Faculty of Engineering

DIESEL – SALINE WATER SEPARATION BY COALESCENCE PLATE

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ABSTRACT

A novel and highly efficient circular phase separator with coalescing medium in counter-current flow was recently developed for treating wastewaters loaded with oil in Malaysia. The coalescing medium consists of 11 layers of inclined dual angle coalescing plates to promote faster rising of oil droplets through coalescence process. By continuous testing the experiment, the oil removal efficiency as higher as 85.2 % can be reached at 0.5×10^{-5} m^3/s flowrate. At the same time, Malaysia is both a victim and contribution to oil pollution. As a victim of pollution, Malaysia has long been exposed to the oil tanker traffic and the risk of oil tanker accidents. When the exploration and exploitation of hydrocarbons in the offshore areas started, Malaysia has since become producer of oil pollution, hence exposing the coastal and marine environment to this contamination. This research was use the same circular phase separator DPCC separator to separate oil from oily saline water. It was found that the oil removal efficiency is 38.64% at the 1.5×10^{-5} m^3/s flowrate.

ABSTRAK

Sebuah novel yang sangat efisien dan pemisah fasa lingkaran dengan penggabungan media dalam arus-arus kontra baru-baru ini dikembangkan untuk memisah minyak dari sisa di Malaysia. Media terdiri daripada 11 lapisan sudut dual cenderung penggabungan pinggan untuk mempromosi lebih cepat pisahan titisan minyak melalui proses coalescence. Dengan ujian percubaan terus menerus, pemisahan minyak kecekapan setinggi 85,2% dapat dicapai dengan 0.5 × 10-5 m^3 / s laju alir. Pada masa yang sama, Malaysia adalah kedua-dua mangsa dan sumbangan terhadap pencemaran minyak. Sebagai korban pencemaran, Malaysia telah lama menghadapi risiko kemalangan kapal tanker minyak. Ketika eksplorasi dan eksploitasi hidrokarbon di kawasan pantai, Malaysia telah menjadi pengeluar pencemaran minyak, maka mengekspos persekitaran pantai dan laut terhadap pencemaran ini. Penelitian ini akan menggunakan pemisah fasa pemisah sama lingkaran DPCC minyak berasingan dari air laut berminyak. Didapati kecekapan pemisahan minyak adalah 38.64% semasa kelajuan air ialah 1.5 × 10-5 m^3 / s.

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DIESEL – SALINE WATER SEPARATION BY COALESCENCE PLATE

WONG KIEW CHIN

This project is submitted in partial fulfillment of

the requirements for the Degree of Bachelor of Engineering with

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To my beloved parents

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CHAPTER 1

INTRODUCTION

1.1 Background

Malaysia is both a victim and contribution to oil pollution. As a victim of pollution, Malaysia has long been exposed to the oil tanker traffic and the risk of oil tanker accidents. When the exploration and exploitation of hydrocarbons in the offshore areas started, Malaysia has since become producer of oil pollution, hence exposing the coastal and marine environment to this contamination.

Currently, oil exploitation activities are confined to South China Sea off the east coast of the Peninsular Malaysia, Sarawak and West Sabah. Beside the oil producing platform, there are two floating marine terminals and storage/export function. Together with production activities, maintenance and servicing operation, the combined picture for offshore petroleum operation is indeed busy. So the risk of the operation mishaps resulting in oil pollution is great.

Although the sources of the impact can be identified, evaluating their real impact is largely speculative. One point that clearly emerges from the above somewhat general appraisal of the impact of offshore petroleum exploitation is that the threat of oil pollution on the environment is great. So great care should be taken to prevent control oil pollution and this could only be possible through stringent legislation and monitoring activities.

The paper attempts to apply the Coalescence Plate that usually used in factories industry to remove the oil from oily sea. It means diesel and sea water separation by Coalescence Plate.

1.2 Environment Policy and Legislation

Under the Malaysian Environmental Quality Act and Regulations, the amount of O&G content allowable in sewage and industrial effluent discharge is 10 mg/L or less. For Interim Marine Water Quality Standards no amount (0 mg/L) of oil and grease is allowable (Appendix A1). The stipulated level of hydrocarbon (oil) content in the effluent is 10 ppm. But the final target should de Standard A inline with advancement of treating facilities and practices of other nations of the world. The continuous dumping of effluent containing oil into the environment in long term would affect the surrounding environment in term of water life and plant growth.

For offshore based facilities, there are no rules or regulations made subsequent to the main legislation. A number of rules and Regulations is on the drawing board to control discharges of oily mixture and solid waste into Malaysian water. The various Acts are interrelated and implementation of Rules and Regulations when they existed should be coordinated to ensure uniformity. Although there is no legal requirement of stipulated oil content level in the effluent disposed offshore, standard industrial practice in other part of the world has been adopted and imposed by PETRONAS. The oil content in the effluent disposed offshore has been set at 100 ppm. Generally the legal requirement on effluent quality is more lax at location offshore than onshore is due to restricted platform space and dilution factor on the open sea.

The final objective is to reduce these criteria to reflect the advancement in treating technology. Some of our platforms are near the shoreline, hence this should be taken into consideration in future Rules and Regulations. As a guideline, the effluent limit should be in line with the Paris Convention requirement of 40 ppm (monthly).

1.3 FREYLIT plate pack technology

Oil Separators are designed in a modular plate pack system which allows the building of separators to the exact specifications and flow rates required by our clients. All sizes available for flow rates from 3 l/sec to 100 l/sec for petrol stations, car park, automobile garages, to large industrial oil separators for power stations, oil terminals, fuel depots, steel mills, oil fields, environmental reclamation operations, etc. with flow rates of more than 2000 l/sec.

FREYLIT supplies oil separators with tanks made of concrete, polypropylene, steel or stainless steel. Concrete tanks are necessary at sites where the separator will be installed underground and a high surface load is expected, for example under a driveway. On the other hand, the lighter weight of FREYLIT separators with polypropylene tanks makes them easier and cheaper to transport and handle for installation.

1.4 Problem Statement

Plate separators are among the most widely applied separator types in the oil industry. Numerous types separator produced by an array of different manufacturers are available in the market today with varying plate shapes, ranging from simply flat to complicated corrugated structures. From the vast body of available literature, there were a few aspects that had not been thoroughly researched or well-studied with respect to plate separators. There is an obvious lack of understanding about the relationship between separation or removal efficiency and plate shape geometry, i.e. the relationship of inclined parallel arc coalescence plates on oil-water separation efficiency due to 1) surface slip, 2) effects of shear with the oil droplets experiencing re-suspension, and 3) dispersion of oil droplets.

1.5 Research Objectives

The main objective of this research is to observe and analyze the efficiency of the Coalescence Plate to the separation of the oily sea water. This paper reports on the investigation outcomes resulted from further theoretical considerations and experimental works on coalescence plate separators. Some constructive details including innovative variations in the inlet and outlet construction were investigated with respect to oil droplets or emulsified oils removal efficiencies from sea water.

The other objective of this research is to determine the relationship between oil concentration of effluent, Q_e and the water sample in taken time, T_e. At the same time, the research is also to analysis and observes the effect of vibration on the DPCC separator by comparing the result with previous research.

1.6 Theoretical Principles (Stockes' Law)

The mechanisms of oil droplets removal from a liquid by gravity separation include the principles of Stockes' Law and Boycott effect. Separation of oil droplets from water is a liquid-liquid separation carried out almost exclusively by gravity separation, either natural or enhanced, using floatation of the oil droplets to remove it from water. Natural gravitational separation is carried out in American Petroleum Institute (API) separators in large tanks. Oil in water is characterized by a spectrum of droplet sizes. The droplet size that must be removed to attain a given effluent concentration depends on the oil specific gravity, concentration and average droplet size present. Design of an enhanced gravity separator size employs the mechanism of the rise velocity υr, is given by Stockes' Law:

$$v_r = \frac{g}{18\mu}(\rho_o - \rho)d^2 \quad 1\text{-}1$$

G = Acceleration due to gravity

μ = Dynamic viscosity of continuous liquid

ρ_o = Mass density of the oil droplet

ρ = Mass density of continuous liquid

Bernoulli Equation

For steady, inviscid, incompressible flow the total energy remains constant along a streamline. The concept of "head" was introduced by dividing each term in Eq. 1-2 by the specific weight, γ = ρg, to give the Bernoulli equation in the following form;

$$P/\gamma + V^2/2g + Z = \text{constant on a streamline} = H \quad 1\text{-}2$$

Each of the term in this equation has the unit of leght and represents a certain type of head. The Bernoulli equation states that the sum of the pressure head, the velocity head, and the elevation head is constant along a streamline. This constant is called the total head, H.

CHAPTER 2

LITERATURE REVIEW

2.1 General

Processes composing contact between oil and water phase are common in industry. The oil-water is the key factor in these processes since it determines the nature of the phenomenon. Emulsion, for example as one of the most common phenomena in industrial processes, shows total dependency on the characteristics of the interface. However, in undertaken this work, it was necessary to ascertain the state of knowledge of the oil-water interface and other related fields to that delineated by the objectives. These fields include the basic theory of the oil-water interface, theology of concentrated emulsions, surface force and emulsion stability, and droplet coalescence and behavior. Some studies focused on understanding these fields, while others have attempted to study the operational aspects of some industrial applications on the basis of the knowledge on these fields. Most of the theories described are valid for any immiscible liquid-liquid mixture. A summary of some of these research efforts are described in the following paragraphs.

2.2 Physical Properties of sea water

2.2.1 Salinity

Salinity is a measure of the total dissolved solids in the water. It is measured in grams of solid minerals in 1 kilogram of seawater, or parts per thousand, which we write as o/oo. (Remember that % is parts per hundred, so to get ppt we add an o.) The reference for salinity currently in use is the Practical Salinity Scale of 1978 (PSS-78) and the units are the Practical Salinity Unit or PSU. This is essentially the same as parts per thousand, but is defined for the modern measurement of salinity.

The total dissolved salt content of a parcel of sea water is its salinity. The average salinity of sea water is 35 grams of dissolved salt per kilogram of sea water [35 g/kg, or 35 parts per thousand (p.p.t. or ‰). 99% of all sea water has a salinity in the range 30 to 37 g/kg.

2.2.2 Density

The density of fresh water is 1.00 (gram/ml or kg/litre) but added salts can increase this. The saltier the water, the higher is its density. When water warms, it expands and becomes less dense. The colder the water, the denser it becomes. So it is possible that warm salty water remains on top of cold, less salty water. The density of 35ppt saline seawater at 15ºC is about 1.0255, or s (sigma) = 25.5. Another word for density is specific gravity.

2.2.3 Pressure

Pressure is a measure of the external force on a parcel of water. Oceanographers generally use units of dbars where 1 dbar ≈ 1 m depth. This is for simplicity since the dbar is a standard unit of pressure, and it is also very near the unit that we use for depth. Also, the equation of state of sea water expects the pressure in dbars, so it is easiest to keep it in that form. On the other hand, the Pascal is the MKS unit of pressure and is 1 NEWTON/M². Since 1 dbar = 104 Newton/m² or 104 Pascals, depths such as 200 meters become pressures of 2 megaPascals or 2,000 kiloPascals, which are not as easy to interpret physically. Engineers usually calibrate sensors in pounds per square inch (PSI), and 1 PSI =

0.6895 dbars or 1 dbar = 1.4503 PSI. To be most accurate one should calculate depth from pressure using the hydrostatic approximation (assuming no fluid motion)

For typical ocean densities of 1027 kg/m3 and acceleration due to gravity of 9.80 m/s^2, the constant of proportionality is 1.0065 dbars/m or only 2/3% error using dbars as meters. Thus, for convenience, oceanographers use dbars although it is not a standard MKS unit of pressure. Note for many publications, you may have to change back to the MKS unit of Pascal.

2.2.4 Boiling Point

When a liquid is heated, it eventually reaches a temperature at which the vapor pressure is large enough that bubbles form inside the body of the liquid. This temperature is called the boiling point. Once the liquid starts to boil, the temperature remains constant until all of the liquid has been converted to a gas.
The normal boiling point of water is 103.7^{o}C.