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Maximize Diesel With UOP Enhanced Two-Stage Unicracking™ Technology

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EXTENDED ABSTRACT

Increasing global demand for high quality diesel has driven technology development at a rapid pace to provide refiners with ever improving ways to meet the demand. For example, European consumption of high quality transport diesel has grown continuously since 1994 at a 4% annual average rate. Over the same period gasoline consumption has declined progressively at an average rate of -2.1% per year. Due to a combination of market forces and tax policy, it is currently anticipated that these trends will continue for the foreseeable future. Similar trends are also seen in other regions of the world.

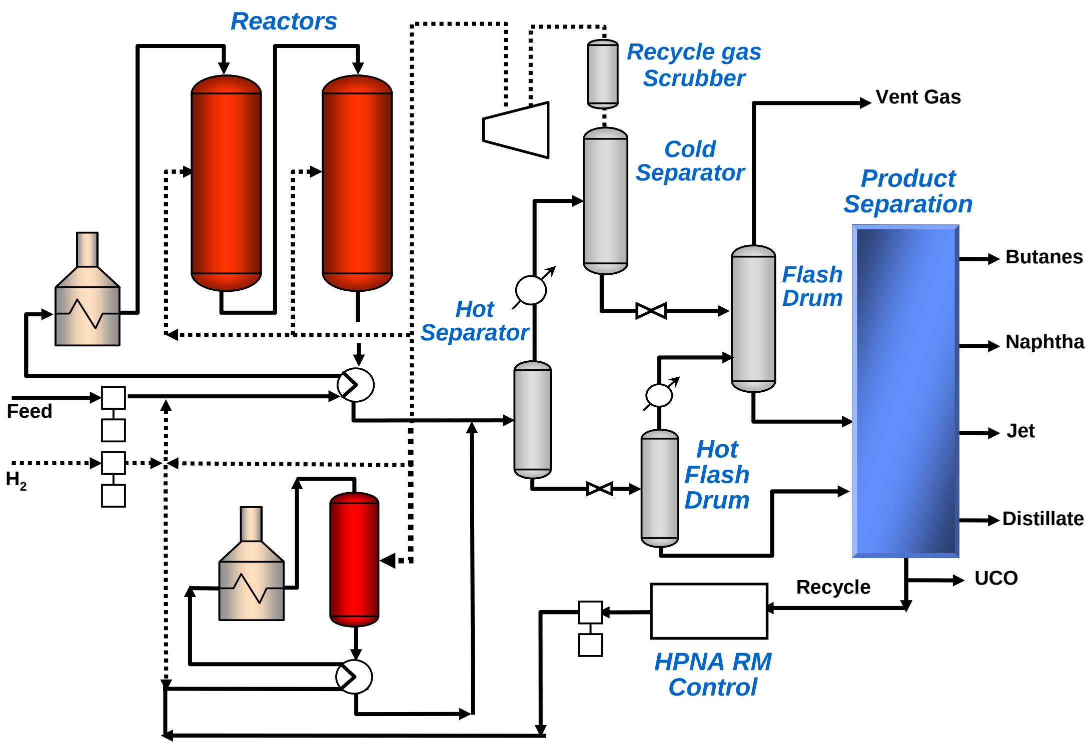
UOP continues to work on new, ever more efficient, approaches to meet this demand and has recently introduces its biorenewables-based UOP/Eni Ecofining™ process technology and the enhanced two-stage UOP Unicracking™ process. This presentation will focus on the enhanced two-stage Unicracking process to illustrate how our knowledge of market forces combined with deep commitment to technology has enabled continued renewal of existing processes and introduction of new ones..

Selective hydrocracking of straight-run vacuum gasoil and heavy cracked gasoils from deep conversion units is one of the most efficient methods to make high quality distillates with minimum production of less valuable side products. UOP’s enhanced two-stage Unicracking process is uniquely suited to handle the difficult task of converting today’s refractory feedstocks, such as heavy cracked gasoils and vacuum gasoils, with their high sulphur and high nitrogen content and a molecular composition consisting of polyaromatics and long chain paraffins. The heavy molecular structure of these feeds can severely inhibit catalyst stability while the high heterocyclics content depresses catalyst activity.

This new process offering is an optimized economic solution that permits refiners to effectively handle these difficult feeds while producing high quality diesels with high selectivity. Its development combines process innovations with new Unicracking catalyst technology to optimize the molecular transformations in the unique reaction environment of each stage. The resulting yields of high quality hydrocracked diesel from heavy high nitrogen feedstocks can be 5 to 7 wt-% greater than achieved by conventional hydrocracking. The new catalyst and process innovations within this technology package may be use in new unit designs or in revamps of existing hydrocracking units.

Starting in the 1950's and 60's many two stage hydrocracking units were designed and built by the predecessors to our current Unicracking process (UOP's Isomax™ and Unocal's Unicracking processes) to maximize naphtha production primarily in North America. These processes produced a mix of high-octane light naphtha and a heavy naphtha product which was an excellent feedstock to catalytic reformers for production of high octane gasoline. Distillate production was typically carried out using single-stage designs with catalysts and process conditions best suited for maximum production of jet and diesel products with, in some selected cases, co-production of high quality bottoms used for lube production or ethylene cracker feeds. While these offerings met market demands of the previous era, recent demand for high-quality distillates and increased regulatory constraints on the composition of diesel products has resulted in renewed interest in two-stage Unicracking designs as cost-effective options for larger capacity maximum distillate hydrocracking units.

UOP's technology renewal efforts then focused on developments in both process and catalyst technologies for this enhanced two-stage Unicracking offering. A typical two-stage design consists of a first-stage whereby the feed is hydrotreated and hydrocracked using catalysts especially designed catalysts for the respective duties. The first-stage effluent is then separated into gaseous and liquid streams followed by fractionation of the liquid effluent into products and unconverted oil. Unconverted oil is recycled to the second-stage hydrocracking reactor. The second-stage hydrocracks the unconverted oil so that overall conversion from the unit can be as high as 100%.



Two-Stage Unicracking Flow Scheme

Optimal configuration of the catalyst systems for two-stage hydrocracking requires a thorough understanding of the reaction chemistry in each stage. The first-stage cracking catalyst, typically in series flow with pretreating catalyst, receives a hydrotreated feed which is largely free of organic nitrogen and sulphur compounds other than small levels of highly refractory species. The feed to the hydrocracking section is rich in paraffins, isoparaffins, naphthenes, naphtheno-aromatics and alkyl-aromatics compounds. The predominant reactions are aromatic hydrogenation, ring opening and de-alkylation of the aromatics and substitutes aromatics, in addition to further isomerisation and cracking of paraffins. The hydrocarbon stream that exits the first-stage cracking reactor is rich in medium to short chain paraffins, naphthenes and alkyl aromatics with short to moderate length side chains.

The distribution of these components is a strong function of catalyst type and reaction severity in the hydrotreating section as well as the depth of conversion in the first-stage cracking section. Heavier cracked products are preserved at lower conversion due to the sequential nature of the isomerisation, primary and secondary cracking of paraffins in the feed. In maximum distillate operation, this means that reducing conversion severity will achieve a highly distillate-selective product slate, including increased heavy diesel yields, and will result in reduced hydrogen-consuming production of light gases.

In addition to control and optimization of process conditions, catalyst design principles when applied to this problem take advantage of improved molecular-scale definition of feed compositions, appropriate selection of catalytic materials, and enhanced knowledge of the impact of specific process conditions on catalyst performance to deliver the needed level of activity and selectivity to meet cycle length and product yields. Once these objectives are achieved, product quality is also optimized by proper matching of hydrotreating and hydrocracking catalysts and the proper balancing of the acid and metal types in the hydrocracking catalyst.

This presentation describes the development and performance of the enhanced two-stage Unicracking process. It will illustrate how the integration of the enhanced fundamental knowledge and the design principles discussed above were pivotal in the successful development of this new offering. The optimization of reaction environments in the two hydrocracking stages will be discussed and a case study from a recent commercial project illustrating the economic benefits of the technology will be presented.