International Journal Of Core Engineering & Management
Volume-4, Issue-12, March-2018, ISSN No: 2348-9510

PERFORMANCES OF UP-FLOW AND DOWN-FLOW REACTORS FOR HYDRO-TREATING ATMOSPHERIC RESIDUE OVER A HYDRO-DEMETALLIZATION CATALYST

Adel Al-Mutairi ,Xiaoliang Ma
Petroleum Research Center. Kuwait Institute for Scientific Research (KISR)
P. O. Box 24885, 13109-Safat-Kuwait
amutairi@kisr.edu.kw

Abstract

The down-flow and up-flow fixed-bed reactors (DFR and UFR) have been used widely in industries. In refineries, both DFR and UFR at high temperature and high pressure are used in the hydrotreating of atmospheric residue to produce the environmentally friendly clean fuel oil. A fundamental understanding and comparison of the performances of these two reactors is necessary. In this study, two reactor systems, one with DFR and the other with UFR, were used for hydrotreating of atmospheric residue (AR) from heavy crude over a hydrodemetallization (HDM) catalyst to compare their performances. The results at the same operating conditions (temperature, pressure, LHSV and H_2/liquid ratio) showed that using UFR displayed the better performance for hydrodesulfurization and hydride-Micro-carbon-residue of the AR than using UFR, while the similar performance for HDM and hydrodeasphaltene. More studies have to pay on the effect of the DFR and UFR on the life time of the HDM catalyst.

I. INTRODUCTION

Atmospheric residues (AR), especially those from heavy crudes, contain a large amount of asphaltenes. Asphaltenes are the species that contain the most hetero atoms, including S, N, Ni, V and others (Klein et al., 2006). An asphaltene molecule may be 4 to 5 nm in diameter, which is difficult to process in refinery (Rana et al., 2007; Riazi et al., 2013). Metals in the asphaltene aggregates are believed to be associated with the asphaltene sheets, making the asphaltene molecule heavier than its original structure (Ancheyta and Rana, 2008). A problem in hydrotreating of AR in the conventional fixed-bed down-flow reactor (DFR) is that the asphaltenes, as a precursor, deposit on the hydrodemetallization (HDM) catalyst surface to reduce the catalyst activity, further to block the catalyst bed. Therefore, an up-flow reactor (UFR) was proposed to relieve this problem. It is necessary to understand and clarify whether the up-flow reactor over the HDM catalyst affects the hydrotreating performance. Presently, the refineries are interested in the sulfur removal from the heavy crudes or their residues to

International Journal Of Core Engineering & Management
Volume-4, Issue-12, March-2018, ISSN No: 2348-9510

produce low sulfur fuel oil (LSFO). In the present study, the hydrotreating of atmospheric residue (AR) from the heavy crude was conducted respectively in the DFR and UFR systems over the similar HDM catalysts at the same reaction conditions to compare their performance.

II. EXPERIMENTAL

The composition and properties of the feedstocks (AR) from the same heavy crude are shown in Table 1. The hydrotreating of the AR over the similar HDM catalysts in the pilot DFR and UFR, respectively, with a catalyst volume of 20 ml was conducted. The catalysts were presulfided under a standard condition. The reactions in both the reactors were at 370 □C, 13.5 MPa of H2 pressure, 800 Nm3/kL and 0.3 h-1 of LHSV for comparison.

Table 1. Composition and Properties of the Feedstocks and Hydrotreated Products

Properties	**DFR**		**UFR**	
	Feedstock	**Product**	**Feedstock**	**Product**
Density, g/cm³	1.025	1.001	1.029	0.991
Sulfur, wt %	5.45	4.60	5.14	3.35
MCR, wt %	16.1	13.4	17	13.1
Asp, wt%	7.9	6.2	10.0	8.0
Ni, ppmw	43	30	70	50
V, ppmw	155	94	155	94

III. RESULTS AND DISCUSSION

Composition and properties of the products hydrotreated in the pilot DFR and UFR over the similar catalysts at the same reaction conditions are shown in Table 1. Since the composition and properties of the feedstocks from different batches were slightly different, the conversion as an index was used in this study for comparison. The conversions for hydrodesulfurization (HDS), hydride-Micro-carbon-residue (HDMCR), hydrodeasphaltene (HDAsp), hydridenickel (HDNi) and hydridevanadium (HDV) were calculated for the DFR and UFR, respectively, and the results are shown in Fig 1. The hydrotreating in the UFR gave the higher conversion for HDS and HDMCR than the DFR, while there were the similar conversions of the DFR and UFR for HDAsp, HDNi and HDV.

International Journal Of Core Engineering & Management
Volume-4, Issue-12, March-2018, ISSN No: 2348-9510

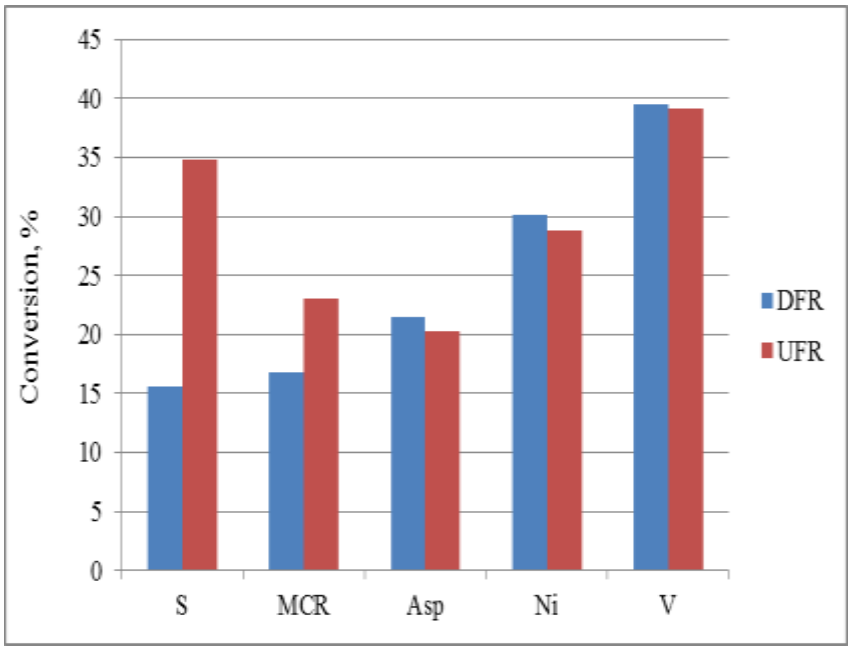

Figure 1. Conversion of HDS, HDMCR, HDAsp, HDNi and HDV for DFR and UFR

IV. CONCLUSION

The hydrotreating of atmospheric residue (AR) from the same heavy crude was conducted respectively in the DFR and UFR systems over the similar HDM catalysts at the same reaction conditions. The results indicated that the UFR has better performances for conversion of both sulfur and MCR than the DFR, while the DFR and UFR showed the similar performance for conversion of asphaltenes, Ni and V. More studies have to pay on the effect of the DFR and UFR on the life time of the HDM catalyst.

ACKNOWLEDGMENT

The authors acknowledge Japan Cooperation Center, Petroleum (JCCP), Kuwait Oil Company (KOC) and Kuwait Institute for Scientific Research (KISR) for financing this research. The acknowledgement is also extended to Kuwait National Petroleum Company (KNPC) for their technical support.

REFERENCES

[1] Ancheyta, J., Rana, M.S. 2008. Future Technology in Heavy Oil Processing. A chapter in Encyclopedia of Life Support Systems (EOLSS).

[2] Klein, G. C., Kim, S., Rodgers, R. P., Marshall, A. G. 2006. Mass Spectral Analysis of Asphaltenes. I. Compositional Differences between Pressure-Drop and Solvent-Drop Asphaltenes Determined by Electrospray Ionization Fourier Transform Ion Cyclotron Resonance Mass Spectrometry. Energy & Fuels, 20, 1965-1972.

[3] Rana, M. S.; V. Samano; J. Ancheyta; and J.A.I. Diaz. 2007. A review of recent advances on process technologies for upgrading of heavy oils and residua. Fuel 86: 1216-1231.

[4] Riazi, M.; M. S. Rana and J. L. Pena Diez. 2013. Chapter-3, Worldwide statistical data on proved reserves, production and refining capacities of crude oil and natural gas, In American Society for Testing and Materials (ASTM) manual series MNL 58. Edited by M. R, Riazi, et al. West Conshohocken, PA ASTM International.