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EFFECT OF VIBRATION ON OIL – WATER IN DROPLETS SEPARATION

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Dedicated to my beloved parents, family, friends and my lover who had supported me to completed my research.

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ABSTRACT

Oil in wastewater is a major cause to the environmental pollutions. The existing multiple-angle Coalescence Frustums Arrangement for Current Flow (MFCC) separator is a cost- effective separator using a gravity separation method. This MFCC separator machine cannot produce 100% efficient although many part of the machine has been changed based on the previous research. A new technology was required for the separator machine to improve it efficiency in separating oil droplets. This research is a "proof-of-concept" to investigate the effects of vibration on the MFCC separator to optimize the efficiency of the separator. Oil-water separations were tested at fixed influent concentration and flow rates. The time interval for the sample of influent and effluent to testing the oil concentration was set as 5 minutes. The efficiency of the separator with vibration was compare with the existing efficiency result of the separator. The efficiency of the separator with vibration was 49% at the first 15 minutes but the existing efficiency of the separator was 62 %.So, the efficiency of the MFCC separator was decreased if vibration is applied.

ABSTRAK

Minyak dalam air sisa merupakan satu punca utama pencemaran persekitaran. Pemisah koalesensi Frustums Tetapan untuk Lancar Arus (MFCC) yang mempunyai beberapa-sudut adalah satu sistem pemisahan yang berkesan dari segi kos yang menggunakan kaeadah pemisahan graviti. Pelbagai bahagian dari mesin ini telah diubahsuai mengikut kajian dahulu, namun mesin pemisahan MFCC ini tidak dapat meningkatkan keberkesanan kepada 100%. Oleh sebab itu,teknologi baru diperlukan untuk memperbaiki kecekapan mesin ini untuk mengasingkan titisan minyak daripada air bercampuran dengan minyak. Kajian ini adalah satu "konsep-dibuktikan" yang mengangarkan kesan pengaplikasian getaran kepada pemisah MFCC untuk mengoptimumkan kecekapan pemisahan. Pemisahan minyak-air diuji pada kepekatan minyak dan kelajuan arus aliran air kedalam mesin ditetapkan. Jangka waktu untuk menguji kepekatan sampel "influen" dan "efluen" adalah 5 minit. Kecekapan pemisahan dengan getaran ini dibandingkan dengan keputusan berkesanan pemisah dahulu yang telah dibuat terhadap mesin pemisahan itu. Kecekapan pemisah dengan getaran ini ialah 49% pada 15 minit yang pertama, namun keputusan kecekapan pemisah dahulu ialah 62%. Oleh itu, kecekapan pemisah MFCC ini menurun jika diterapkan dengan kesan getaran

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LIST OF ABBREVIATIONS

Hz	-	Hertz
D	-	Displacement
V	-	Velocity
a	-	Acceleration
HF	-	High-frequency
CPS	-	Cycles-per- second
MFCC	-	Multiple-angle Coalescence Frustums Arrangement for Current Flow
CPM	-	Cycles-per-minute
rpm	-	Revolutions per minute
FM	-	Frequency modulated
API	-	American Petroleum Institute
ppm	-	Parts per million
CPI	-	Coalescing plate interceptor
PVC	-	Polyvinylchloride

CHAPTER 1

INTRODUCTION

1.1 General

Activities of oil discharges into main stream waters have been a long-term global problem. Presence of oil in water has deleterious effects to the environment and health; oil discharge creates potential hazards and consumes or decrease dissolved oxygen necessary to aquatic life. It was estimated that approximately 706 million gallons of

waste oil enter the oceans every year (Embach, 2010). If drastic measures are not taken, sooner or later the seas will be densely polluted with oil.

Besides, oil that contains volatile organic compounds partially evaporates and loses some percentage of its mass and becomes more dense and viscous in water (Embach, 2010). As oil mixes in water, a small percentage of it dissolves in the water. The oil residue becomes partially invisible or forms a thick mousse in the water. The crude oil would emulsify when spilled in sea water and some percentage of oil would form water-in-oil-emulsions (w/o), often nicknamed 'chocolate mousse' (Gaaseidnes and Turbeville, 1999).

According to Asatekin and Mayes (2008), the oil industry produces large amount of wastewaters through drilling and oil refinery processes. During drilling, oil and water mixture are brought to the surface and water needs to be separated from oil. Oil becomes a very useful resource when the water compound is removed from it. This separation processes were used in cleaning up oil spills in the open waters. The Oil Pollution Act of 1990 was enforced by the U.S Congress to improve oil spill prevention under its provisions that the Oil Spill Liability Trust Fund was provided for the cleanup process, if any oil spill incident happens (Embach, 2010).

Currently, there are numerous types of oil-water separators available in the markets. Most of the separators are based on the gravity separation principles. However, the specific applications of the separators would usually depend on the characteristics of oil sizes and types of oils. Furthermore, there are cutting edge technologies being applied in the oil-water separator to produce high-efficiency outcomes. The effect of vibration had been used in the separator to produce a separation in the granular mixture. According to Catherall *et al* (2007), a vertical vibration effect causes the binary granular mixture to separate through the gravity force. The heavy particles on the separator with vibration effect will settle faster cause the gravity force which pull the denser particles.

1.2 Vibration Technology

Vibration is a very useful technique in an industry to figure out the malfunction of a machine and would function as useful equipment. Even machines are well and in good operating condition will have some vibration because of small or minor defects. Therefore, each machine will have a level of vibration that indicates as normal of inherent. The vibration level was used to monitor the machine components; whether or not it is faulty from basis of vibration signals receive from the machine components (Kumaraswamy *et al*, 2002). Apart from that, vibration technology can also be applied in the oil fraction process in petroleum industry. According to Xiao *et al.* (2004),

vibration force introduction in the reservoir was considered to help the movement of oil in one or more ways by diminishing capillary forces, reducing adhesion between the rock and fluids or causing oil droplets to come together into stream that flow with the water flood.

1.3 Problem Statement

The coalescing plate separators widely used in the oil-water separation. This type of separator is based on the gravity separation method which is to improve the limitation of the gravity separation method. Although this type of separator is better than the gravity separator, this separator also has some limitation such as size of oil droplets.

The existing multiple-angle Coalescence Frustums Arrangement for Current Flow (MFCC) separator is also based on the gravity separation method. This separator is effective in separating the size of oil droplets more than 10μm. The efficiency of this separator is mostly influenced by the flow rate of the sample and the concentration of the oil. The efficiency of this separator is not consistent for all types of condition. Although, the efficiency of the MFCC separator is higher than the normal ones it cannot reach 100% rate of efficiency or closer. To increase the separator efficiency, some new

technology is required. So, this research is conducted to use the effect of vibration in to produce a more efficient separator.

1.4 Research Aim

The aim of this research is to conduct "proof-of-concept" i.e., to find out if "vibration" enhances oil-water separation or improves oil removal efficiency for the existing Circular Coalescence Plates Separator (Multiple-angle Coalescence Frustums Arrangement for Current Flow (MFCC) Separator).

1.5 Specific Objective

The primary objective of this research is to remove oil droplets with sizes of 10 μm and more in diameters by applying vibration on the separator during the entire process period. Then, the oil removal efficiencies of the separator with and without vibration in water/wastewater loaded with oil droplets are compared.

1.6 Hypothesis

The effect of vibration causes fatigue in machines. This fatigue and damage are due to vibration that changes the direction and magnitude of the machine parts. So, if vibration is applied in this Circular Coalescence Plate Separator, it is hypothesized that oil-water separation would be enhanced. Hypothetically, the effect of vibration in the separator machine will help the oil droplets move faster to coalesce with small oil droplets to rise to the surface. The coalescing frustums will assist oil droplets to coagulate and float to the surface to be collected. The vibration can act as catalyst to increase the oil droplets energy to move faster. Besides, once the oil droplets attain the buoyant force after coalesce with other small oil droplets, it will rise to surface to be separated. So, if effect of vibration is applied in the separator it would enhance oil droplets to reach the buoyant force in a shorter period of time and the oil droplets would rise to the surface in a relatively shorter period of time as well.

CHAPTER 2

LITERATURE REVIEW

2.1 General

Vibration is a force that causes changes in the position or coordinate of an object. In a simple term, vibration can be described as an oscillation or repetitive motion of an object around the equilibrium position. In real life, the vibration force cannot be detecting through naked eyes but can be felt by touching the vibrating object. In fact, the most inexperienced drivers will also realize that something is abnormal if the steering wheel vibrates or when the engine wobbles. It is natural to relate the condition of a machine with its vibration level. Vibration can cause damage to structures, fatigue failures in machine components, physical damages in the product, and limiting the processing speed of machines. Subsequently, vibration also has adverse effects on

human. The primary effects to humans are motion sickness, speech disturbance, and breathing.

The vibration of an object is due to the excitation force. This force may be externally applied to the object or it may originate from inside the object. The rate and magnitude of the vibration force for a given object can be determined by the excitation force, direction, and frequency of the object (Mobley, 1999). Excitation force was used to identify the problems inside the machine.

2.2 Theory of Vibration

Vibration can be defined as an oscillating motion of a particle or body about a static reference point (Dimarogonas and Haddad, 1992). Vibrations can be differentiated as free vibration and forced vibration .The free vibration occurs when a system oscillates under the natural frequency and when no external forces are implied. Vibration that takes place under the excitation of external forces is called forced vibration. When the excitation is oscillatory, the system is forced to vibrate at the excitation frequency (Chan, 2008).). Based on the Shabana (1995), the theory of vibration can be related with the oscillatory motion of a physical system which the motion may be harmonic, periodic or a general motion where the amplitude varies with time. .