than a single type of deposition running throughout the overall process of wastewater treatment, (see Figure 2).

Now we explain all the sedimentation subprocesses required:

Figure 2. General scheme of the sedimentation process



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2.1 Primary sedimentation

In this stage, sedimentable solids and floating material in raw sewage are removed, thereby reducing the amount of suspended solids [1], [4-6].

As such, this first stage deals with removing coarse contaminants from the water, that is, materials such as:

- Rocks
- Waste of toilet used, paper, diapers, etc.
- Organic Waste as meat, solid manure.
- Industrial waste as metals, plastics etc.
- Once as much of these pollutants have been removed, water can move onto the following stages, where most advanced contaminant-removal techniques can be applied.

2.2. Intermediate sedimentation

At this point, solids and biologically grown components perform intermediate biological reactions (e.g. trickling filters of the first stage are removed).

2.3. Secondary sedimentator

Secondary processes are a fundamental step in the process of sedimentation. Here, biomass and suspended solids bioreactors are involved; activated sludge and trickling filters are removed.

In some cases there is a third kind of sedimentation to remove suspended solids, and flocculated or chemically precipitated treatment of wastewater plants takes place.

In the design of sedimentation tanks it is important to consider the following general criteria:

- Provide a uniform minimizing tributary input speed and a distribution circuit.
- Provide adequate and rapid collection of sedimentation sludge and foam.
- Minimize the output currents, limiting loads on the weir overflow. The effluent must exit without altering the contents of the tank.
- Provide sufficient room to store sludge thickening and allow for its proper depth.
- Provide free edges larger than 30 cm.
- Reduce the effects of wind with screens and dumps.

- Evaluate design options.
- Uniformly distribute the flow between the sedimentation units.

3. Sedimentation tanks

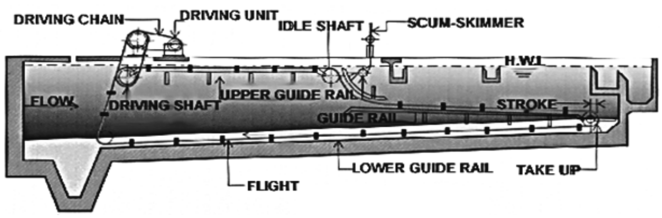
An important factor for the proper functioning in the process of sedimentation is the type of tank in which the waste water is stored. The characteristics in terms of the geometric and functionality of the tank according to inflow and outflow of material determine the success of the process. There are basically three types of sedimentation tanks, namely horizontal flow tanks, radial flow tanks and upward flow tanks [7]. The first type of tank corresponds to rectangular tanks with a slope toward a sludge removal chute at the bottom of the inlet end. Although called horizontal flow tanks, the wastewater enters a lower weir crest departure and, during its journey through the flow tank, is exposed to short-circuit current density and level. The heavier solids are deposited on the inlet end and the lighter solids progressively move towards the outlet. On the other hand, radial flow tanks are circular, with a central hole sloping toward the bottom; the affluent is located in the middle at a lower level than the landfill perimeter departure, having a somewhat radial flow and lift, reducing the ratio between input and output. Upward flow tanks can be square or circular, consisting of a pyramid or inverted cone with a background strongly sloped towards a central well; the influent enters the center and flows down, then it moves radially and in an ascending way towards the output to the landfill.

- Horizontal flow tanks with manual collection and removal by emptying the tank.
- Upward flow tanks with collection through settling in a deep hopper extraction and by pressure provided using a differential head.
- Horizontal flow and radial flow tanks with mechanical harvesting and extraction due to pressure provided by a differential head.

The use of mechanical sludge collection equipment has the following advantages: i) it allows having smaller volumes of sludge in the tank, ii) it requires less manpower for sludge removing as well as adjustable frequency and period of sludge removing activities according to the requirements of the sludge processing operations, iii) the operation of the sweeper sludge can be adjusted and controlled automatically as less mud remains in the tank, iv) there is a smaller risk of septic damage. On the other hand, the disadvantages of mechanical harvesting equipment are the cost and maintenance in terms of sludge removing.

3.1 Primary sedimentation tanks

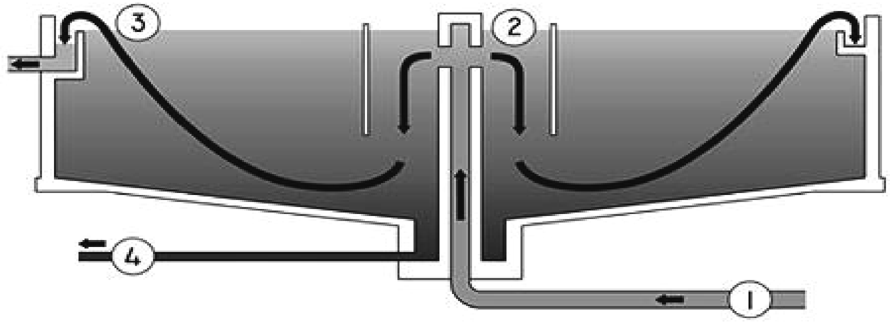
Figure 3. Rectangular sedimentation tanks chain up and paddle down with sliding bridge



Source: [1].

Primary sedimentation tanks are those receiving raw wastewater, usually for secondary biological treatment. These tanks may be rectangular or circular (Figures 3 to 5). With rectangular tanks (Figure3), raw wastewater enters through a variety of openings near the surface of the inlet at the end of the tank; then it moves along the tank at a very low speed to finally discharge through the end opposite to the landfill. At the entrance, a short screen dissipates the tributary speed and directs the flow downward. The suspended sedimentable solid material is deposited at the bottom of the tank and is drawn to the sludge hopper either by a mechanical scanning system or by pending action provided at the bottom. The sludge is periodically removed from the sludge hopper for treatment and disposal. In many tanks of a drive system, a skimmer weir positioned near the outlet is installed. The skimmer can be provided with a grid line along its upper end.

Figure 4. Circular tanks for primary sedimentation



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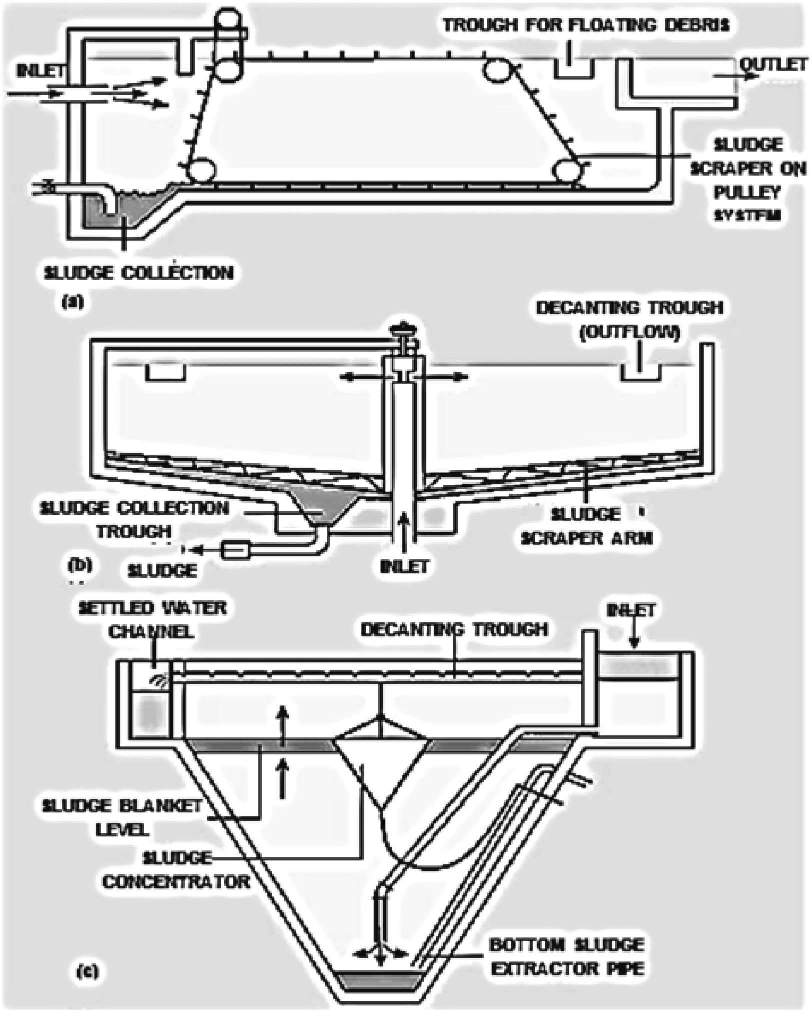
In a circular tank (Figure 4 and 5) the wastewater enters through openings at the top of a central vertical pipe and flows radially toward the peripheral outlet weir. Usually, the tank is equipped with a sludge plow which directs the sedimentable solids toward the sludge hopper positioned in the center. The floating solids migrate to the edge of the tank and are retained by a screen placed in front of the dump output. A skimmer attached to the arms of the brush can pick up the sludge, and the surface scum is drained through the foam channel.

In rectangular tanks, the length/width ratio ranges from 3:1 to 5:1; in water depths greater than 2 m, the lower length is of 90 m, with widths of 3 to 24 m and a gradual slope at the bottom to the sludge hopper. When the width is greater than 6 m, it is preferable to use multiple cleaning equipment with various sludge hoppers; thus allowing the use of widths equal to 24 or more. In circular tanks the diameter is generally less than 90 m, with water depths of 2-4 m and bottom slopes of 8%. These tanks are widely used because the sludge sweeper requires fewer moving parts than the driving mechanism of rectangular sedimentation, and also because the walls can be thinner than those of rectangular tanks. Although the turbulence at the entrance, well below the tributary, is great in a circular sedimentator as the water flows into the landfill, proper output speed decreases due to the greater length of the perimeter landfill.

Figure 5. Typical settlers, top with central metering and sweeper sludge removal center for central hydraulic suction evacuation perimeter below



Source: [5]

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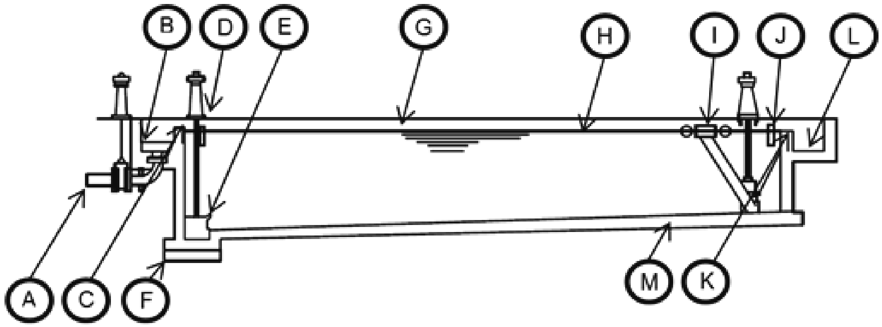
Figure 6. Tank for sedimentation with horizontal flow and manual cleaning



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Where: A. Feed pipe; B. Flow channel; C. Inlet flow; D. Screen; E. Sludge channel; F. Sludge valve; G. Top level of water; H. Free edge; I. Floating arm of material extraction; J. Effluent outlet; K. Effluent channel; L. Fund.

The basic design standards of primary sedimentation tanks sewage are included in the following table 1, [7].

The impact of surface charge and retention time on the removal of BOD (Biochemical Oxygen Demand) and SS (Suspended Solids) varies according to the characteristics of wastewater, solids concentration and other factors. It is important to consider that the surface charges must be small enough to ensure satisfactory operation of the sedimentator in peak flows. Surface fillers are used generally with nominal

Table 1. Standards for Primary Sedimentation design

Reference	Superficial charge m/d	Retention time h	Deep m	Inflow charge l/sm
Metcalf y eddy	32-48	1.5-2.5	3-5	1.4-5.8
10 states regulations	41	-	>2.1	<2.2
Naval design	49	-	4	<14
Army of EE.UU. Manual	12-41	2.5	2.5-4.5	0.7-1.7
Steel &Mcghee	24-60	1-2	1-5	-
Fair et al.	-	2	3	-
Sundstrom&Klei	-	1-4	-	-
Usepa	24-49	-	3-5	-
Tchonbanoglous& Schroeder	30-60	-	3-5	-
IWPC	30-45	2	>1.5	1.2-5.2

Source: own elaboration

retention times and allow two to three hours of average flow. In all cases, for future conditions, the actual retention periods during the first years of operation of the plant are larger.

According to Metcalf & Eddy [6], the burden on the landfill overflow has little effect on the efficiency of primary sedimentation tanks. It is important to maintain a minimum flow rate that does not drag the sendimentable sludge and that has proper placement of landfill overflow.

The flow rate should be less than 1.5 m / min to prevent slurry solids; critical drift velocity can be calculated using the equation (1) of Camp and Shields, namely:

$$v_c = \left[\frac{8k(s-1)g * d}{\mathbf{f}}\right] \qquad (1)$$

Where:

Vc = critical drift velocity, m / s
k = 0.04 for materials single-granular or k = 0.06 for viscous material
f = 0.02 to 0.03, friction factor Darcy - Weis bach
s = specific gravity of the particles
g = gravitational acceleration, m/s2
d = particle diameter, m

In order to prevent entrainment of mud, other authors recommend lower flow rates than fifteen times the critical velocity of sedimentation. The speed at input channels in the primary clarifiers must be greater than 0.3 m/s for 50% of the design flow. The dissipation screens rate should be installed within a range of 0.6 to 0.9 m from the inlet end, with a submergence depth of 46 to 61 cm. The top of the screen should allow the passage of foam on it. For the input unit landfills can be used together with submerged flow speeds of 3-9 m/min and gate valves or holes perforated screens. In a circular tank, the central input shaft must have a diameter of 15 to 20 % of the tank diameter and, typically, submergence equal to half the depth of the tank.

In rectangular primary sedimentation tanks, the sludge hopper is usually placed in the center of the tank. The hopper can be up to 3 m deep, with slopes greater than 1.7 % on the side walls and a maximum width of 0.6 m.

Sludge lines should be as short as possible, at least 25 cm in diameter, with standalone flow rates of 1.2 m / s. At each change of direction a well inspection should be placed. When calculating friction losses in sludge pipes, it should be noted that these losses are three to four times greater than for water.

Sludge removing manual tanks must provide adequate storage of sludge to ensure that the increased flow produced by removing services in the tank (sludge removal) does not increase the concentration of suspended solids in the other tanks. In these tanks the slope of the floor for easy cleaning may be of 2.5% to a longitudinal central channel and of 1% drop to the pit of sludge in the inlet end. A tank must be emptied manually, with sludge removing occurring in periods of minimum flow and the activity must be down for at least an hour before sludge removing in order to allow sedimentation of the sludge. The supernatant is extracted by a telescopic arm, a float valve, or by extraction, leaving only the sludge in the tank without alteration. Then the mud is pushed manually into the hopper outlet using rubber broom sweepers. Finally, the floor is washed with water or effluent. This process should be carried out at least once a week in primary sedimentation tanks for manual cleaning.

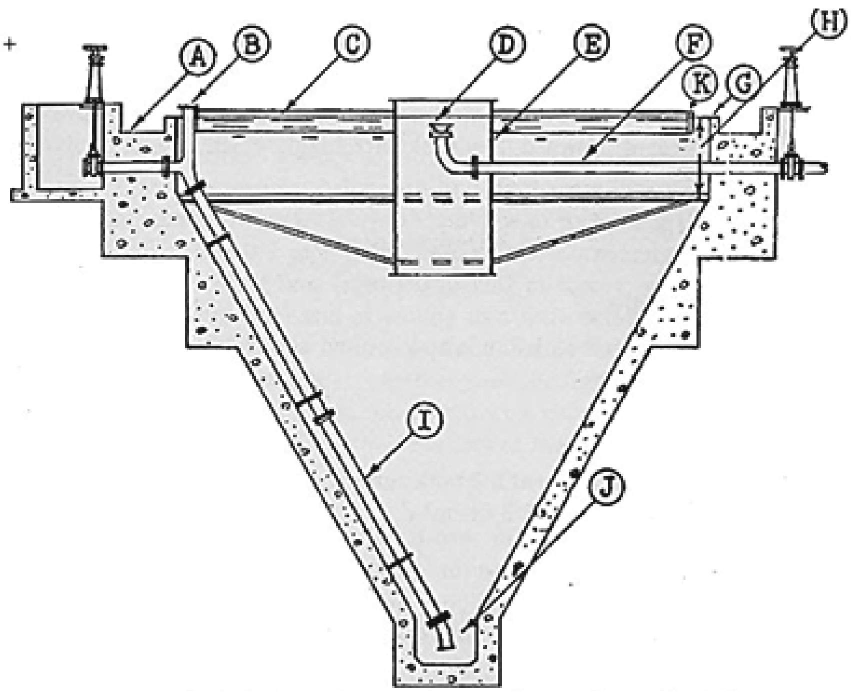
In mechanical sludge tanks, cleaning the blocks sludge and removing material may happen with highly variable frequencies, usually once a day or every two days; however, many tank sweepers run continuously and sludge is removed permanently. This system allows uninterrupted dosing for sludge digesters, but can cause clogging of the sludge pipes due to low flow rates. Therefore, the procedure is proposed to be performed at a frequency no shorter than eight hours.

Sludge removing manual tanks must be placed at a distance from the outlet weir in the range of 0.6 m to 1.5 m with foam retention screens with submergence of 0.3 m to 0.6 m in order to prevent leakage of tributary foam.

3.2 Ascending flow tanks for small plants

Figure 7 shows the representation of a tank with upward flow rates typically found in small wastewater treatment plants.

Figure 7. Primary sedimentation upward flow tank



Source: [5].

Where: A. Effluent channel; B. Rodding eye; C. Top water level; D. Bellmouth inlet; E. Stilling box; F. Feed pipe; G. Peripheral weir; H. Side water depth; I. sludge pipe; J. Sludge sump; K. Scum baffle.

These tanks allow removing sludge without having to empty, offering a quite comfortable operation and producing a good effluent. These tanks are designed with surface charges of 29 m / d, retention times of two to three hours, pyramidal inclined walls of 60 degrees to the horizontal plane, and slopes of 50 ° in the corners. The dimensions are usually 5-9 m2. The volume of the upper portion can be deduced by subtracting the volume of the pyramidal portion and knowing the required surface area; then the depth of the vertical walls is calculated. The effluent discharge of the pipe is vertical and it should provide speeds greater than 0.3 m / s for minimum flow. The dimension of the stilling box must be 1 to 1.2 m2, with more than 0.15 m above the water level and extending below the bottom edge of the vertical wall. The outlet weir should be protected with a screen of foam and preferably should have adjustable openings forming the V-sharply inclined walls. These walls are required for the lower portion of the tank to ensure the sliding of the mud down the well, in which the slurry dipping pipe goes. The well may be square, of 0.75 to 1.0 m on a side. The sludge removal pipe, which ends at a short distance above the water level, poses a horizontal branch, positioned 1.5 m below the water level in the sludge discharge chamber side of the inspection tank. The slurry is drawn through such bypass and the vertical extension of the pipe serves as visual observation pipe. The mud exits through the differential pressure that is provided on the lateral discharge inspection camera. The mouth of the sludge pipe must be placed 1.5 meters above the tank's bottom to prevent clogging and should have a minimum diameter of 15 cm. The foam screen must be placed 0.3 m from the landfill perimeter departure. The foam is pushed manually onto the side weir and removed at suitable intervals. The percent of sludge solids in these tanks can be from 3 to 4% and substances must be reduced to 65%.

4. Process variables

In the sedimentation stage, it is necessary to evaluate some physical variables that lead to control and protection actions. Regardless of the kind of tank geometry, the requirements in terms of inlet flow must be satisfied, namely level and pallet torque.

4.1 Inlet flow

The inlet flow has been appropriate according to sedimentation velocity. There are many kinds of flow meters in the industry. All of these meters are based on measuring the fluid's proprieties by exploiting particular techniques, namely:

- Differential pressure
- Positive displacement
- Inferential
- Oscillatory for fluids
- Electromagnetics
- Ultrasounds
- Direct and indirect mass
- Thermic variations
- Close pipe flow meters
- Solid properties
- Open channel

The main selection criteria are:

- Stream rate
- Accuracy
- Repeatability
- Environment to be held in the measurement
- Type of output power required
- Waste acceptable load
- Cost of the Energy needed to operate
- Cost of installation (adaptation of control systems, panels, etc.).
- Cost of Maintenance

- Type of fluid to measure
- linearity
- Speed of response

Generally, for PTAR, electromagnetic-base meters are used. The electromagnetic-based flow meter provides great accuracy for measuring all conductive flows such as industrial process waters or southwesters; the electromagnetic flow meter makes use of a square wave to measure in-filled pipe systems. The measure is based on the principles of faraday induction law, when a specific voltage is induced in a conductor that moves through a magnetic field, such voltage is proportional to the velocity of the motion.

In the electromagnetic flow meter, the induced voltage is sensed by two electrodes in actual contact or through capacitive means (without contact). An electromagnetic transducer amplifies the signal and converts it into a standard signal and a frequency/pulse signal (a pulse sent per one cubic meter). The measuring tube is made of an electrically insulated material.

4.2 Level

In a tank, it is very important to protect and monitor the level of its content. In the industry, it is common to use on/off switches for level control, but the instruments to be used ultimately depend on the specific situation and should only be activated under critical conditions. The technology available provides us with new methods to sense the liquid level applied to waste water (e.g. radar-based measurements). With this technology, it is possible to measure the liquid level and the sediments level as well.

Radar technology makes use of extremely short microwave pulses emitted by the antenna system in the direction of the material to be sensed, the pulses are reflected by the material's surface and received back again by the antenna. They propagate at the speed of light. The time elapsed from emission to reception of the signals is proportional to the level in the tank.

For liquid applications, two different emitting frequencies are available. The compact, high frequency devices are particularly suitable for applications where high accuracy is required; low frequency devices can penetrate foam and strong condensation and are thus suitable for very difficult process conditions.

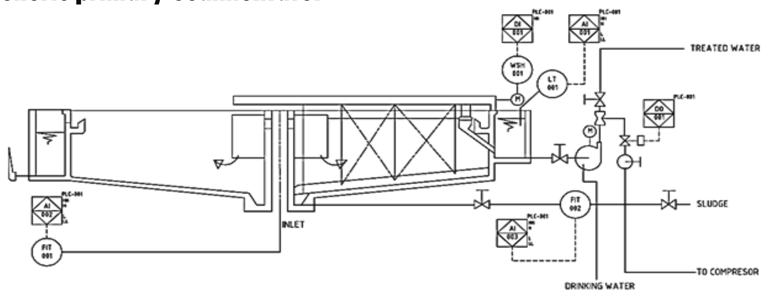
5. Basic control philosophy

5.1 Drawings for reference

- **P&ID**

As a reference, we used the P&ID shown in figure 8; however, these features of the project can be used in other types of sedimentator.

Figure 8. P&ID generic primary sedimentator



Source: own elaboration

5.2 Control and monitoring syste

5.2.1 Control system

The control system is based on PLC architecture (Allen Bradley RS LOGIX 5000) when sending the signals to the process, either from a sensor or a simulator. The PLC is in charge of monitoring and sending signals, setting the corresponding alarms or shutting down the system, controlling pallet speed and allowing particular actions when the tank is full and the by-pass mode should be initialized.

5.2.2 Operation center

For the process, there is only one operation center located in the control room of operations at the all PTAR.

5.2.3 Operation mode

The following paragraphs briefly explain the operation modes of motorized devices and control devices.

5.2.3.1 Motorized devices

In general, control of the motorized devices is carried out through the following commands.

Local command:

- Emergency stop.
- Start local
- Stop local
- Test
- Remote command:
- Auto-man selector
- Run mode
- Fault status

5.2.3.2 Regulatory control loop

In general, the regulatory control loops are:

- Remote/manual
- Remote/automatic.

5.2.4 Primary sedimentation

5.2.4.1 Operation condition

The pre-treatment of water occurs from the distribution chamber through the pipes, which might range from DN200 to DN1200, their diameter depends on the highest flow to be handled at rush hours.

The flow was measure before entering the sedimentator.

According to the dimensions of the tank, the process of sedimentation may take from 1.5 to 2.5 hours during the time the bypass is operating.

The level sensor indicates when the tank is full and starts the process of sedimentation. If the level reaches a critical value, the input to the distribution chamber will be stopped until the abnormal condition passes to the critical state.

The pallet is turned on in order to evacuate the floating sediments and underwater sediments.

The underwater sediment flows are then measured.

5.2.4.2 Control loops

In the sedimentation process, in a basic operation, two control loops are used, namely liquid control level and torque control.

5.2.4.3 Liquid control leve

The most basic level of control is the on-off controller, with a basic control action only when the level reaches a critical point. In this situation, the PLC has to close the valve and shut off the pre-treated water flow to the sedimentator.

However, the objective is to make use of more advanced controllers that not only close the valve in emergency cases, but also provide open/close cycles according to the changes in flow rates, thus allowing the analysis of different behaviors according to inflow variations. In order to obtain these features, it is necessary to use the radar level sensor, see table 2.

Table 2. Loop Parameter and Description of Liquid control level

Loop parameter	description
Control loop	level control
sensor	LIT-01A
Control type	On- off
Controlled variable	Tank level
Manipulated variable	Valve on- off inlet

Source: own elaboration

Torque control

The sedimentation pallet is essential for the evacuation of sediments. For this reason it is important to provide the motor with protection strategies so as to safely generate the torque to the pallets. When there is an obstruction object that generates an over toiler and so poses a risk on the use of the pallet, it is important that the PLC generates an alarm or a fault condition and turns off the process, see table 3.

Table 3. Loop Parameter and Description of Torque control

Loop parameter	description
Control loop	Torque control
sensor	WSH-01
Control type	On- off
Controlled variable	torque
Manipulated variable	Motor

Source: own elaboration

6. Conclusions

In order to apply basic engineering, it is important to constrain the conditions of operation by limiting physical characteristics such as dimension, diameter and distances. With these data, the specification of sensors can be selected as appropriate.

The devices for a circular sedimentator are much simpler and easier to maintain than those corresponding to the rectangular sedimentator. However, rectangular sedimentators are more efficient when dealing with solids. The selection of the sedimentator type and dimensions do not represent a constraint on the type of devices.

References

[1] J. A. Romero R., "*ratamiento De Aguas Residuales, Teoría y Principios de diseño*", 2010.

[2] Honeywell, "Unisim Design software." 2010.

[3] Rockwell, "Rockwell Software RSLogix5000 Control Logix Programming." 2005.

[4] MinDesarrollo, "Reglamento Técnico del sector de agua potable y saneamiento Básico RAS - 2000e." 2000.

[5] F. Woodard, "*Industrial waste treatment handbook*". United States: Butterworth-Heinemann, 2001.

[6] G.T. Metcalf y Eddy, "*Ingeniería de aguas residuales*", vol. 1. Mc Graw Hill, 2008.

[7] G. T. Metcalf y Eddy, "*Ingeniería de aguas residuales*", vol. 2. Mc Graw Hill, 2008.