Experimental Method for Retrofit Designs

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One of the contributing factors to air entrainment at the beginning of the water treatment process in AguaClara plants is the waterfall effect inside the Linear Flow Orifice Meter (LFOM). This effect is composed of two basic entrainment mechanisms: 1) the surface of the jet of water becomes sufficiently turbulent to entrain air before it reaches the surface water; and 2) the penetrating jet creates a void from which small air bubbles pinch off. To minimize the effect of these entrainment mechanisms the following retrofit design options were calculated and tested in lab:

1) Pipe Inside LFOM: A pipe of a small diameter would be placed within LFOM with about a few inches of separation between the outer surface of the pipe and the inner surface of the LFOM.
2) Vertical/Inclined Plane: A vertical or inclined plane would be placed within the LFOM that would prevent the water jets from hitting the surface of the water directly.
3) Bucket with Holes: A bucket would be placed inside the LFOM that would catch the water jets and slow down the inflow of water by using an orifice.
4) Bucket without Holes: Rather than have an orifice slow down the flow of water in the LFOM, the bucket would be over flooded so that the water dribbles down the side of the bucket.

See the retrofit designs page for visuals of each option.

In addition to these designs, we also tested for the three limiting parameters of foam formation from water jets. You can find the summary of this experiment at the Experimental Method for Limiting Parameters of Foam Formation from Water Jets page

Calculations

As a team, we worked in MathCAD to calculate the distance that the jets of water coming into the LFOM would travel inside the LFOM. If we had discovered that a bucket inserted into the LFOM below the orifices could catch the jets before they hit the water, the bucket theory would be a viable option. We determined that all but the top three jets of water would in fact hit the far wall of the LFOM before reaching any size bucket that we could place in the LFOM. Also, we used MathCAD to determine the size of the orifice needed in the bottom of the bucket to maintain the plant flow rate. We determined that the orifice would have to have a 4.5cm radius, which was far too large for our buckets. The MathCAD calculations eliminated both the bucket theory and the bucket with a hole theory as possible solutions. The MathCAD files are attached.
(Please document equations used and summarize results obtained on the wiki as well)
Jet Distance Calcs 7-13-09.xmcd
CDC_Retrofit_Designs.xmcd

Testing

After eliminating both bucket theories, we decided that testing the last two designs in a lab would not be difficult and would give more realistic, tangible results than our calculations.

We used the pilot plant to test our retrofit design in an environment that replicated the actual plants as closely as possible. We set the flow rate of the pilot plant at about 150L/min, which, coupled with the 7.5cm-diameter LFOM, would be roughly comparable to the 400L/min, 15cm diameter LFOM in the plant at Cuatro Comunidades.

The Vertical Plane and "Pipe within the LFOM" tests and results can be found at the vertical plane page and the "pipe within a pipe" page.

Results and Discussion

We were able to document results for each variation of the designs visually with photographs and short movies on cameras, see the gallery below to view the photos.

Photos from laboratory testing of retrofit designs

Top view of LFOM in action

Initial set-up of LFOM

6cm "Pipe wi

Vertical/Incline plane

5cm "Pipe within the LFOM"

Initial amou

3cm "Pipe within the LFOM"

Conclusions

At the end of all of our testing, we found that inserting a vertical plane into the LFOM would not effectively reduce the bubble formation enough to solve the problem. However, we did determine that inserting a 5cm-diameter pipe would effectively reduce the amount of bubbles produced by the LFOM, while not constricting the overall plant flow rate. This would translate to about a 10cm-diameter pipe in the AguaClara plant at Cuatro Comunidades. Hopefully this design change can be easily executed in the AguaClara plants in Honduras to fix the foam problem.

No labels