Monitoring techniques for porous media filter beds

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The Problem

Porous media filter beds such as those currently used by the Up-Flo Filter are effective at treating Urban Surface water pollution. The Up-Flo Filter removing fine particles by more than 80%. [1] However, there is a problem in regards to maintaining this performance. This is due to lack of knowledge of when the filter media becomes clogged, leading to it failing before maintenance occurs or it being unnecessarily changed when the filter media is still functioning.

The strategy to fix this

This project proposes a sensor system that would be able to test when the media has become clogged. A potential strategy is shown in Fig. 1 below.

Here the electrical probes will sit in the filter bed at various lengths which will allow for the sensor system to detect whether the modules are saturated, what the height of the water and filter media is. These probes measure the conductance between each set of probes. As the system entrap pollutants the conductivity measured would change as the properties of the filter media would also change. This would allow for more information of the state of the media to be collected and by comparing it to reference data programmed into the module it can be an indicator of whether the modules are clogged.

Acoustic response

One other technique that is to be used is through the use of acoustic transmission through the filter media, as demonstrated in Fig 3.

As shown in Fig. 3 as an acoustic wave travels through the porous media the filter particles absorb and reflect the wave as it is transmitted. This of course causes energy loss leading to attenuation of the wave by the time it reaches the other acoustic transducer. By measuring this attenuation numerous properties of the filter media can be calculated, such as density and porosity. This can be done through various equations such as Equation 1 and 2. [2]

$$\alpha_p = \frac{\omega}{c_p} \beta$$

Eq. 1

$$C_p = \sqrt{\frac{c_m^2}{\mu} + \left(\frac{u_d}{u_0}\right)^2 \frac{\rho_b}{\rho_0}}$$

Eq. 2

Eq. 1 relates the attenuation to the angular frequency, loss tangent of the material and phase speed. Knowing the frequency and loss tangent the phase speed can be calculated which is related to the properties of the material and the speed of the acoustic wave in water. Thus essential data of the material can be calculated. Since this information will change substantially when the filters become clogged it will provide useful indicator of when the filters need replacing.

Conclusion

Combining both the acoustic and the electrical conductance techniques an effective sensor system can be developed. It would be able to acquire useful data such as density, porosity and saturation of the media which will be a useful indicator of when the filter media is clogged. This would improve the maintenance of the filters as this would be reported back to the relevant operator. This sensor system will help to make the filter more sustainable and to have a higher performance over time.

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