Simulation and planning of a petroleum refinery based on carbon rejection processes

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Abstract

Old refineries were mostly designed and constructed to process light and medium crude oils and cannot operate with heavy or extra-heavy crude oils. Significant changes need to be done in such refineries if the decision is made to modify the regular diet from light to heavy petroleum, particularly in the bottom-of-barrel processing. Treating the heavy portion of petroleum, i.e. atmospheric and vacuum residua can be carried out by means of two types of technologies based con hydrogen addition and carbon rejection, both aiming at increasing the hydrogen-to-carbon ratio of the feed. Making the decision about which technology is the best for a particular case is not an easy task. Various aspects need to be taken into consideration such as type and properties of the crude oil to be refined, desired products, e.g. maximum production of gasoline or diesel, prices of oil and distillates, among others. In the case of new refineries, they can indeed be designed for processing heavy crude oils, aiming at generating as much profit as possible by converting crude oils into valuable products.

Optimization has become an attractive tool to achieve this goal. Linear Programming (LP) has been the most widely used technique in refinery planning and optimization. The advantage of LP is its quick convergence and ease of implementation.

A petroleum refinery is in fact highly nonlinear. With the regulations on the process industry to produce suitable products that meet stricter product specifications while at the same time meeting environmental restrictions, a more accurate model needs to be developed.

It is the object of this work to develop a model to optimize and simulate a simplified petroleum refinery scheme, considering carbon rejection processes (visbreaking, coking and gasification) for residua processing and to develop a superstructure of such a scheme.

Figure 1 shows the simplified refinery scheme. The crude oil is first fed to a crude distillation unit (CDU), where different distillates are produced and sent to hydrotreating plants (HDSN, HDSJF, HDSLGO and HDSG for naphtha, jet fuel, light gasoil and blend of heavy gasoil, light gasoil and heavy vacuum gasoil, respectively). Hydrodesulfurized naphtha and gas oils blend are further fed to catalytic reforming (REF) and fluid catalytic cracking (FCC). Vacuum residue is processed either in delayed cocking (DC) or visbreaking (VB) or gasification (GF) units. Subproducts from the different processes are incorporated to the corresponding hydrotreating, e.g. naphthas from HDSJF, HDSLGO, HDSG and VB are put together with straight-run naphtha as feed to HDSN. Due to the high content of sulfur and unsaturated compounds coker naphtha is

not blended with the other naphthas but it is hydrotreated separately (HDSNDC) and then mixed with the hydrodesulfurized naphthas and fed to the reformer. If the Visbreaking Unit is used, a residue is obtained, which is used to prepare fuel oil.

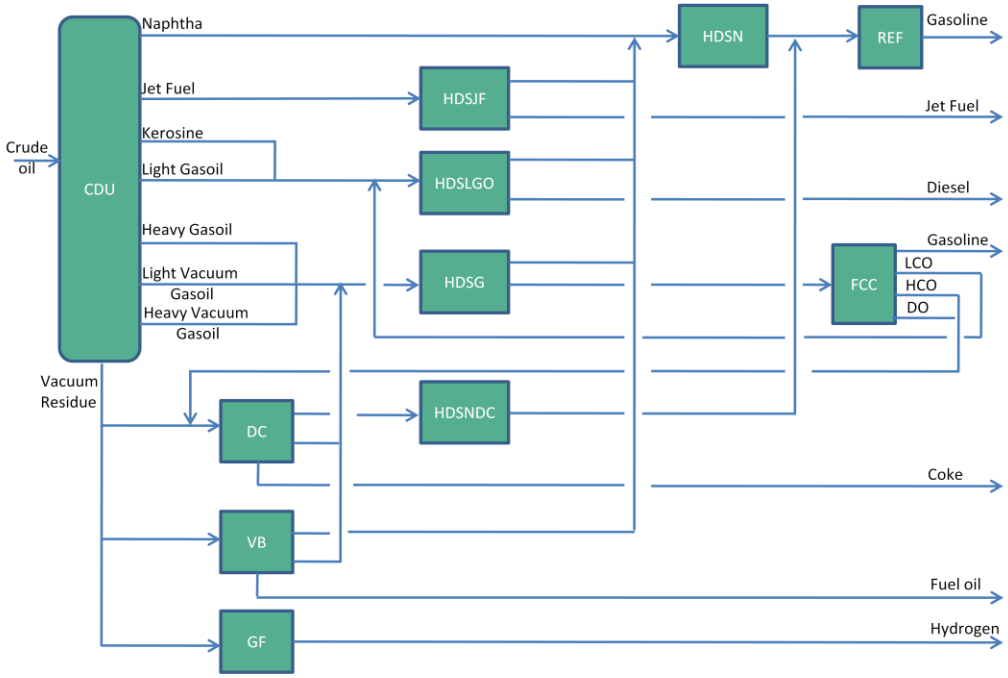

Figure 1. Superstructure of the simplified refinery scheme