**Predictive Model of Delayed Coker Unit for Studying Variations in Feed.**

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**Highlights**

* Delayed Coker
* Process Simulation
* Scenario studies
* Feed flexibility

**1. Introduction**

Delayed Coking is a thermal process in which a residuum material from a vacuum distillation unit in a refinery is rapidly heated in a furnace and then thermally cracked in coke drums under appropriate conditions of temperature and pressure. Typical products from a Delayed Coker unit include Sour Off Gas, Sour LPG (C3s and C4s), full range of Stabilized Coker Naphtha, Light Coker Gas Oil (LCGO), Heavy Coker Gas Oil (HCGO), and Coke (Green Coke). In ADNOC Refining, the Delayed Coker Unit is designed for a feed blend of Vacuum Residue (VR) and Hydrotreated RFCC (Residue Fluidized Catalytic Cracker) Slurry. Depending on the availability of feed from its upstream units, and depending on dynamic market scenarios, the feed to a Delayed Coking unit might vary in terms of quality due to variation of blend ratios, as well as in feed rate. Hence, as reported in this present study, a predictive model was developed using a commercial simulation software to conduct scenario studies for various feeding scenarios (feed throughputs and blend ratios) to assess the expected impacts on the products yield and properties, prior to introducing these in real operations.

**2. Methods**

Delayed coking is a highly endothermic reaction with the furnace supplying the necessary heat of reaction. The exact mechanism of coking is quite complex and determination of the chemical reactions occurring would be quite challenging.

A commercial simulation software was utilized in the current study, whereby a base case was calibrated using a design case, denoted as Design Case 1. Data required for this calibration of the base model included: (a) Feed analysis for each stream in the feed blend, e.g. specific gravity, distillation curves, sulfur and metals content etc., (b) detailed operating conditions for each equipment of the unit including delayed coker furnace, coke drums, and the separation column, and (c) product analysis and yields for each product stream from the unit.

This calibrated model was validated by testing the model against another design scenario, denoted as Design Case 2, in addition to a set of operating data denoted as Scenario 3. The prediction for these cases indicated a very good match, and henceforth the calibrated model was utilized for prediction of an additional scenario, denoted as Scenario 4. Feed for theese cases are as in Table 1.

**Table 1:** Feed blend percentage for each case

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Flow Rate Percentage (%)** | | | |
| **Feed** | **Design Case 1** | **Design Case 2** | **Scenario 3** | **Scenario 4** |
| Vacuum Residue | 85 | 85 | 83 | 85 |
| RFCC Slurry (0.1 wt% S) | 15 | - | - | - |
| RFCC Slurry (0.2 wt% S) |  | 15 | - | - |
| Hydrotreated Atmospheric Residue | - | - | 17 | 15 |

**3. Results and discussion**

Tabulated below are results for these predicted scenarios.

**Table 2:** Products yields simulation results for different feed scenarios compared to the calibrated case

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Yields (wt%)** | | | |
| **Products** | **Design Case 1** | **Design Case 2** | **Scenario 3** | **Scenario 4** |
| Gas | 4.7 | 4.7 | 4.21 | 4.191 |
| LPG | 4.82 | 4.82 | 5.64 | 5.596 |
| Light Coker Naphtha | 16.67 | 16.52 | 18.94 | 18.659 |
| Heavy Coker Naphtha | 8.71 | 8.623 | 9.8335 | 9.713 |
| Light Coker Gas Oil | 26.53 | 26.29 | 29.93 | 29.68 |
| Heavy Coker Gas Oil | 6.25 | 6.31 | 5.68 | 5.72 |
| Coke | 32.14 | 32.7 | 25.1 | 25.74 |

The presentation will include a detailed discussion of these results and the source of these variations of the individual yields.

**4. Conclusions**

A commercial Delayed Coker unit was simulated, whereby one set of design data were used to calibrate the model, and validated using a second set of design data and actual operating data. Parametric prediction cases were performed and validated directionally to provide operational guidelines to the refinery process engineers for assessing unit performance and limits of feed flexibility for the various feeding scenarios. The coke product yield has been significantly impacted while using hydrotreated atmospheric residue in the feed blend. These step-out predictions have also been made available for refinery production planning personnel to generate Linear Programming (LP) vectors for input for production planning software.

**References**

1. Delayed Coker Operating Manual, ADNOC Refining, 2014.