Residence Time versus Aspect Ratio of Conventional Oil/Water Separators

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ABSTRACT

This research work investigated the variation of the residence time of wastewater in relation to the Aspect ratio of conventional oil/water separators. It was found that the residence time increases as Aspect ratio increases. Thus, residence time varies in direct proportion with the Aspect ratio of conventional oil/water separators.

Keyword: *Aspect ratio, residence time*

INTRODUCTION

Wastewater is a combination of the liquid or water-carried wastes removed from residences, institutions, commercial and industrial establishments together with such groundwater, surface water and storm water as may be present (Metcalf & Eddy Inc., 2003).

An oil/water separator is a chamber designed to provide flow conditions sufficiently quiescent so that globules of free oil rise to the water surface and coalesce into a separate oil phase to be removed by mechanical means. Oil/water separation theory is based on the rise rate of the oil globules (vertical velocity) and its relationship to the surface loading rate of the separator. The rise rate is the velocity at which oil particles move toward the separator surface as a result of the differential density of the oil and the aqueous phase of the wastewater (American Petroleum Institute, 1990).

The Aspect ratio of oil/water separator can be defined as the ratio of its length to its width, (Length: Width). This research work emphasizes the benefits associated with increasing the length of oil/water separators in relation to the residence time of wastewater in the separator. Increasing the length of the separator increases the distance traveled by the wastewater in the separator.

According to Wkipedia (2015), residence time (also known as removal time) is the average amount of time that a particle spends in a particular system. This measurement varies directly with the amount of substance that is present in the system. Residence time begins from the moment that a particle of a particular substance enters the system and ends the moment that the same particle of that substance leaves the system. If the size of the system is changed, the residence time of the system will be changed as well. The larger the systems, the longer the residence time, assuming inflow and outflow rates are held constant. The smaller the system, the shorter the residence time assuming steady state conditions (inflow and outflow rates are constant).

$$\tau = \frac{\text{System capacity to hold a substance}}{\text{Flow rate of the substance through the system}}$$

It can be represented by the equation below:

$$\tau = \frac{V}{q}$$

Where, τ is the residence time, V is the volume of the system, and q is the flow rate into the system. (Wikipedia, 2015).

In relation to oil/water separator, the residence time of the wastewater in the separator is the period of time taken for the wastewater to enter the separator and exit the separator. It is the difference between the time of exit from the separator and the time of entry into the separator. It is equivalent to the volume of the separator divided by the flow rate of the wastewater into the separator. It is also equivalent to the distance travelled by the wastewater in the separator divided by the velocity of the wastewater in the separator. Mathematically, residence time can be defined as below

$$Residence\ time = \frac{occupied\ volume\ of\ separator}{Flow\ rate\ of\ wastewater\ into\ the\ separator}$$

or

$$Residence\ time = \frac{distance\ travelled\ by\ wastewater\ in\ the\ separator}{Velocity\ of\ wastewater\ in\ the\ separator}$$

or

$$Residence\ time = Exit\ time\ from\ separator - Entry\ time\ into\ the\ Separator$$

METHOD

Oil/water separators of different Aspect ratios, 1:1, 2:1, 3:1, 4:1 and 5:1 were constructed with steel plates. The different oil/water separators were separately connected with a Flow meter and a Holding tank. The wastewater was flowed through each separator at the same flow rate and the residence time recorded for each separator.

$$Residence\ time = Exit\ time\ from\ separator - Entry\ time\ into\ the\ Separator$$

RESULTS AND DISCUSSION

While keeping flow rate and number of baffles constant, the residence time of the wastewater in the separator increased with increase in the aspect ratio of the separator, as shown in the graph below. Thus, residence time is directly proportional to Aspect ratio. The wastewater had the longest residence time in the separator with Aspect ratio 5:1 and the least residence time in the separator with Aspect ratio 1:1. This trend can be explained by the fact that the length or distance traveled by the wastewater increases with increase in the Aspect ratio of the oil/water separator.

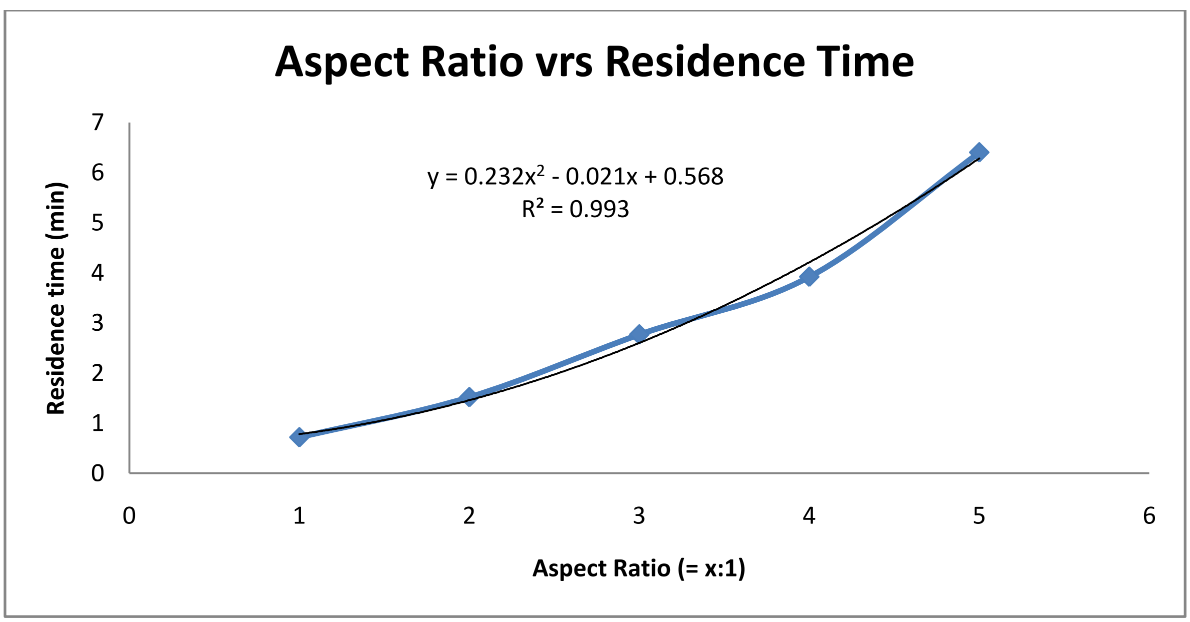

Figure 1.1: Plot of Residence time against Aspect ratio

CONCLUSION

Variation of the Aspect ratio of oil/water separator changes the residence time of wastewater in oil/water separator. The residence time increases as Aspect ratio increases. Thus, residence time varies in direct proportion with the Aspect ratio of oil/water separators.

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