2011 2nd International Conference on Chemical Engineering and Applications
IPCBEE vol. 23 (2011) © (2011) IACSIT Press, Singapore

Integrated HRH with conventional process to produce synthetic crude oil

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Abstract. Heavy Residue Hydroconversion (HRH) is a new nano catalytic process to convert heavy residue to lighter products [1]. The application of this process is investigated for converting heavy crude oil to light syn. crude. The process and economy of two cases have been studied in this article both with the capacity of 20000 BPD. The first case a standalone HRH unit to produce syn. Crude oil is studied and the second case is a combination of two processes: a conventional process TDA (Thermal De Asphaltening) and HRH which is named integrated HRH. In the first case syn. crude by the API 30 is producing and the economic evaluation shows that this plant is feasible for the difference price of 20 dollars and higher between feedstock and product. Second case syn. crude by the API of 31.5 is producing and plant is feasible for the difference price of 15 dollars and higher between feedstock and product. Therefore HRH is a feasible alternative to upgrade heavy crude oil and make residue and metal free syn. crude in lower capacities, as low as 20000 bbl/d.

Keywords: Hydro cracking, heavy residue, hydro converting, upgrading

1. Introduction

Since world reservoirs are facing with reducing light and medium oil and increasing heavy oil production, research of new methods to convert heavy oil to light crude is inevitable. Also world refineries are "medium and light oils-based" designed and a big struggle concerning of existing refineries is the reduction of the light and medium oil of reservoirs. A variety of processes are developed which can be categorized into two groups of carbon rejection and hydrogen addition. HRH process is a nano-catalytic base cracking in presence of hydrogen for converting heavy crude oil with API less than 10 to light crude with API of more than 30 and also for converting heavy residues to middle distillate products. With consideration that millions BPD of extra heavy crude will be produced during next years, HRH process is able to convert 90-95% of heavy components to light ones that its product is residue free and increase added value (Achieving up to 110% volume yield) and also remove all heavy metals and 60-80% of Hydrocarbon-bonded sulphur is converted to H2. Furthermore heavy feed metals are eliminated from the feed and recovered in a proprietary separation process as metal oxides. Above all HRH process has the following environmental advantages: The level of sulfur content in the oil products is extensively reduced and therefore, the less sulfur will emit during the refining and further process conversions. Coke is not produced with high carbon content as a by-product. Resulted synthetic crude oil enables refiners to produce clean refined products with high quality (free of suspended solid and sulfur) [1].

1.1. HRH applications

High flexibility of HRH makes it a unique process to upgrade heavy crude and residues to light products. Different applications are possible for HRH [1]:

- Wellhead application to make syncrude from heavy crude oil

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- Integrated Wellhead application to make syncrude from heavy crude oil
- Refinery application, to install new refinery based on HRH
- Retrofitting existing refineries

In this paper the first and second applications are investigated. 2 different cases are studied for similar FEED and capacities: 20000 BPD HRH plant and 20000 BPD Integrated TDA+HRH plant

The HRH process has been run with a variety of feeds, in this article the feed specifications for these cases are mentioned in table-1.

The economic assumptions for the cases are as follow:

- Construction duration: 2 years
- Production duration: 25 years
- Working days per year: 330 days
- Exchange rates: 1.36 USD =1 Euro

TABLE 1 FEED SPECIFICATION

CRUDE ASSEY Analysis			
SPECIFICATION	Unit	Qty	TEST METHOD
Specific Gravity@15.56/15.56 C	-	0.9630	ASTM D-4052
API	-	15.40	ASTM D-4052
Sulphur Content	Wt.%	3.20	ASTM D-2622
H_2S Content	PPM	<1.0	RIPI
Nitrogen Total	Wt.%	0.32	ASTM D-3228
Base Sediment & Water	Vol%	6.00	ASTM D-96
Water Content	Vol%	4.00	ASTN D-95
Salt Content	P.T.B.	>150	ASTM D-3230
Pour point	C	-16	ASTM D-97
R.V.P.	PSI	2.00	ASTM D-323
Asphaltenes	Wt.%	9.7	IP-143
Wax Content	Wt.%	3.60	BP-237
Drop Melting point of Wax	C	54	IP-31
Carbon Residue(CONRD)	Wt.%	8.50	ASTM D-189
Nickel	PPM	19.0	UOP-800
Vanadium	PPM	138.0	UOP-800
Iron	PPM	104.0	UOP-800
Lead	PPM	<1.0	UOP-391
Sodium	PPM	0.1	UOP-391

1.2. Case-1 Stand alone 20,000 bbl/d HRH plant

HRH plant can be built near the oil field to produce more marketable crude while removing pricing risks associated with diluents and crude differentials. Stand alone HRH unit consist of the following parts:

Reaction, Separation, Sour gas and sour water treatment consists of :HP-Amine Scrubber, LP- Amine Scrubber, Amine Regeneration, Sour Water Stripper, Desulfurization (Claus Plant)., Catalyst regeneration, Hydrogen unit consists of : Hydrogen Generation Plant (H2 Plant), Hydrogen Purification., Solid product handling , Storage consists of :Tank farm, Chemicals Storage, Solid Products Handling, Flushing oil system., Water, Steam, Condensate unit consists of :Raw Water System, Drinking Water System, Chilled Water System, Demineralization / Deaerator Water System, Cooling Water System (is deleted), Steam System,Condensate System ,Slop System,Waste Water System., Auxiliary System consists of :Steam Generator, Compressed Air / Instrument Air, Nitrogen System, Natural Gas System, Off gas/ Fuel gas, Electrical Equipment /Emergency Diesel Generator, Control Room, Laboratory, Sanitary Facilities., Emergency and Safety System consists of : Flare System, Fire Fighting System.

In this scheme of HRH process, a simple flash separation is used to separate the heaviest portion of the feed (350^+) by the API <10 for upgrading.

The heavy portion of the feed is sent to the reaction section, where a mixture of feed, hydrogen which is produced in H2 unit and catalyst are heated in a furnace and sent to the reactor for cracking and hydrogenation. Due to the efficiency and selectivity of the nano-scale catalyst, reactions occur perfectly under moderate pressures and temperatures. Heavy components are cracked, hydrogenated and converted to lighter products.

HP sour gases, LP sour gases, product and vacuum residue are separated in the separation section. HP sour gases mostly containing un-reacted hydrogen and very light hydrocarbons are sent to a HP Amine Treating Unit for H2S removal. H2S is sent to a sulphur plant and sweetened gas (contain very light hydrocarbons and hydrogen) is sent to a Hydrogen Purification unit. Very light hydrocarbons are recovered for use as fuel gas and hydrogen is recycled to the reaction section. LP sour gas sent to an LP Amine Treating Unit for H2S removal. H2S is sent to sulfur plant, where sweetened gas is recovered as fuel gas. Lights liquid product is sent to a product tank farm, while heavy hydrocarbons are heated and sent to vacuum distillation. From the vacuum column LVGO is sent to a product tank. Vacuum bottom is cycled back to the reaction section and the catalyst which is accumulated in the vacuum residue is sent to the catalyst regeneration section.

In the catalyst recovery and regeneration section, the catalytic complex remains in the distillation residue that is first separated by filtration then is recovered by burning and adding a solvent to the resulting ash. Regenerated catalyst sent to the reaction section, metal oxides are dried and sent outside the battery limit and sulphite is converted to crystallized ammonium sulphate. As a residue treatment alternative in the recovery section, in order to produce medium pressure steam, catalyst can be recovered from a gasification unit instead of using a burner.

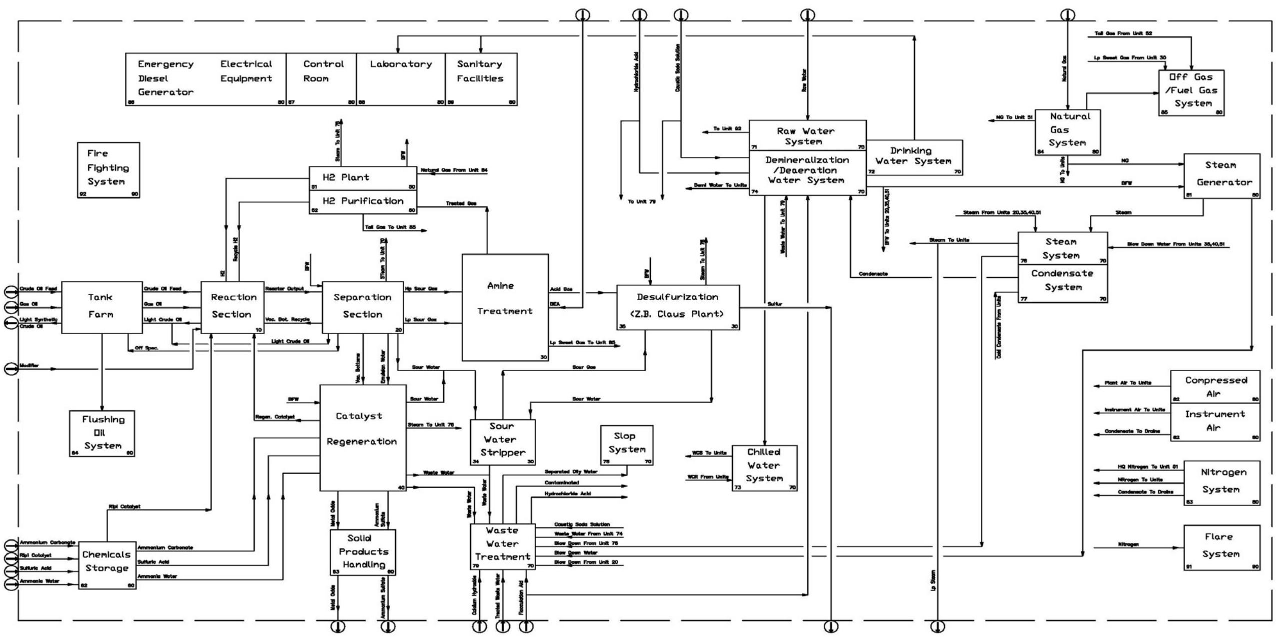

Fig.1HRH block diagram

Product distribution for mentioned cases are indicated in table-2

TABLE 2 PRODUCT DISTRIBUTIONS [2]

PRODUCT	Density kg/m3	WT%
IBP – 180 °C	753.6	15.5
180-350 °C	894.1	77.68
350-520 °C	952	6.82
API	30	100

Note: API 30 as target product is conservative and it is possible to go beyond API 30 by HRH Material balance is indicated in table-3.

TABLE 3 MATERIAL BALANCE HRH PLANT [2]

Inlet	**Kg/hr**
Feed , Heavy Crude Oil	125598 (20000 bpd)
Catalyst Solid	5.8
Ammonia Water	1140.0
Sulfuric Acid	0.6
Outlet	
Product	120642 (20880 bpd)
Ammonium Sulfate	850
Metal Oxide	105
MP Steam	51000

The economic figures are evaluated for two level of natural gas price as mentioned in table-4.

TABLE 4 ECONOMIC FIGURES FOR HRH PLANT) [2]

Case :1	20000 BPD	
Catalyst consumption(kg/bbl)	0.0057	
Investment cost:	500 MM$	
PRODUCT-FEED Price($/bbl)	IRR %	NPV MM$
Natural gas price: 7.2 c/m3		
20	15.3	136.9
25	17.16	233.1
30	24.17	527.9
Natural gas price: 15 c/m3		
20	13.94	80.5
25	15.88	176.3
30	22.84	471.5

1.3. Case-2 Stand alone 20,000 bbl/d Integrated TDA + HRH plant

In this case an integration of HRH with a conventional TDA (Thermal De Ashphaltene) unit is presented. In a conventional TDA unit, disarranging thermal stability of crude oil in presence of an additive will result in sedimentation of ashphaletene molecules. Crude oil first is send to TDA unit which heavy metals along to asphalten separates from crude oil using a new technology developed in research institute of petroleum industry (RIPI) [3]. Nanometer particles of ashphaltene aggregate to micrometer ones during heating into a specified temperature and some aggregation agent addition.

During this process about 37% of rich ashphaltene crude separate from bulk crude oil which its API reaches to 24 from 15.4. TDA by-product, rich ashphaltene heavy residue, is sent to HRH unit. Finally light Syn. Crude "Product" is obtaining by mixing both units' products as per figure 2.

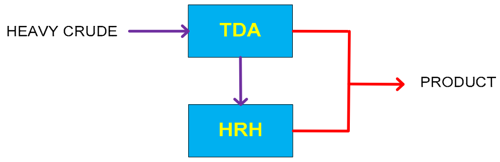

Fig.2 General Scheme of HRH+TDA

Block diagram of this case is indicated in Fig-3.

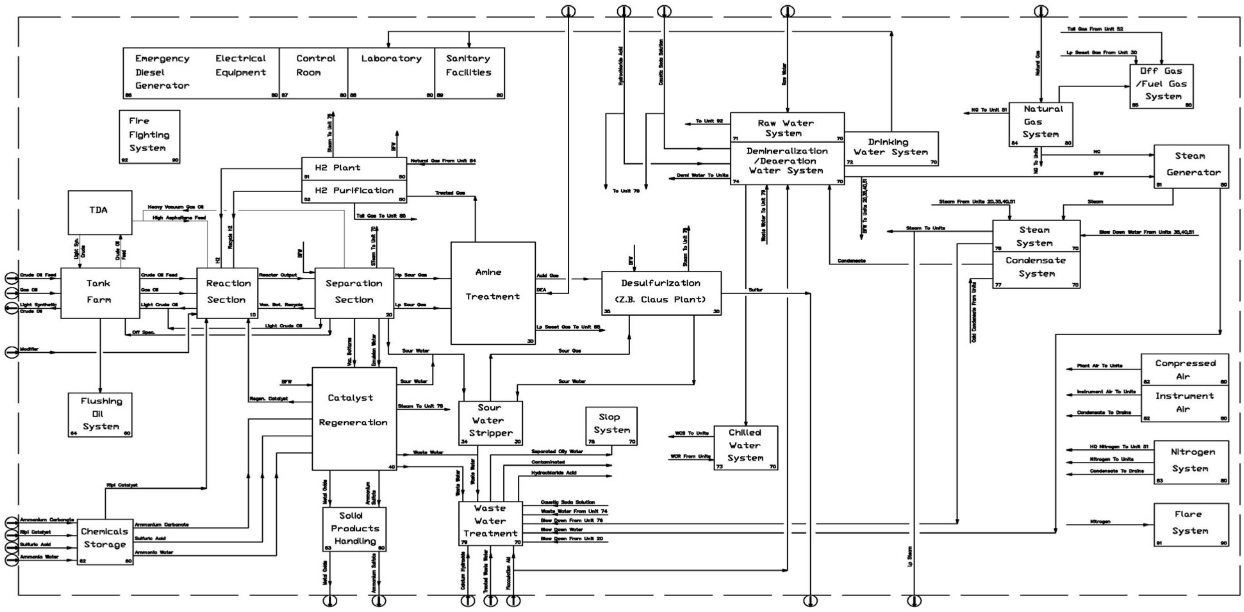

Fig.3 Block diagram of HRH + TDA

Material balance is indicated in table-5

TABLE 5 MATERIAL BALANCE (HRH +TDA)

Inlet	Kg/hr
Crude Oil Feed	125598 (20000 BPD)
DEA	10.6
Stabilizer	5.9
Modifier	474.3
Catalyst Solid	4.93
Ammonium Carbonate	107
Ammonia Water	1015
Sulfuric Acid	0.6
Outlet	
Product	121954 (21525 BPD)
API	31.5
Ammonium Sulfate	850
Metal Oxide	105
MP Steam	24000

The economic figures are indicated in table-6

TABLE 6 ECONOMIC FIGURES FOR 20,000 BBL/D (HRH+TDA)

Case :	20000 BPD TDA + HRH	
Catalyst consumption (kg/bbl)	0.006	
Investment cost:	404 MM$	
PRODUCT-FEED Price ($/bbl)	IRR %	NPV MM$
Natural gas price: 7.2 c/m3		
15	14.99	98.5
20	20.81	300
25	26.34	502
30	31.65	703
Natural gas price: 15 c/m3		
15	13.56	51
20	19.5	252.7
25	25.12	455
30	30.19	646.7

2. Conclusion

This study indicates that stand alone HRH plants to produce syn. crude from heavy crude are feasible in all cases with more than 20,000 bbl/d capacity. These economic indications and the flexibilities of HRH to feed type, and also considering the fact that HRH catalyst are mostly recovered and recycled to the process; make the HRH as a unique alternative to upgrade heavy crude oil.

3. References

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