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Effect of Aspect Ratio on the Oil Separation Efficiency of Conventional Oil/Water Separators

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ABSTRACT: This research work investigated the effect of Aspect ratio (length:width) on the oil separation and oil separation efficiency of conventional oil/water separators. It was found that the oil separation and the oil separation efficiency increased with increase in the Aspect ratio of the oil/water separators. Thus the oil separation and oil separation efficiency of conventional oil/water separators vary in direct proportion with Aspect ratio.

INTRODUCTION

Wastewater is any water that has been adversely affected by anthropogenic influence and it comprises liquid waste discharged by domestic residences, commercial properties, industry and/or agriculture and can encompass a wide range of potential contaminants and concentrations (Wikipedia, 2011).

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 stormwater as may be present (Metcalf & Eddy Inc., 2003).

Not much of the water entering industrial works actually becomes part of the manufactured products, only a small fraction is consumed or lost by evaporation; the larger fraction is employed non-consumptively and it becomes spent water that may contain many pollutants; though practically every kind of material entering a plant may become an impurity in its wastewaters – raw materials and auxiliary, intermediate and end-products, by-products and waste products, lubricants etc are among the pollutants [Fair and others, 1981].

Water produced during oil and gas extraction operations constitutes the major waste stream on the basis of volume in the oil and gas industry. The Oil and gas industry produces approximately 14 billion of water annually (Arthur and others, 2005). Thus, oil/water separation is a major concern in the manufacturing and petroleum industries.

Removal of free or floating oil, a component of many industrial wastewaters is generally effected or accomplished in oil/water separator. Oil/water separators are remediation devices that separate oil from water and/or wastewater. They remove oil and other water-insoluble hydrocarbons and settleable solids from wastewater or oil-contaminated water. Oil/water separators are used in many industries – petroleum industry, food processing industry, manufacturing industries, wastewater treatment plants, marine applications etc. One major limitation of oil/water separator is that they cannot be used for the removal of dissolved or emulsified oils such as coolants, soluble lubricants, glycols and alcohols. Oil/water separators may be used for several different purposes; to treat wastewater, to meet secondary containment requirements or as part of oil production process (US Environmental Protection Agency, 2005).

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 an oil/water separator is the ratio of its length to its width (Length:Width). Increasing the length of the separator translates to increasing the distance by the wastewater in the separator. It also translates to increasing the residence time of the wastewater in the separator. Furthermore, it translates to increasing the contact time and coalescence between oil globules. These attributes are what this research work set out to maximize vis-à-vis the oil separation efficiency of oil/water separators.

The performance of oil/water separators can be measured in many ways. Typical examples of performance measures are oil separation efficiency, suspended solids separation efficiency, flow rate capacity, reliability, operator training/attention required and ability to operate without service or maintenance. Under given conditions, the primary criterion for judging oil/water separator performance or effectiveness is oil separation efficiency. It is often the main criterion in determining final discharge water quality (Ultraspin Inc, 2015).

The oil separation efficiency of oil/water separators can be calculated as concentration of oil in the influent minus concentration of oil in the effluent divided by the concentration of oil in the influent. According to Ultraspin Inc. (2015), the oil separation efficiency can be expressed as

$$Separation\ Efficiency, E = \frac{C_i - C_o}{C_i}\ x\ 100$$

E = Oil Separation efficiency

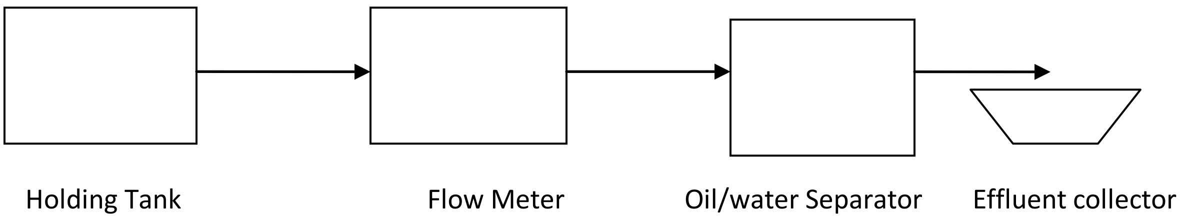
C_i = feed inlet concentration (mg/l)

C_o = discharge outlet concentration (mg/l)

METHODOLGY

Conventional oil/water separators of different Aspect ratios 1:1, 2:1, 3:1, 4:1 and 5:1 were constructed with steel plates. The oil/water separators were connected to a holding tank and a flow meter.

Wastewater samples of different oil concentrations were flowed from the Holding tank through the Flow meter and the oil/water separators at the same flow rate. The oil concentrations in the influent and effluent samples were determined in the laboratory and recorded. The oil separation efficiency for each oil/water separator was calculated as below.



$$Separation\ Efficiency, E = \frac{C_i - C_o}{C_i}\ x\ 100$$

E = Oil separation efficiency

C_i = Concentration of oil in the influent (mg/l)

C_o = Concentration of oil in the effluent (mg/l)

RESULTS AND DISCUSSION

While keeping number of baffles and flow rate of wastewater constant, it was observed that oil separation efficiency increased with increase in aspect ratio of the oil/water separators as shown in the graphs below. This can be explained by the fact that the residence time of the wastewater in the separator increased with increase in aspect ratio leading to increasing contact time and increasing coalescence between oil globules with the resultant increase in oil separation efficiency as Aspect ratio increases.

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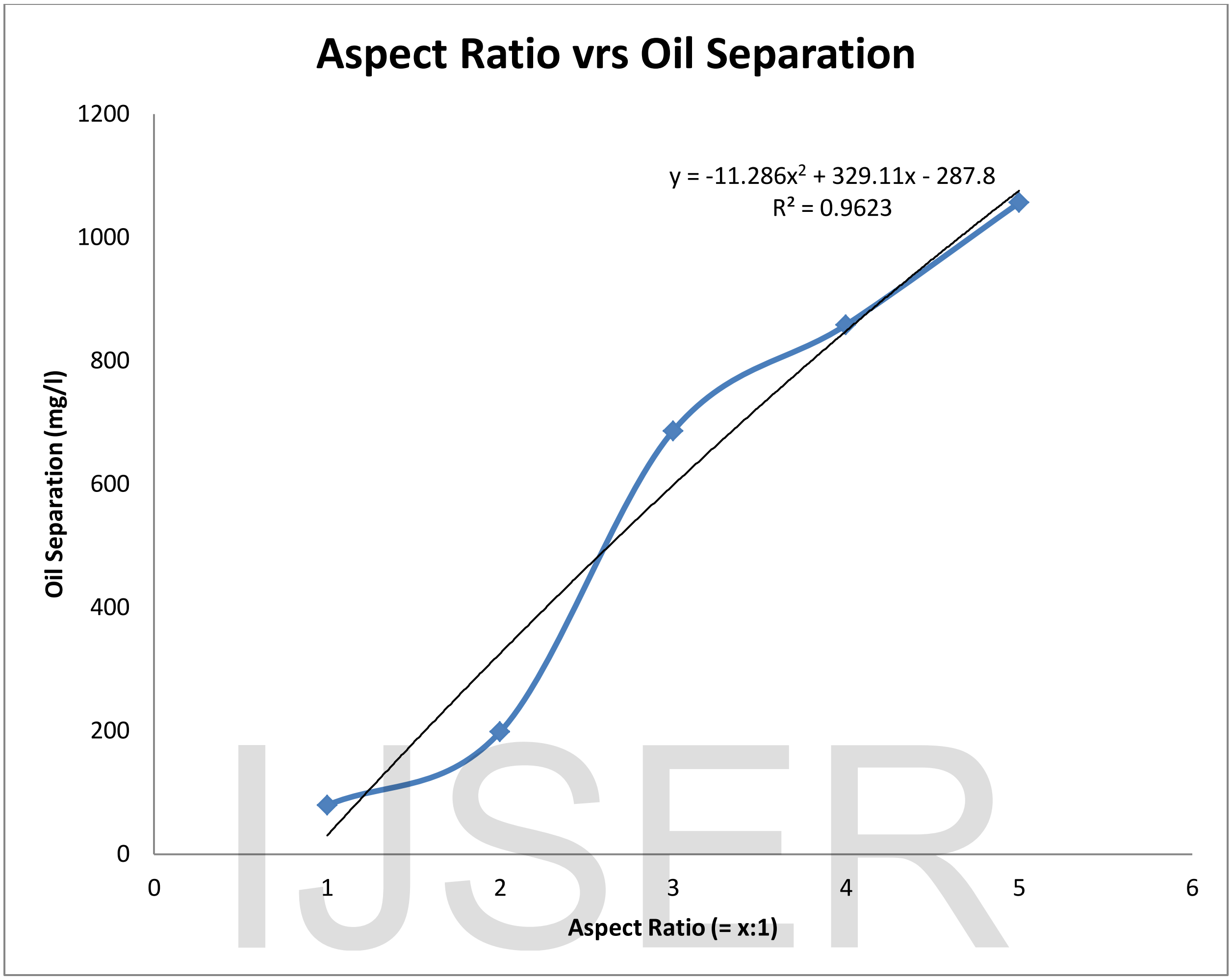

Fig. 1: Plot of Aspect Ratio versus Oil Separation

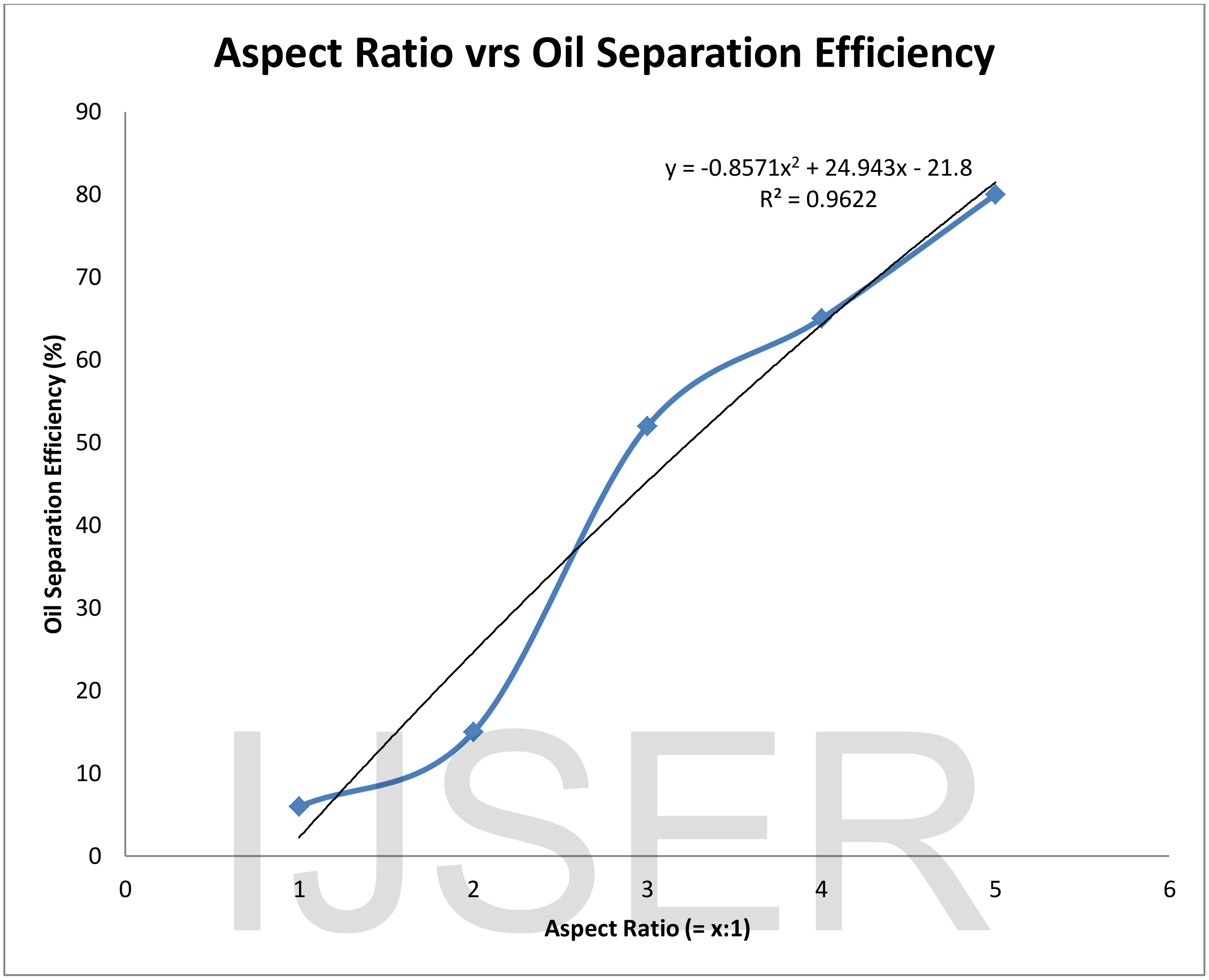

Fig. 2: Plot of Aspect Ratio versus Oil Separation Efficiency

CONCLUSION

Aspect ratio affects the oil separation and the oil separation efficiency of conventional oil/water separators. The oil separation and oil separation efficiency increase with increase in Aspect ratio. This trend establishes that, under given conditions, the oil separation and oil separation efficiency of oil/water separators vary in direct proportion with Aspect ratio. Thus, the oil separation and oil separation efficiency of conventional oil/water separators can be optimized by optimizing the Aspect ratio.

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