

PERPUSTAKAAN UMP



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OIL-IN-WATER EMULSI

... FOR VISCOS CRUDE OIL FLOW

IN PIPELINE

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Thesis submitted in fulfillment of the requirements
for the award of the degree of
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LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
API	American Petroleum Institute
CCD	Center Composite Design
EIA	U.S. Department of Energy Information Administration
FFD	Fractional Factorial Design
HLB	Hydrophile-Lipophile Balance
IFT	Interfacial Tension
pred. R ²	Predicted Coefficient of Determination
Adj. R ²	Adjusted Coefficient of Determination
vol	volume
o/w	Oil-in-water
w/o	Water-in-oil
RSM	Response Surface Methodology
hp	Horse Power
°C	Degree Celsius
mL	Milliliter
mPa.s	Milipascal.second
mL/min	Milliliter per minute
kg/cm ²	Kilogram per centimeter square
µm	Micro-meter
R ²	Coefficient of Determination
wt	Weight
%	Percent
µ	Viscosity
τ	Shear Stress
α	Alpha
φ	Volume Fraction
K	Consistency index
Θ	Degree angle

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ABSTRACT

With the increasing energy prices and the drive to reduce CO₂ emission, universities and industries are challenged to find new technologies in order to reduce energy consumption, to meet legal requirements on emissions, and for cost reduction and increased quality. Traditional methods of transporting heavy crude oils in pipelines are disadvantages from both economic and environmentally perspectives. In this study, the potentials of o/w emulsion technique for transporting viscous crude oils in pipeline as alternative and cost effective method was investigated. The study began with characterisation studies of both types of crude oil and emulsion to provide understanding of fundamental issues such as conventional transportation methods, partial upgrading, pipeline heating, and dilution with lighter crude oils. The aim is to investigate the various factors affecting the preparation of stable crude o/w emulsion, the influence of the emulsion as well as to obtain optimised operating conditions, upon which further developments on pipeline transportation of viscous crudes as concentrated o/w emulsion process could be developed. Two types of crude oil samples were used in this study; heavy oil obtained from Petronas Refinery, Melaka and blend oil was formulated by 60-40% (heavy oil-light oil) which is light oil obtained from Petronas Kerteh. The Fractional Factor Design (FFD) in Design Expert 7.1.6 followed by Center Composite Desing (CCD) was used for optimization study. Results that were obtained have shown that, both crude oils used were stabilised within 1% surfactant used. The analysis of variance (ANOVA) shown the stability was significant with R² value at 0.9753 for heavy o/w emulsion and 0.9572 for the blend o/w emulsion. Results have indicated heavy o/w emulsion shown transitional flow while blend o/w emulsion shown turbulent flow. The addition of 40% of light oil to heavy oil has reduced the blend oil viscosity from 478.1 mPa.s to 113.40 mPa.s. The rheological study was successfully investigated and emulsion showed Newtonian behaviour for both types of crude oil. Meanwhile the predicted model of o/w emulsion (using Power Law) showed at 30-60% by volume shown non-Newtonian shear thinning flow behaviour. The results obtained was exposed the capability of o/w emulsion technique as another promising pipeline technique in the transport of viscous crude as concentrated o/w emulsions. Further works are nevertheless required to provide deeper understanding of the mechanism involved to facilitate development of an optimum system applicable to industry.

ABSTRAK

Dengan kos penjanaan tenaga yang semakin meningkat dan usaha mengurangkan pelepasan karbon dioksida, universiti dan industri diminta untuk mencari teknologi baru untuk mengurangkan penggunaan tenaga, untuk memenuhi keperluan undang-undang ke atas pengeluaran, dan untuk pengurangan kos dan peningkatan kualiti. Kaedah tradisional untuk mengangkut minyak mentah berat menggunakan saluran paip adalah kelemahan dari kedua-dua perspektif ekonomi dan alam sekitar. Dalam kajian ini, potensi teknik minyak dalam air emulsi untuk mengangkut minyak mentah likat dalam perancangan sebagai kaedah alternatif dan kos efektif telah dikaji. Kajian ini bermula dengan beberapa kajian pencirian dari kedua-dua jenis minyak mentah dan emulsi untuk memberi pemahaman isu-isu asas seperti kaedah pengangkutan konvensional, peningkatan separa, pemanasan saluran paip, dan pencairan dengan minyak mentah ringan. Tujuannya adalah untuk menyiasat pelbagai faktor yang mempengaruhi semasa penyediaan emulsi minyak mentah berat dalam air yang lebih stabil, pengaruh faktor-faktor ini terhadap emulsi dan juga untuk mendapatkan keadaan operasi yang optimum, di mana perkembangan terbaru mengenai isu pengangkutan saluran paip minyak mentah likat sebagai proses emulsi minyak dalam air boleh dimajukan. Dua jenis sampel minyak mentah telah digunakan dalam kajian ini; minyak berat yang diperolehi daripada Petronas Penapisan, Melaka dan campuran minyak telah pun diformula dengan 60-40 % (minyak mentah berat–minyak mentah ringan) dimana minyak ringan diperolehi daripada Petronas Kerteh. Rekabentuk pecahan pemfaktoran dalam pakar reka bentuk versi 7.1.6 diikuti oleh rekabentuk komposisi berpusat telah digunakan untuk bahagian pengoptimum. Keputusannya telah menunjukkan bahawa bahawa kedua-dua jenis minyak mentah yang digunakan adalah stabil dalam keadaan 1% surfactant yang digunakan. ANOVA telah menunjukkan bahawa kestabilan adalah penting dengan R^2 bernilai pada 0.9753 untuk emulsi minyak berat dalam air dan 0.9572 untuk gabungan emulsi minyak dalam air. Keputusan juga telah menunjukkan emulsi minyak berat dalam air memberikan aliran peralihan manakala gabungan emulsi minyak dalam air memberikan aliran bergelora. Penambahan 40 % minyak ringan kepada minyak berat telah mengurangkan kelikatan minyak campuran dari 478.1 mPa.s kepada 113.40 mPa.s. Kajian reologi telah berjaya disiasat dan emulsi menunjukkan tingkah laku Newtonian untuk kedua-dua minyak mentah. Manakala ramalan model emulsi (menggunakan Kuasa Hukum) adalah menunjukkan diantara 30-60% mengikut isipadu dan menunjukkan tingkah laku rincih bukan Newtonian penipisan. Keputusan yang diperolehi dalam kajian ini telah menunjukkan keupayaan teknik emulsi minyak berat dalam air sebagai satu lagi teknik saluran paip yang menjanjikan pengangkutan minyak mentah yang likat sebagai kepekatan emulsi minyak berat dalam air. Namun, kerja-kerja selanjutnya diperlukan untuk memberi pemahaman yang lebih mendalam tentang mekanisma yang terlibat bagi memudahkan pembangunan sistem optimum yang sesuai dengan industri.