SEPARATION OF CRUDE OIL EMULSION VIA MICROWAVE HEATING TECHNOLOGY

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DECLARATION

I declare that this thesis entitled “Separation of Crude Oil Emulsion via Microwave Heating Technology” is the result of my own research except as cited in references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	: …………………………………………
Name of Candidate	: Siti Nuurul Huda binti Mohammad Azmin
Date	: April, 2009

Special Dedication of This Grateful Feeling to My…

Beloved husband,

that always love me,

Cute daughter that give us a happiness,

My friends, my fellow colleague,

Supportive Lecturer

Dr.Abdurahman Hamid Nour,

and all faculty members.

For all your care, support and believed in me.

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ABSTRACT

Emulsion is a mixture of two immiscible substances which is divided into two types of emulsions either a water-in-oil emulsion or oil-in-water emulsion. Emulsion is unstable. For economic purpose, pipeline consideration and for efficient refinery operations, the produced crude oil must dewatered and necessary to separate the water completely from the crude oils before transporting them. In this study, two types of crude oil with three volume ratio of water-oil 50-50%, 30-70% and 20-80%(w/o) were used and they were added by four different types of surfactants (Triton-X-100, Tween 80, Span 80 and SDDS) in different concentration which are 0.5%, 2.5% and 4.5%. Then this water-oil volume ratio and surfactant was heating by using microwave at two different powers which are 180 watt and 720 watt. The findings from this study are microwave heating technology can be an alternative method for demulsification for water-oil emulsion. Microwave heating technology can be use for more effective, time and energy saving and low cost method for demulsification process compare to the conventional methods

ABSTRAK

Emulsi adalah campuran kepada dua cecair yang terlarut campur, dibahagikan kepada dua jenis iaitu air di dalam minyak emulsi dan minyak di dalam air emulsi. Emulsi adalah tidak stabil. Untuk tujuan ekonomi, pertimbangan kepada saluran paip dan untuk kecekapan kilang penapisan minyak mentah, minyak mentah yang dihasilkan perlu di buang air sepenuhnya daripada minyak mentah sebelum ia di angkut. Tujuan kajian ini adalah untuk mengkaji kestabilan minyak mentah menggunakan *surfactant* yang berbeza dan mengkaji kecekapan microwave untuk membuang air dari minyak mentah berbanding dengan kaedah biasa. Dalam kajian ini, dua jenis minyak mentah dengan tiga dengan nisbah isipadu air dan minyak iaitu 50-50%, 30-70% dan 20-80% dan kemudiannya di tambah empat jenis *surfactant* yang berbeza (Triton-X-100, Tween 80, Span 80 and SDDS) dengan kepekatan yang berbeza iaitu 0.5%, 2.5% and 4.5%. Kemudian nisbah isipadu air-minyak dan *surfactant* dipanaskan pada tenaga(power) yang berbeza iaitu 180 watt dan 720 watt. Penemuan dalam kajian ini adalah, teknologi pemanasan menggunakan microwave boleh menjadi kaedah alternatif untuk proses membuang air dari minyak mentah. Teknologi pemanasan menggunakan microwave boleh digunakan untuk lebih berkesan, menjimatkan tenaga dan masa dan murah untuk process membuang air dari emulsi berbanding cara biasa.

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CHAPTER I

INTRODUCTION

1.1 Background

Petroleum is a mix of naturally organic compounds contains primarily hydrogen, carbon, oxygen. There are two types of petroleum which come straight out of the ground in form of liquid. The first one is called as crude oil and the second one is called as condensate. Crude oil is a dark and viscous liquid and condensate is a clear and volatile liquid. Crude oil usually in black color but it also comes in other colors like green, red or brown but they are not uncommon. Crude oil is come into two characteristics either it is light or heavy. Their characteristics depend on how this crude oil is vaporizing when it is heating, or it is added by chemical agents. It is light if it is a volatile oil and is heavy if it is viscous. A significant portion of the world crude oil is produced in the form of emulsion (Abdurahman and Rosli, 2006). Emulsion is a mixture of two immiscible substances. It is divided into two types of emulsion either a water-in-oil emulsion or oil-in-water emulsion. Butter and margarine are example of water-in-oil emulsion because oil is surrounding the water droplets. For milk and ice cream, they are example of oil-in-water emulsion because water is surrounding the oil droplets. Emulsion is unstable. There are three types of emulsion instability which are flocculation, creaming and coalescence. Flocculation give a meaning when the particles form clumps, while creaming occur when the particles concentrate towards the surface or bottom depends on their relative density of two phases, and coalescence means that the particle coalesce and form liquid layer. The instability of emulsion gives some problem for industries. So that, for economic purpose, pipeline consideration and for efficient refinery operations, the produced crude oil must dewatered and necessary to separate the water completely from the crude oils before transporting them (Abdurahman and Rosli, 2006). In order to dewatered of crude oil, there are some methods that use in industry for example dewatered of crude oil emulsion by using microwave heating, dewatered of this crude oil by using chemical which act as surfactants (surface active substances) that can increase the kinetic stability of emulsion greatly, dewatered of this crude oil by using heat which involve radiation, conduction and convection process or dewatered of this crude oil by using electrical energy.

1.2 What is an emulsion?

Emulsions are colloidal dispersions in which a liquid is dispersed in a continuous liquid phase of different composition (Laurier L.Schramm, 2005). Dispersed phase is referred to an internal phase and continuous phase is referred to an external phase. In most emulsions, one of the liquids is in aqueous while the other is hydrocarbon and usually comes in form of oil. There are two types of emulsion that we can distinguish by determined which kind of liquid form the continuous phase (external phase). They are

- Oil-in-water (O/W) for oil droplets dispersed in water.
- Water-in-oil (W/O) for water droplets dispersed in oil.

Below is the picture to distinguish between O/W and W/O

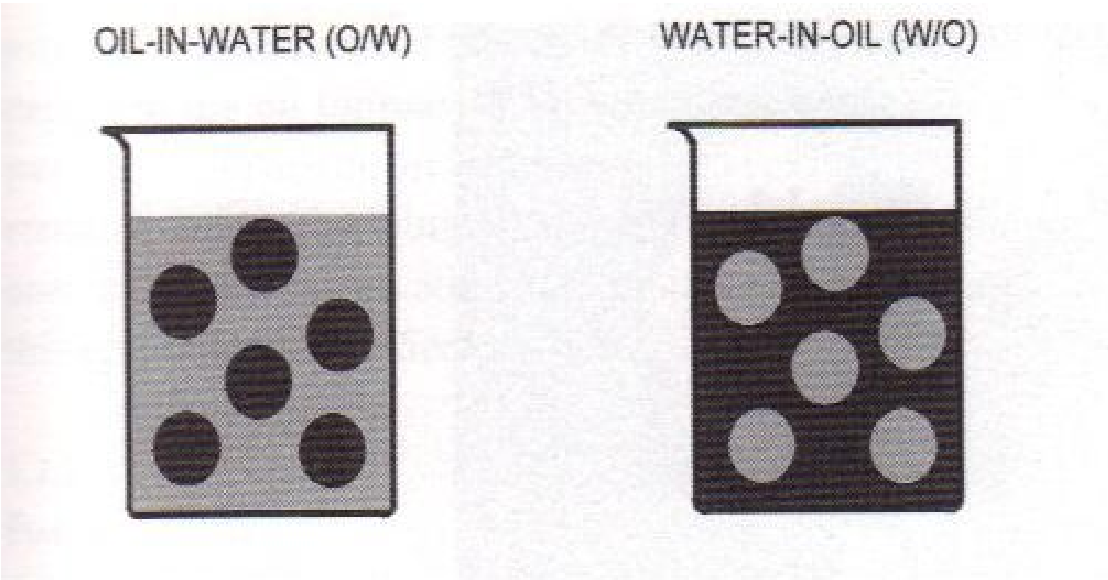

Figure 1.1: Oil-in-water emulsion (O/W) and water-in-oil emulsion (W/O) (Laurier L.Schramm. 2005)

1.3 Emulsion characteristics

In separation process, the characteristics of the emulsion are very important. For example, the produced water in oil-water mixture must be separated from the oil, treated, and disposed properly. The sellable crude oil also must comply with certain product specifications, including the amount of basic sediment and water (BS&W) and salt. Water-in-oil (W/O) mixture or oil-in-water (O/W) mixture may be loose (water can be separate easily) or they can be tightly (water is difficult to separate from the emulsion).

1.4 Emulsifier

A substance which is used to stabilize the emulsion is called as emulsifier or frequently it is called as surfactants. This emulsifier is use widely in our life. The example of using of emulsifier is detergent (act as emulsifier) which is use in cleaning process. This detergent will chemically react with the water and oil, and then it will stabilize the interface between water or oil droplets in suspension. This principle is exploited in soap to remove grease for cleaning process. A wide variety of emulsifiers are used in pharmacy to prepare emulsions such as creams and lotions. Emulsifier is very important because it is tend to promote dispersion of the phase in which they do not dissolve very well. That is why they are used to stabilize the emulsion. Emulsifier can turns into water-in-oil or oil-in-water but it is depends on the volume fraction of both phases and on the type of emulsifier.

Figure 1.2: Example of emulsifier (20 ml ampule of 1% propofol emulsion) use in for intravenous injection.

1.5 Demulsification

Demulsification is a process of oil and water separation from emulsion (Laurier L.Schramm,1992). Typical demulsification techniques include thermal, electrical, chemical, acoustic, or mechanical method (Novales *et.al*, 2003). Not all of crude oil emulsion can break by demulsifies because the demulsification mechanism of demulsifier is quite complicated. In chemical demulsification process, chemical which called as demulsifier is added to the water-in-crude oil emulsion. The demulsifiers are surface active agents (surfactants) and develop high surface pressure at crude-oil-water interface (Graham *et al*, 1980) and (Mukerji *et al*,1989).

1.6 Problem Statement

In petroleum industry, both desirable and undesirable emulsions permeate the entire production cycle, including emulsion drilling fluid, injected or in situ emulsions used in enhanced oil-recovery process, well head production emulsions, pipeline transportation emulsions, and refinery process emulsion (Schramm, L.L, 1992). In some emulsion, there are not only water and oil, there are also have solid particle or gas. In order to overcome the problems in this petroleum industry, we need to remove this solid particle, gas and we also need to separate oil and water by using demulsification process. Below is the table for both desirable and undesirable emulsions.

Table 1.1: Table of desired and undesired of emulsion in petroleum industry (Laurier L.Schramm. 2005)

Undesirable	Producing (well head) emulsions	W/O
	Producing oil-well and well-head foams	G/O
	Fuel oil emulsions	W/O
	Oil-floatation process froth emulsions	W/O, O/W
	Oil-floatation process diluted froth emulsions	O/W/O
	Oil-spill mousse emulsions	W/O
	Tanker bilge emulsions	O/W
	Distillation and fractionation tower foams	G/O
	Fuel oil and jet fuel tank (truck) foams	G/O
	Migrating fines in a reservoir	S/W
	Dispersion of asphaltenes in crude oils	S/O
	Migrating fines during secondary and enhance oil recovery	S/W
	Producing (well head) solids in conventional oil recovery	S/W, S/O
	Oils-sands tailing ponds	S/W
	Oil field surface facility sludges	S/W, S/O
Desirable	Foam drilling fluid	G/W
	Foam fracturing and stimulation fluids	G/W
	Foam acidizing fluid	G/W
	Producing (well-bore) foams cold, heavy oil-recovery	G/O
	Oil-floatation process froths	G/O
	Fire fighting foam	G/W
	Heavy oil pipeline emulsions	O/W
	Well-stimulation emulsions	W/O, O/W
	Oil and oil-sand flotation process emulsions	O/W
	Emulsion drilling fluid - oil emulsion mud	O/W
	Emulsion drilling fluid - oil based mud	W/O
	Asphalt emulsion	O/W
	Enhanced oil recover *in situ* emulsion	O/W
	Emulsion fuel emulsion (70% heavy oil)	O/W
	Transportation fuel emulsion (70% heavy oil)	O/W
	Sludge from acid stimulation treatments	W/O, O/W
	Blocking and diverting foams	G/W
	Gas mobility control foams	G/W
	Drilling fluid (mud) suspensions	S/W
	Well stimulation and hydraulic fracturing suspensions	S/W
	Well cementing slurries	S/W
	Oil-sand slurries in bitumen recovery	S/W
	Producing (well-head) solids primary heavy oil recovery	S/W

* dispersion abbreviations include water(W), oil(O), gas(G) and solids(S)

1.7 Objectives

At the end of this study, it is necessary

- To study crude oil emulsions stability using different surfactants in different concentration, different volume ratio of water-oil of crude oil emulsion and different type of crude oil.
- To examine the performance of microwave application in demulsification of water-in-crude oil emulsions in comparison to the conventional methods.

1.8 Scope

To achieve the first objective which is to stabilize the crude oil emulsion, it is necessary to add 4 surfactants in different concentration into the crude oil in order to

- Test the effectiveness of different surfactants in different concentration of surfactant in stabilizing emulsions.
- Test the effectiveness of different volume ratio of water-oil crude oil emulsion in stabilizing emulsions.
- Compare the effects of different emulsifier when they are added to the crude oil (either the effect of adding these types of emulsifier can cause the emulsion is quickly formed or the emulsion is slowly formed)

To achieve the separation of crude oil emulsion via microwave heating technology, this study must be able to

- Identify whether the temperature distribution in the microwave heating technology is same or not at the top, bottom and middles of the graduater beaker (put thermocouple at these place)
- Identify the volume of water in separation process after heat using microwave technology at certain time (5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60 minutes) for both heavy crude oil at two different power supply (720 watt and 180 watt) by using the same initial volume (200 ml).

- Determine the amount of water separation in percent or it is called as separation efficiency, e (e = volume of water layer over original amount of water times 100%) for both heavy crude oil (Dubai and Kuwait crude oil)
- Determine and compare the time needed to complete the separation process (the volume of the crude oil emulsion left in the gradually beaker is constant at that time) of two different types of crude oil (Dubai and Kuwait crude oil) by using the same initial volume (200 ml).
- Compare the effect of separation process of crude oil emulsion via microwave heating technology and stability process in terms of :

- The time taken to complete the separation of crude oil emulsion.
- The volume of crude oil emulsion left in the gradually beaker for microwave heating technology and stability process.

CHAPTER 2

LITERATURE REVIEW

2.1 Invention of How to Separate Water-in-Oil Emulsion

In the refining industry every attempt is made to extract the maximum usable petrochemical product from the crude oil retrieved from deep within the earth or under seas. It is very seldom case that to have a pure sweet product emerge. More often than not, the crude oil emerges partly as an emulsified mixtures contains of oils, waxes, tars, salt and mineral laden water, fine sands and mineral particulates. Upon storage at the well and refinery sites, some natural settling and layer by layer will form, but emulsion of oil and water is very difficult to separate. Among the many chemical and physical separation techniques, those that act to separate oil molecules from water molecules at their boundary interface with economy serve the best oil recovery industry.

Physical separation techniques employ conductive heating to reduce surface tension at the oil and water boundary interface and centrifuging to separate the less dense oil from water. In the situations in which the oil contains a large number of polar molecules with a hydrophilic (water loving) end and a hydrophobic (water hating) end, reduction of surface tension by direct heating alone will not sufficient. Under that conditions in which complex organic compounds increase the density of the oil fraction to nearly that of water, the centrifuge depends on the difference in component densities, will fail to separate the components completely.

Chemical additives used as emulsion breakers often present an economic cost and additional contaminated water disposal problem. In most situations a combination of physical and chemical process are required to separate oil and water in the emulsions.

Laboratory and field tests have proven that the application of radio frequency (RF) microwave energy to oil-water emulsions will result in separation of water and oil of this emulsion. As the RF energy agitates the water molecule while a highly polar molecule spins and twists rapidly in the oscillating radio frequency field, the oil-water interface bond is broken. The hydrophilic polar ends of the oil binding molecules also are vibrated most by the radio frequency field. This shearing effect help in the coalescence (combination) of oil droplets separated from the water droplets and finally breaking of the emulsion is occurred. The vibration at the polar interface creates localized heating to further help the separation of the constituents.

2.2 Preparation of emulsions

There are many methods to prepare the emulsions. In classical methods of emulsion preparation, the emulsifier is dissolved into the most soluble phase and after that the second phase is added. Then, the shear is applied to the mixture using vigorous agitation or high speed mixing. For O/W emulsions the agitation must be turbulent and is crucial to producing sufficiently small droplets (Breuer. M.M, 1985).

2.3 Types of Surfactants and the Using of Them in Our Living