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STUDY ON RHEOLOGICAL BEHAVIOUR OF HEAVY CRUDE OIL EMULSION FOR PIPELINE TRANSPORTATION

Engineering

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ABSTRACT

Emulsification Of heavy oils is usually the most common practice for transporting heavy oils through pipeline systems. In this project, we determined the various parameters of a sample of crude oil by using the apparatus Viscometer and investigated its rheological behaviour.

KEYWORDS

emulsification, heavy crude oil, viscometer, rheology

1.1 INTRODUCTION

Emulsions are naturally formed mixers of oil and water from oil wells. There are two types of emulsions: oil-in-water, (O/W), and water in-oil, (W/O). To separate oil and water, emulsion must be treated. The typical methods for transporting a heavy viscous crude oil include blending it with a diluent such as light crude, or heating the crude oil and then transporting it through a well-insulated pipeline. A drastic reduction in the apparent viscosity of the oil-in-water emulsion makes this Emulsion pipeline technology feasible and profitable method for transporting viscous crude oils. After oil meet the specifications of the pipeline oil component is measured and transported to its destination. The selection of the type and concentration of the surfactant or chemical depends on the physical and chemical properties of crude oil and water, rheology of the emulsion.

Economic advantages of Emulsion pipeline are -

i) The emulsions formulated for pipeline transportation are generally much less viscous than virgin crude oil.
ii) The pressure capacity of the pumping equipment can be reduced, or a pipeline of smaller diameter can be used. This reduces the capital investment.
iii) Compared to the heated oil pipeline, insulation is not desirable which eliminates the cost of heating the oil.

1.2 MATERIAL USED

- APPARATUS: M3600_Automatic_Viscometer.
- Magnetic Stirrer for mixing the crude oil and water.
- Thermometer was used to measure the temperature of crude oil to find pour point.
- CHEMICALS USED: Sodium Carbonate. Acetone , Diesel for cleaning purpose.

1.3 Experiment and outcomes

There are two experiments done

1. Finding of various parameters without creating emulsions and mixing of surfactant at different temperatures are listed below.
2. Finding of various parameters by creating emulsions and mixing of surfactant at a temperature (30◦C) is listed below.

Table1.1: Rheology Of Oil Sample At 40◦c

Step	Step Time	Total Time	Temp	Shear Rate	Speed	Shear Stress	Viscosity	Gel	Rb Factor	Fann® 35 F1	Fann® 35 F1
	(S)	(S)	(°F)	(1/S)	(Rpm)	(lb/100ft2)	(cP)	(lb/100ft2)		Reading (deg)	Gel Dial Read (deg)
1	591	591	97	17.023	10	14.616	411.208	20.254	1	13.699	19.4
2	591	1182	100	102.138	60	48.859	229.102	61.805	1	45.793	59.2
3	591	1773	101	170.23	100	68.695	193.268	156.809	1	64.384	150.2
4	591	2364	100	510.69	300	171.634	160.959	190.426	1	160.861	182.4
5	591	2955	102	1021.38	600	290.023	135.992	292.738	1	271.82	280.4

Table1.2: Rheology Of Oil Sample Oil At 30◦c

Step	Step Time	Total Time	Temp	Shear Rate	Speed	Shear Stress	Viscosity	Gel	Rb Factor	Fann® 35 F1	Fann® 35 F1
	(S)	(S)	(°F)	(1/S)	(Rpm)	(lb/100ft2)	(cP)	(lb/100ft2)		Reading (deg)	Gel Dial Read (deg)
1	591	591	89	17.023	10	33.826	951.654	86.861	1	31.703	83.2
2	591	1182	87	102.138	60	103.565	485.617	149.918	1	97.065	143.6
3	591	1773	88	170.23	100	155.556	437.643	161.611	1	145.793	154.8
4	591	2364	87	510.69	300	295.452	277.076	295.661	1	276.908	283.2
5	591	2955	88	1021.38	600	295.661	138.636	295.661	1	277.104	283.2

Table 1.3: Rheology Of Oil Sample At 25◦c

Step#	Step Time	Total Time	Temp	Shear Rate	Speed	Shear Stress	Viscosity	Gel	Rb Factor	Fann® 35 F1	Fann® 35 F1
	(S)	(S)	(°F)	(1/S)	(Rpm)	(lb/100ft2)	(cP)	(lb/100ft2)		Reading (deg)	Gel Dial Read (deg)
1	591	591	83	17.023	10	25.682	722.552	36.749	1	24.07	35.2
2	591	1182	81	102.138	60	140.731	659.892	144.49	1	131.898	138.4
3	591	1773	81	170.23	100	222.79	626.799	222.998	1	208.806	213.6
4	591	2364	81	510.69	300	294.826	276.489	294.826	1	276.321	282.4
5	591	2955	82	1021.38	600	294.826	138.244	294.826	1	276.321	282.4

Table.3.1: After Emulsion, The Rheology Of The Oil Sample At 30°c:

Step #	Step Time	Total Time	Temp	Shear Rate	Speed	Shear Stress	Viscosity	Gel	Rb Factor	Fann® 35 F1	Fann® 35 F1
	(S)	(S)	(°F)	(1/S)	(Rpm)	(lb/100ft2)	(cP)	(lb/100ft2)		Reading (deg)	Gel Dial Read (deg)
1	591	591	91	17.023	10	39.463	1110.262	48.233	1	36.986	46.2
2	591	1182	90	102.138	60	146.578	687.305	147.622	1	137.378	141.4
3	591	1773	90	170.23	100	237.614	668.507	238.867	1	222.701	228.8
4	591	2364	90	510.69	300	295.661	277.272	295.661	1	277.104	283.2
5	591	2955	91	1021.38	600	295.661	138.636	295.661	1	277.104	283.2

During emulsification of crude oil, three kinds of oil/water mixture were observed:

(I) An oil-in-water emulsion.
(2) A mixture visually less viscous than the heavy oil while more viscous than the oil-in-water emulsion. This mixture neither adhered to the glass vessel like oil nor dispersed quickly when poured into water like an oil-in-water emulsion. As a matter of fact, it was a complex mixture with a continuous water film around oil bubbles.
(3) A highly viscous water-in-oil emulsion.

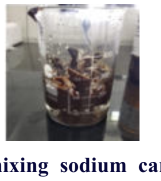

Figure 1.1: (without mixing sodium carbonate) no emulsion formed

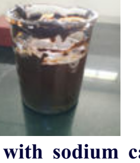

Figure 1.2: After mixing with sodium carbonate at 16000ppm emulsion is formed

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CONCLUSION

From the experiment, it was concluded that the oil sample under study is highly viscous and waxy in nature. Different emulsions were prepared by oil content, Na_2CO_3 .The development of oil water emulsion caused a considerable decrease in viscosity even at higher oil content, enabling emulsions to be easily transported through the pipelines.

- The pour point of the heavy crude oil after emulsification was measured.

Based on the above result the following understanding have been developed-

I) Shear stress v/s shear rate : as shear stress increases shear rate also increases but at 500 and 1000 shear rate is constant.

II) Shear stress v/s speed: as shear stress increases speed increases, at 300 and 600 rpm speed remains constant for some time.

III) Shear stress v/s temperature: As shear stress increases temperature remains constant but at 97˚F and 99˚F shear stress increases and 150lb temperature decreases also at 101˚F shear stress remains constant.

IV) Shear stress v/s Time: At 500s shear stress remains constant at 10lb and at 1500s, 2500s, 3000s shear stress is 70lb, 180lb, 290lb respectively.

V) Viscosity v/s speed: at 0rpm, viscosity is at 400cp and decreases at 50rpm and a slight increase at 50rpm and decreases till 100rpm and keeps decreasing till 300rpm and viscosity decreases again from 300rpm and decreases till 600rpm.

VI) Viscosity v/s Shear rate: viscosity is high at 0% of shear rate and decreases slightly as shear rate % increases.

VII) Viscosity v/s Temperature: viscosity fluctuates as temperature increases.

VIII) Viscosity v/s time: viscosity is high at starting and decreases; at 1500s viscosity is high then again decreases.

IX) Temperature v/s time: temperature and time fluctuates as time and temperature increases.

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