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Experimental study of a vane-type pipe separator for oil–water separation

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A B S T R A C T

An experimental study of a new vane-type pipe separator (VTPS) was conducted for the possible application in the well-bore for oil–water separation and reinjection. Results by using particle image velocimetry (PIV) reveal a better flow field distribution for oil–water separation, which is formed in VTPS than that in hydrocyclone. The effects of split ratio, the oil content, guide vanes' installation and number of guide vanes on oil–water separation performance have been investigated experimentally. Compared to a traditional single hydrocyclone, VTPS shows a good separation performance as the water content at the inlet of VTPS reaches 79.9%, the oil content at the water-rich outlet is about 400 ppm while the split is near 0.70. These results are helpful to provide a possibly new design for downhole oil–water separation.

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Keywords: Vane-type pipe separator (VTPS); Oil–water separation; Well-bore

1. Introduction

When the produced water in mature oil fields continues to increase, it is of great significance to separate the ever-increasing volumes of water from oil downhole and inject it into a suitable formation. The adoption of these measures could not only extend the economic exploitation of oil fields, but also maintain the reservoir pressure (Chapuis et al., 1999).

The mentioned process is attractive but needs further investigation about the structure optimization of separator for the limited space in the well-bore. Traditional downhole separator is hydrocyclone which is a kind of tangential inlet structure combining with a long small cone tail and an upflow tube (Ogunsina and Wiggins, 2005). According to the number of tangential inlets, traditional hydrocyclone could be classified into two types: "multi-inlet" (Jiang et al., 2002) and "single-entry". While due to the well-bore's small diameter, hydrocyclone with a single-entry is chosen in most cases (Bowers et al., 1999). According to information on the downhole hydrocyclone installations in North America, it works in wells' diameter larger than 135 mm with water content of greater than 88.4% (Veil et al., 1999). These downhole applications present the limitation of hydrocyclone and there is not much experience with hydrocylone used on streams with high oil content as well. These restrictions are mainly due to the shortcomings of hydrocyclone's entry. The "single-entry" caused by the limited space is always small. Small inlets are more likely to cause oil droplets break-up (Listewnik, 1984) and thus exacerbate the difficulties of oil–water separation process (Meyer and Bohnet, 2003). Besides, the "single-entry" makes the structure of hydrocyclone asymmetric and so does the flow field which would cause the oil core start to weave, oscillate (Schutz et al., 2009) and re-mixing of oil droplets between the oil core and water to happen (Thew, 1986). If the oil phase is re-emulsified, it would be quite difficult to separate oil droplets from water and even lead to the presence of some oil droplets in water injected to a disposal zone. The potential problems of this lasting oily-water stream reinjection will add to the difficulties in subsurface injection of the produced liquid (van den Broek et al., 2001) and reduce the field oil production. To solve the above problems, Sooran et al. tried to improve the separation efficiency through the redesign of inlet structures. Michdet and Sangesland (1996) studied hydrocyclones with a small tube inside the underflow tube so as to recollect the oil phase in the underflow. However the quantity of water-removal would be lowered considering the fact that the underflow tube of hydrocyclone is already very small. Klasson et al. (2005) and Zhao et al. (2010) presented a new method

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