Journal of Farayandno – Vol. 18 – No. 81 (2023): pp. 18-30

National Iranian Oil Refining and Distribution Company (NIORDC)

Journal of Farayandno

Research Paper

Experimental Study on Emulsion Stability: Application of Static Mixers for Dispersion of Water in Crude Oil

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Received: 15 Feb 2023 **Accepted:** 4 Apr 2023

1. ABSTRACT

Mixing or dispersing operation is an important section in chemical processes. Because of several advantages like: low capital cost, low operating cost, low maintenance cost and low required space; static mixers are applied in many industries. In crude oil desalting process, static mixers for dispersion of the dilution water in crude oil is proposed by this study; which conventionally mixing valve is used. Type of the static mixer in the applied operating conditions effects on the properties and the stability of the resulted emulsion. In a pilot scale setup, three types of SMV, HMS and LPD static mixers have been investigated; for different conditions of water fraction (2-15 v %) and crude oil flow rate (86-144 l/h). The experimental results show that SMV outcomes the most stable emulsion which is not appropriate for desalting process. Against, LPD is the optimal choice for this application, regarding to the emulsion properties.

Keywords: Static Mixer; Emulsion Stability; Desalting Process; Crude Oil.

2. INTRODUCTION

Mixing operation is an important section in chemical processes. Static mixers are replacing instead of mechanical mixers which require an electrical motor and a massive vessel for feed and product holding. Nowadays, different types of static mixers are applied in many chemical plants [1]. Chemical reactions, mixing of gases and liquids, homogenizing of immiscible liquids, gas-liquid phase contact for mass transfer improvement, heat transfer enhancement for high viscose fluids, and solid blending are several examples of these processes [2]. In continuous processes, static mixers are appropriate alternative for conventional mechanical mixers; because of superior performance and lower costs [3].

Commercial static mixers include a wide range of simple and complicated geometries with several adjustable parameters that could be optimized for special applications. Number of series elements install in static mixer, length to diameter dimensional ratio of each element are important parameters. Commercialized design of static mixers usually has tolerable standards that make them appropriate for a wide range of applications [4].

In crude oil desalting process, a fresh water is injected to the feed to dilute its salinity, which is called as dilution water. In conventional desalting process, a manual or an automotive control valve is used at inlet line of desalter for appropriate dispersion of water in oil, which is called as mixing valve. However, the half-open state of this valve and the resulted pressure drop helps to improve the mixing operation, but this method has some side effects. Important operational subject is that improving the mixing quality through increasing the pressure drop, will produce a severe w/o emulsion which is difficult for separation in next step in electrostatic desalter. This may make the operator to draw off a massive volume of the stable emulsion of crude oil, as it is called the rag layer, from the desalter to the off-spec tank [5].

Replacement of the static mixers instead of the conventional mixing valves in crude oil desalting process could prevent the above-mentioned operational problems. Since emulsion kinetic stability is vital from the aspect of the downstream separation process, selection of the appropriate type of static mixer and the precise operating condition is so imperative. As regards, none of the previous researches has been studied on this subject, the object of this study is to investigate three

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Please Cite This Article Using:
Mohammadi, M., Pirzadeh, A., "Experimental Study on Emulsion Stability: Application of Static Mixers for Dispersion of Water in Crude Oil", Journal of Farayandno, Vol. 18, No. 81, pp. 18-30, In Persian, (2023).

types of commercial static mixers, consists of SMV, HMS and LPD. Furthermore, the effect of several operating conditions including crude oil flow rate (86-144 l/h) and water fraction (2-15 v %) is studied in a pilot scale set-up.

3. MATERIALS AND METHODS

3.1. Material

The type of the crude oil that has been used in the experiments of this study is categorized as the light crude oils with an API degree of 29.7. It has been selected from a main petroleum field of National Iranian South Oil Company, which is called Maroon-6.

3.1. Pilot Set-up

The experiments of this study are conducted in a pilot scale set-up. Crude oil is directed from its storage vessel via an adjustable flow dosing pump with a pressure of 7 Barg. It is entered to the tube side of a heat exchanger and heated up to 70 ℃ using the hot oil that is circulated in the shell side of the heat exchanger. On the other hand, water is injected from its storage vessel via another adjustable flow dosing pump. The resulted stream is entered to the static mixer and a sample of the produced emulsion is taken from a sampling valve in the outlet line. The static mixer is installed as an internal piece in a 10 cm length flanged ½ inch pipe segment that could be replaced by different types of SMV, HMS and LPD. The number of series elements in the constructed static mixers is six. A dimensional drawing of the constructed LPD type static mixer is presented in Figure1.

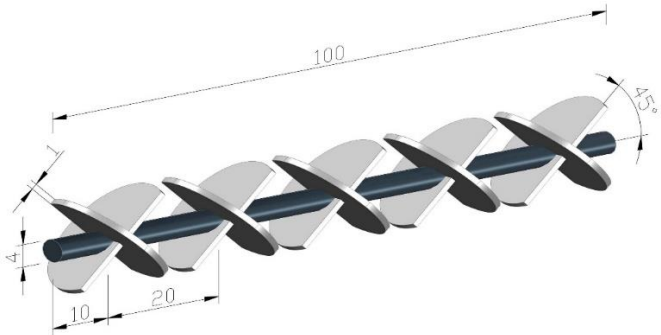

Figure 1. Dimensional drawing of the constructed LPD type static mixer

3.1. Procedure of the Experiments

The required volume sample of the produced emulsion is taken during each experiment, after ensuring that the operating conditions become stable. According to standard procedure of "Bottle Test", some portion of the sample is filled in glass test-tube and placed in the rack vertically. Then, the height of the separated water at tube bottom is tracked and recorded in the following days. This factor is used as the emulsion un-stability indicator.

4. RESULTS AND DISCUSSION

4.1. Crude Oil Flow Rate

As the turbulency of the flow inside the static mixer depends on the crude oil flow rate, this parameter influences on mixing quality and emulsion stability. Three different flow rates of crude oil, consist of 86, 112 and 144 l/h are tested for SMV type static mixer. The results are presented in Figure 2.

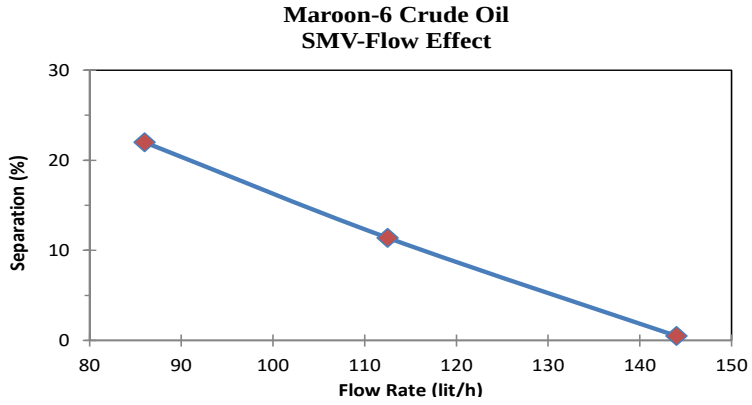

Figure 2. The effect of crude oil flow rate for SMV type static mixer

4.2. Water Fraction

Water cut that injects to the crude oil feed is another important factor in mixing and separation of the desalting process. Three different water cuts of 2, 10 and 15 v% are tested for SMV type static mixer. The results are presented in Figure 3.

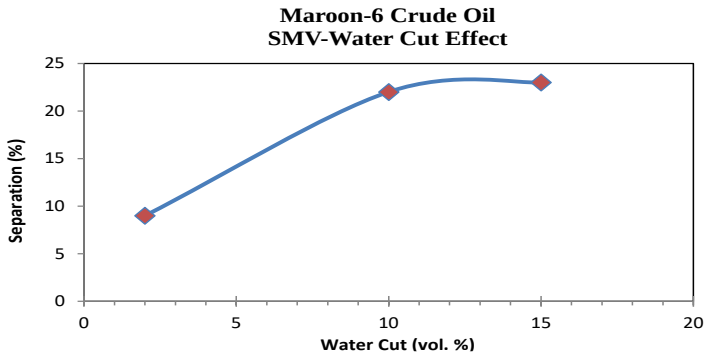

Figure 3. The effect of water cut for SMV type static mixer

4.3. Type of Static Mixer

Type and geometry of static mixer may have the most important influence on w/o emulsion stability control in the desalting process. Three different types of static mixers consist of SMV, HMS and LPD are experienced in this study. The results are presented in Figure 4.

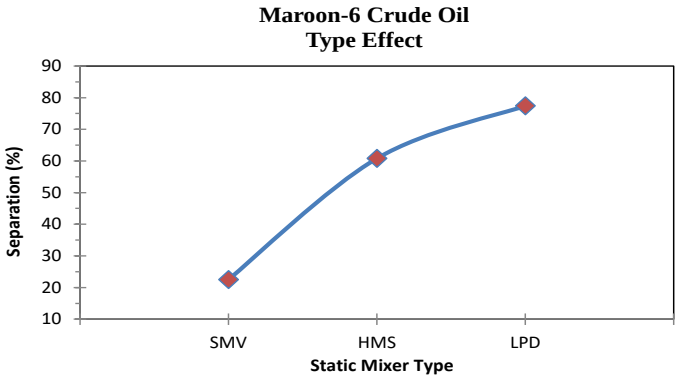

Figure 4. The effect of static mixer type

5. CONCLUSION

Application of the static mixers instead of the conventional mixing valves in crude oil desalting process has been studied experimentally in a pilot scale set-up. The results shows that type of static mixer and operating conditions effect on the properties and the stability of the resulted emulsion. Three types of SMV, HMS and LPD static mixers have been investigated; for different conditions of water fraction (2, 10 and 15 v %) and crude oil flow rates (86, 112 and 144 l/h). The experimental results show that emulsion stability strongly increases with crude oil flow rate. Furthermore, these results demonstrate that emulsion un-stability increases with water cut to some extent. According to the experimental results, SMV type of static mixer produces the most stable emulsion which is not appropriate for desalting process. On the other hand, LPD type of static mixer presents the most controlled unstable emulsion in the industrial operating conditions. So this type of static mixer is the optimal choice for the proposed application.

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