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Precipitation pool design and study of physical water treatment for decarbonizes water production unit

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Abstract
This plan is to refine and recycle the sewage of sand filters reverse washing of Mashhad power plant. By designing a 200 cubic meter precipitation pool, 85 percent of the turbidity of the water is removed after washing the filter; the recycled water is then transferred to a water de-carbonating unit to be reused. So by recycling the power plant sewage, it is somehow possible to make up for the high water consumption of the power plant and by introducing other ways of physical refining it is possible to pave the way for improvement of refining other sewage plants.

Key words: Precipitation pool, Sediment settlement, Reverses washing, Calcium carbonate, Reuse water

1 Introduction

One of the major pollutions in all industrial activities and among electricity power plants is industrial wastewater which is necessary to be controlled to prevent bad effects; therefore it economizes the consumption of water source in the country. Generally, supplementary processes can reverse the key production of wastewaters in power plants in industrial and steam power plants, furthermore, water can be reprocessed in applications which are in need of water. In the management of water sources in areas that use wet cooler towers, it is necessary to utilize backwater in water and steam and cooler cycles. In accordance to the existing statistics, the measurement required for a water steam power plant with wet cooler towers is equivalent to 2 to 3 cubic meters in each megawatt upon the time which has been estimated that shows the growth procedure, water consumption and wastewater production with regards to the increasing rate of the growth of electricity production in country. Also, about 85% of the turbidity of water caused by the washing of the filters is recycled to be reused in the water de-carbonization unit by designing sedimentation pools to detract the usage of water. Hence we can produce make up water for power plants and with the introduction of other methods of physical filtration, power plant sewage filtrations can be improved. Power plant sewages in one steam power plant have been divided into four categories according to their quality, which are: salt sewage inclusive species solutions salt, poison sewages (in chemical washing equipment) species heavy metal, inhibitors and detergents, sludgy sewage including the suspense of species, and reverse wash filtrations and unclean wastewater on fuel and oil.
Therefore, in this research, design of precipitation pool and study of physical water treatment is carried out for de-carbonization in the water production unit in Mashhad power plant.

2 Sedimentation pools

The separation of solid materials by sedimentation pools is a physical process in the sewage treatment. Sedimentation which is caused by gravity is used after the biologic processes and when the value of solid material is high. The attributes of the sedimentation of the suspended materials depend on the nature of the material. The attributes are usually affected by density, size and shape of the particles. Sewages based on these attributes are divided to three categories: First category: dilute suspension of solid particles which are not clotted settle independently from other particles. Second category: dilute suspension of solid particles which can be clotted with a density of under 500 milligrams per liter that is admixed by collision to another and the rate of sedimentation of these coagulations are more than the prime ingredient. Third category: Suspensions with an identified concentration in which the particles are placed in an identified place to settle comparatively. Output water treatment pool of active mud is included in this category [1]. This material in sedimentation conform Stock's law [2]:

$$F_d = 6\pi\mu.R.V \tag{1}$$

If friction force plus drag force equal gravity the ingredient rate has achieved the limit rate or sedimentation rate and the particles slump by weight force. This rate is the highest substance rate [2]:

$$V_s = \frac{2}{9}\frac{(\rho_p - \rho_f)}{\mu} gR^2 \tag{2}$$

Species of physical precipitator are:

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- Sedimentation tanks without a scraping system: usually cylinder, horizontal and plate type.
- Sedimentation tanks with a scraping system: cylindrical sedimentation tank, rectangularity sedimentation tank.
- Sedimentation tanks with a mud suction system [3].

3 Materials and methods

3.1 Method of computing rectangular pools dimension

Sedimentation is one of two operations solid-liquid separation in treatment and filtration processes. In most water treatment process, a higher portion of the solid particle separation is performed with sedimentation so less force is applied on the filters. In some cases, less filtration is needed as sedimentation removes 95 percent of water smeary which has been past in the coagulation unit [4]. The First sedimentation theory exhibit was performed in 1904 by Hazen and it explained surface loading of sedimentation pool as a basic factor in designing and it has more effect than residence time in the production of water quality. This theory deployed in 1946 by Camp with his idea that he uses low depth pools and more sedimentation pools built today [1, 5] same figure 1.

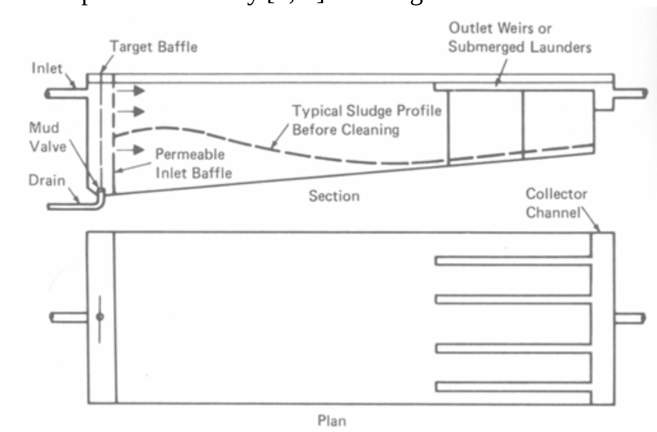


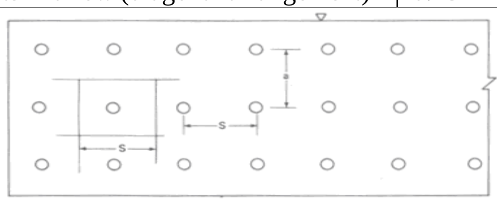
Figure 1.Lateral and upside of rectangular sedimentation pool

Each sedimentation pool has four important zones: 1) inter zone 2) sedimentation zone 3) gathering mud zone or exit zone 4) output zone [6, 7].

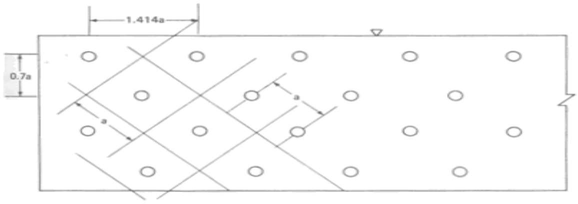
Initially, the row numbers are estimated then the holes in the row and then the distance of the holes are computed. The velocity gradient of different holes sizes [1] have been given in table 1. Data in table 1 set with assumption volumetric flow rate Q=1 m^3/s, ingredient rate V_p=30 cm/s, buffer wall surface 45 m^2 (2m×22.5m), holes surface Q/V=1/3=3.33 m^2 , and head drop $1.7\times(0.3)^2/20=7.8$.

Table 1. Design leaky buffer for entrance

Port diameter (m)	0.152	0.18	0.254	0.304
Area per port (m^2)	0.017	0.032	0.05	0.071
No. of ports reqd.	188	104	67	47
Wall space 1 port (m^2)	0.244	0.43	0.67	0.96
Avg. port spacing, m (a)	0.49	0.66	0.82	0.98
G sec^{-1}	9	5	4	3
Horizontal row spacing estimate , m	0.34	0.47	0.59	0.7
No. horizontal rows	6	5	4	3
No. ports 1 row	31	21	17	16
Final spacing between rows	0.33	0.4	0.5	0.67
Final distance between ports in a row (diagonal arrangement)	0.73	1.07	1.32	1.40



A) Vertical arrangement



B) Diagonal arrangement
Figure 2. Holes arrangement in entrance buffer

3.1.2 Sedimentation zone
Second important section of the sedimentation pool is the sedimentation zone. In convenient conditions, the depth of this zone is between 1 to 2 meters. These pools are usually built long with a low width so that a part of it is left for the entrance of designs for the absence of information and also for the effects of the outputs and partly for the sake of controlling the density of the flow. In a nutshell, the length of the sedimentation pool is calculated to be multiples of 3 to 6 in width.

3.1.3 mire store zone
This zone depends on the operation of the input and output parts. Properties and depth of this zone depend on the cleaning method, the time between each cleaning and the estimated amount of sludge (estimate production sludge) in a crystallization unit that works well, the diameter of sludge in the input is more than the output [10].

3.1.4 experimentations analysis
For the design of a pool for retrieval of this water, there must be an identified volumetric flow rate and material measure. For the measurement of the amount of material, two samples are taken from the sewage of filters which have been washed. In two steps of sampling 3 exemplars were obtained, one in the beginning another in the middle stage and third in end of the washing and so necessary time needed for the formation of a layer of sediment and the amount of sediment was measured in each exemplar. In the exemplars with 250 CC volume which was obtained from the middle step, after 15 minuets of washing, two separation phrases were formed. The top phase included approximately 200 cc of clean water, however, there was no smeary measuring machine available so it was not possible to state the small amount of the smeary in the water, therefore a consultation was made with the engineers of the treatment unit in the power plant, thus, the conclusion was obtained that this smeary measurement is suitable for reversing into the treatment cycle. The bottom phase with almost 50 cc volume included smeary grout of calcium carbonate after being cleaned by filters 12.57 gr of moist sediment, after drying in an oven with 90^{o}C, 4.02 gr dry sediment was obtained which means 16.08 gr/lit of sediment exists in the middle exemplar.

3.1.5 output zone
For controlling the flows of density for the variation of smeary and temperature variation in the output zone of the sedimentation pool there must be engender walls with maximum length even near the half of the length of the pool as shown figure 5.

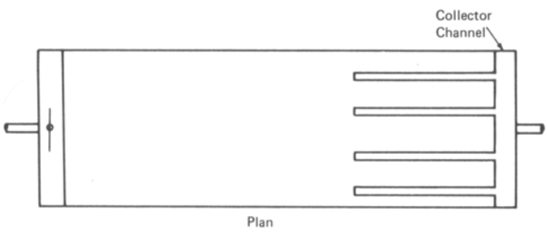


Figure 5. Walls in output part

4 Design sedimentation pool for sewage treatment unit of Mashhad power plant

4.1 Recognition existent condition
One of the important processes in the treatment unit of Mashhad power plant is that it removes water hardness that is the decarbonisation process. Water hardness caused because of bicarbonate ion, HCO_3^-, is removed by the process shown below. Water that exits the sump after one stage in detracting material enter the decarbonisation reactor and mix with lime and chloroferric, during the reaction under HCO_3^- ions become $CaCO_3$ sediment. Addition of alkali

solution like ammoniac solution or lime water gives interim hardness to water product OH^- ion so annul HCo_3^- and unwanted metal settle into carbonate:

$$Ca^{2+} + HCO_3^- + OH^- \rightarrow CaCO_3(s) + H_2O \quad (3)$$

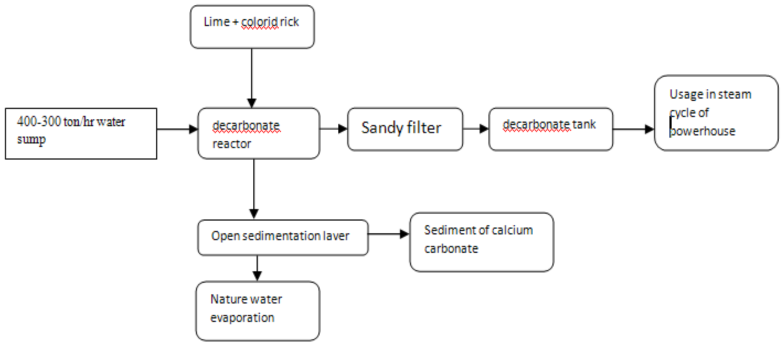


Figure 6. Flow chart decarbonation process of Mashhad power plant

After water has been divided into two sections, relatively clear water is entered into the filter from the top end of the reactor into the sandy filter to remove the remaining sediment. Furthermore, grout is produced from the bottom of the reactor with 10 to 20 m^3/hour that include sediment with 87% calcium carbonate and 13% undesolvable $Mg(OH)_2$ which is guided into sedimentation laver.

5 Design of sedimentation pool

5.1 Design

For the design of different parts the qualifications below must be considered: input water volumetric flow rate of 200 m^3/hour, sediments dry weight with water about 3.2 tons (reference to result of calculation), a grout phase volume with 200 m^2 about 40 m^2, land with dimension 15×20 meters, sediments must have water so that it can be transported by a pump to the evaporation pools so that the remaining water can be evaporated and gathered by a tractor and transported.

5.2.1 Residence time

With respect to the results obtained from the experiments made, the maximum residence time is about one hour. Since the process is discontinuous the evaporator can choose the time gap for the ejection of water, however, the residence time is recommended not to be more than 24 hours due to the of growth plants and the decrease in the water quality.

5.2.2 Generic dimension

Since land dimension is 15×20 and 200 m^3 space is necessary for water storage, therefore, the chosen length and width of the pool is 18×9 meters, furthermore, the depth of the pool can be discussed in the next section. However, in the sedimentation pools, in order to the prevent turbulence caused by air or flows that are engender by the variety of ambient temperature, and so for making the gathering of the sewage easier, usually, the relation of the length to the width is about 6 for pools, and the width is divided into three parts.

5.2.3 Design of input part

Since the water volumetric flow rate of 200 m^3 is unfixed during one hour and changes in the different steps of the washing and the changing filters, also because of the discontinuity of the process there is no limited for residence time therefore there is hardly a need to design a network of water distribution with the usage of absorbent baffles and distribution channels for the steady entrance of water in the width of the pool.

5.2.4 Sedimentation zone

There is the possibility for the sewage flow to be unsteady throughout the width of the pool, thus it is suggested to perform the canalization from one point instead of having each individual section canalized, this way, there are less operational problems and the process would become less costly. Therefore with notice to this discussion the designed below should take place.

5.2.5 Bottom design

With regards to the recommended 5% slope for the length of pool, from the output to the input, the depth of the input section is 0.9 more than output, therefore, with notice to the recommended 10% slope from the borders to center line, the produced volume of the depth of center line in the output part will be 0.45 meter and the volume will be 72.9 m^3, respectively.

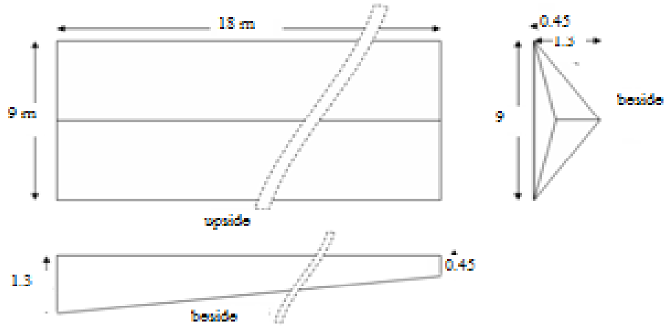


Figure 8. Bottom plan of sedimentation pool

5.2.6 Design topside of pool

With attention to the volume 72.9 m^3 for the base, 127.1 m^3 is remaining. Therefore, the dimension of the cubic section of the pool obtains 9*18*0.8 so for safety reasons and for keeping in mind the qualification other than the design, a depth of one meter has been considered.

5.2.7 Design centric walls

In order for the gathering of the sludge is performed well, and does not decrease in properties as the walls have been considered for their sake, two walls are considered that can be observed in figure 9, with a gap of 3 meters. For the prevention of the gathering of water behind the walls during filling and emptying of the pool, it has been thought to place holes with one meter gaps in between each hole, and a diameter of 7 to 10 cm (depending on the condition of the structure of the pool) in the walls As a result, the volume of each wall and the final volume of the pool is 2.52 m^3 and 230 m^3, respectively.

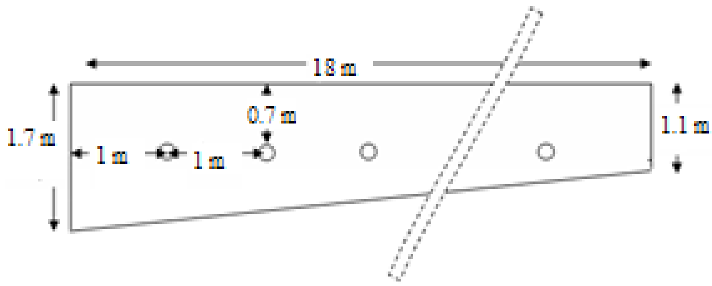


Figure 9. Beside walls that in median pool

Since the volume of every 200 m^3 exists 40 m^3 grout, the estimation dimensions for the zone that is filled by grout, is 40.5 m^3 in volume (figure 10).

5.2.8 Canalization

The Canalization pipe sits in deepest point under input area of water. With respect to the results of the experiments (the existent of maximum of 4 gr dry sediment in 50 cc grout) as an estimate, the density of residual grout is always less than 1.5gr/cm^3 so it is easily transported by a clay pump. A 3D view of the designed pool is shown in figure 10.

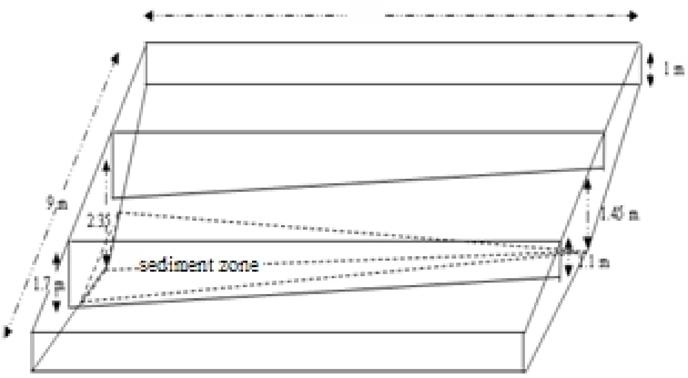


Figure 10. Three dimensional sides of design pool

6 Conclusion

With notice to the discussed topics and the importance of the reprocessing of power plant sewage, there is the necessity of the usage of the retrieval process of sewage using the back washing process of the sandy filters of the power plant. In this research, it is shown that about 80 percent of the input sewage into this process is converted to water that is usable and only 20 percent of it is used as condensate sewage which is exited from the process, so with regards to the non-adaptation qualitative index of the condensation of sewage to national standards of the environmental protection organization of Iran, therefore, this sewage is guide into natural vaporization pools. Generally, the advantages of the use of the retrieval process of power plant sewage with the usage sedimentation pools are notified below:

- The prevention of discharge of different sewages of the power plant into the environment.
- A partial production of water for the supply of the usage of water in the power plant.
- A minimal usage of water and a the perseveration the country's' water source.
- Since the production material has a top purity of calcium carbonate, we can use them in different consumptions in industrial and agricultural areas.
- With few changes in the input and output system of water, these pools can be used for similar sewage treatments.

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