BALDWIN

OIL WATER SEPARATORS BASIC DESIGN

The basis of oil water separation is Stokes' Law

$$V_R = \frac{(\rho_w - \rho_o)\, gD^2}{18\,\mu}$$

STOKES' LAW

As the rise velocity of a droplet is directly related to the size of the separation system, the most critical factors to be considered when sizing a system may be determined from Stokes' Law (ie, the greater the oil droplet rise rate, the smaller the system). These critical factors include:

Density of Oil

The greater the density difference (P_W - P_O) the greater the rise velocity.

Viscosity/Temperature

The lower the viscosity (μ) the greater the rise velocity. Viscosity is a temperature dependent parameter. At higher temperatures the viscosity of the oil is lower, hence, the higher the temperature the faster the rise velocity of the droplet.

Droplet Diameter/Emulsification

Stokes' Law is proportional to the square of the droplet diameter (D) and hence the droplet size is the most important factor to be considered when addressing the design of an oil water separation system.

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MINIMUM DROPLET SIZE

The minimum droplet diameter removed, or more correctly, **the size of the smallest droplet to be 100% removed** is the key factor in correctly designing and guaranteeing the performance of any oil water separation system.

The smallest droplet to be 100% removed is a variable parameter which is dependent on the following factors:

1. The concentration of oil in the influent stream.

2. The concentration of oil required in the effluent stream (treated water).

3. The level of emulsification of the oil water mixture, ie the ***droplet distribution***.

Droplet Distribution

Various factors can effect the size of oil droplets in an application, these include the surface tension of the oil, the presence of surfactants in the water and the shear forces being exerted on the mixture. Shear forces are derived from transferring the fluid once it has become contaminated, ie, piping systems, valves, bends, etc, and most importantly pumps. The more severe the shear forces the smaller the droplet becomes.

Before a system could be accurately designed it was imperative that some quantitative measure of the effect of these shear forces be determined. Research on the subject was originally undertaken by the General Electric Corporation in the late 60's and early 70's. Their approach was to assume that the droplets would exist as a Normal Distribution (which is completely described by a mean and standard deviation), and to set up scenarios involving various pumping arrangements (including pneumatic diaphragm, helical rotor, sliding shoe, rotary vane and centrifugal style pumps) and measure the droplet distributions resulting from these scenarios.

From these results it would then involve a simple statistical analysis to predict the effluent quality resulting from the CPS (with a predetermined droplet size being removed).

The next step was to conduct trials with known inlet conditions (oil concentrations, temperature, oil densities and levels of emulsification [specific style pumps]) and measure the outlet oil concentration. Knowing the size of the droplet 100% removed in the system (by calculation) thus enabled the correct oil droplet distribution to be "back calculated".

These factors were then developed into a computer program that calculates the number of coalescing plates and configuration required to produce the desired effluent quality.

This patented program is used exclusively by Baldwin Industrial Systems for all system designs.

To show an example of this the following formula is used to specify/design a CPS system.

$V_R = {}^{Q}/_{A}$

Where V_R = rise rate of droplet (Stokes' Law)
Q = Flowrate
A = projected area of CPS ∗

∗ This should not be confused with surface area. The projected area is the total area of the coalescing plates in **plan** view.

Example:
Compare the projected area of a $5m^3/hr$ CPS that removes a 20µ droplet and a $5m^3/hr$ CPS that removes a 30µ droplet.

Using the above formula and Stokes' Law gives us:

71.43m^2 (projected area) to achieve **20 µ** removal and only
31.85m^2 is required to remove a **30 µ** droplet!

During July-September 2001, Baldwin conducted extensive trials at Velcon Filters in Colorado, USA to determine the relationship between the Influent droplet distribution and the Effluent quality. These trials were carried out using various types of oils and various types of pumps.

The results of these trials provide Baldwin with a more accurate "performance prediction" and a CD/Video is available outlining the actual trials.

We trust this information is of use and if you have any questions please do not hesitate to contact us.

Regards

Robert Crawford
Director