Study on Compositional Analysis of Selected Cuts of Kuwait Heavy Crude Oils and Its Impact on Hydroprocessing

Over a period of three years, from fiscal 2010 to 2012, JCCP and Kuwait Institute for Scientific Research (KISR) implemented the Study on Compositional Analysis of Selected Cuts of Kuwait Heavy Crude Oils and Its Impact on Hydroprocessing in Kuwait.

1. Background

Kuwait meets its domestic demand for oil products by mixing crude oil for export with heavy crude oil and processing them at three refineries in the country. The country also exports surplus oil products such as diesel fuel. Furthermore, to maintain a steady revenue from crude oil, it needs to process new heavy crude oils such as Lower Fars crude oil and Eocene crude oil within the country and maintain its export of relatively light Kuwait Export crude oil (KEC). Toward this end, Kuwait National Petroleum Company (KNPC) is promoting two projects simultaneously—a new refinery project and a clean fuel project at its existing refineries.

Under this situation, KNPC has strongly requested KISR to conduct a study on the development of desulfurization catalysts and the evaluation of catalyst performance for diesel fuel and heavy oils. Thus, KISR requested JCCP's technical cooperation, and commenced a study with the participation of Nippon Mining Research & Technology Co. Ltd. (now JX Nippon Research Institute, Ltd.) and Kyushu University.

Presentation of the results of the study to KNPC

Invited engineers

2. Overview

1) Implementation period: April 1, 2010 – March 31, 2013 (three years)
2) Overseas counterpart: KISR
3) Participating companies: JX Nippon Research Institute, Ltd., Kyushu University
4) Activities: This study was implemented with emphasis on the following three objectives.
   (1) To evaluate the reaction characteristics of the feedstock for diesel fuel produced from heavy and ultra-heavy crude oils, and heavy oil by compositional analysis before and after desulfurization reaction in a hydrodesulfurization unit.
   (2) To examine ideas concerning the direction of improvement for the development of new high-performance catalysts, with a focus on demetallization catalysts for the desulfurization of heavy oil feedstock. Also, to propose outstanding combinations of commercial catalysts and to select and provide a catalyst for use in a pilot test based on that knowledge.
   (3) To propose test conditions for the pilot test apparatus at KISR, and to examine and propose improvements for operations, the collection of samples and analysis items, as necessary.

First, four types of crude oil, including crude oil for

Test apparatus at Kyushu University

Test apparatus at KISR

export, heavy crude oil, Lower Fars crude oil and Eocene crude oil, were transported from Kuwait to Japan, to secure feedstock oils for the test to be conducted in Japan on the distillation of diesel fuel fractions (260 – 340°C fractions, 340 – 350°C fractions, 350 – 360°C fractions) and bottom oil (fractions above 360°C). Using these feedstock oils, a reaction test was performed by using an autoclave at Kyushu University, and a reactivity analysis was performed of desulfurization characteristics according to the different types of crude oil.

The desulfurization reactivity of diesel fuel fractions is largely influenced by the difference in type of crude oil, but it was found that the sulfur content of 260 – 340°C fractions could drop below 10 ppm regardless of crude oil type. It was also found that there are many impediments to reducing the sulfur content of two fractions of heavy cuts of Lower Fars crude oil and Eocene crude oil to below 10 ppm (340 – 350°C fractions and 350 – 360°C fractions).

With respect to bottom oil, a microanalysis and structural analysis was performed of vanadium and nickel, which influence desulfurization. The result showed that desulfurization is more difficult than demetallization.

The pilot tests conducted at KISR included an evaluation of the reaction characteristics of the bottom oil of four types of crude oils in fiscal 2011 and an evaluation and test of catalyst life conducted using the bottom oil of the heaviest Lower Fars crude oil in fiscal 2012. The results of these tests indicated practically the same trend as the results of tests conducted in Japan, and indicated the successful transfer of relevant technologies.

3. Presentation at the Kuwait-Japan Joint Symposium

In fiscal 2011, KISR presented the results of the above study at the 13th Kuwait-Japan Joint Symposium held at KISR on January 17 and 18, 2012 as an interim report meeting for the study. KISR and Kyushu University each gave a presentation, with KISR giving a general description of the study, and Kyushu University introducing the results of advanced structural analysis and an evaluation of reactions in the autoclave test unit.

The presentation by Kyushu University invited many questions and comments, and inspired deep interest in molecular structures, such as of carbons, sulfur and metals inside crude oil and in the comparison with the reaction results. Moreover, it elicited a request from KISR for research on the reactions of heavy fractions in atmospheric residue and the deterioration of catalyst after mid-operation of the desulfurization unit.

Kuwait-Japan Joint Symposium

4. Observations

In this study, which focused on four types of crude oil in Kuwait, the reaction conditions and desulfurization catalysts were sought for ultra-deep desulfurization of diesel fuel fractions, the molecular structure of desulfurization-resistant chemical species was revealed, and suggestions were offered for operational improvement of the hydrodesulfurization unit and other facilities. With respect to the bottom oil fractions of the four types of crude oil, as well, the characteristics of demetallization/desulfurization reactions were sought, a structural analysis and reaction analysis were performed on feedstock oil and product oil at the molecular level, and suggestions were offered for operational improvement in the refinery.

It is hoped that these results will contribute to KISR's new refinery project and clean fuel project at existing refineries, and to ultimately strengthening ties between Kuwait and Japan.

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