ROLE OF SOLVENT DEASPHALTING IN PROCESSING PETROLEUM RESIDUES IN REFINERIES

G.S. Dang & B.S. Rawat

Solvent Deasphalting (SDA) is basically a liquid-liquid extraction process. The conventional applications are in producing extra heavy viscosity grade lube oils called bright stock/cylinder oils and in upgrading bottom of barrel by recovering incremental/additional feedstocks from vacuum residues for secondary conversion units like Fluid Catalytic Cracking/Hydrocracking. Some newer applications include making of quality bitumen from waxy crudes, low sulphur fuel oils etc. Industrially, propane, butane and pentane (C₃-C₅) solvents, either alone or their combinations for greater flexibility, are being used widely. To improve the process economics, novel features like supercritical solvent recovery, better counter current columns, etc. are being incorporated in existing and new grass-root deasphalting plants. The SDA process in combination with thermal cracking processes etc. is further contributing in reducing the availability of short/vacuum residues in refineries.

INTRODUCTION

Refineries are being faced currently with need to produce more and more light and middle distillates and less of residue/residual fuel oil due to changing product demands world wide. This need coupled with increasing supply of relatively heavier crude oils in world market presents a major challenge to the refiner. To meet this challenge together with "bottom of barrel" processing i.e. converting residual stock to lighter and middle distillates, the solvent deasphalting (SDA) process has gained considerable importance, like any other carbon rejection or hydrogen addition residue upgrading process.

SDA traditionally is in use for producing extra heavy viscosity lubricating oil, generally called bright stock and for producing feedstocks for secondary conversion units like Fluid Catalytic Cracking (FCC) and Hydrocracking (HC) from vacuum/short residues. It is basically a liquid-liquid extraction process using a number of light hydrocarbon solvents mainly propane, butane and pentane, either alone or their appropriate combinations like propane-butane or butane-pentane depending upon nature of the feedstock and the desired end product quality.

SOLVENT DEASPHALTING (SDA)

Vacuum residue also referred as short residue is generally the feedstock for deasphalting units. Alternatively depending upon suitability, it goes either for bitumen manufacture or is blended with other lighter oil fractions to produce heavy fuel oil, for which the demand is continuously decreasing. Solvent deasphalting, as stated earlier, utilizes light hydrocarbon solvents and produces valuable extract product, called deasphalted oil (DAO) and thus reduces the net availability of vacuum residue in a refinery. When propane is used as solvent, the process is called propane deasphalting (PDA) (Figure-1) and it produces DAO which is finished into extra heavy viscosity grade lube oil (bright stock, viscosity 35 cst at 100°C & CCR below 2.0%).

PDA operating conditions are optimised for each feedstock to obtain desired quality of DAO. In general, the operating conditions¹ with respect to temperature and pressure lie between 50 to 80°C and 27 to 37 kg/cm² respectively. Solvent to feed (S/F) ratio varies from 6 to 10 by vol. Counter current extraction columns, RDC or baffled tray, are in use industrially. In conventional PDA units all the solvent is separated from the DAO and asphalt streams in a series of progressively lower pressure flashes and the remaining traces of solvent are stream stripped from the oil. The solvent is condensed and recycled in the process.

For vacuum residues not suitable for producing bright stocks, SDA is used to recover incremental or additional feedstock for FCC/HC units. These conversion processes enhance the yield of lighter and middle distillates in the refinery. Since the uses of propane precipitated asphalt are limited, the short residues are extracted/deasphalted deeply, using heavier and less selective paraffinic solvents i.e. C₄-C₁₂. Commercially butane and pentane and to some extent hexane have found wider applications. While still heavier solvents like heptane, etc. have been used for separating asphaltenes at laboratory or pilot plant scale. With butane and pentane, the yield of DAO or demetallised oil (DMO) is increased by a factor of 2 to 3 as compared to propane DAO yield.

¹ Mr. G.S. Dang and Mr. B.S. Rawat are associated with Indian Institute of Petroleum, Dehradun.
of 20 to 50%, depending upon nature of the feedstock and the operating conditions used. Solvent blends like \( C_3 \), \( C_4 \), and \( C_5 \), etc. have also been used and are claimed to provide more flexibility with respect to temperature of operation. Low boiling lighter petroleum fractions/gasolines\(^a\) (b < 65\(^\circ\)C), free from aromatics, are also being used to produce DMO.

The propane solvent rejects both resins and asphaltenes whereas heavier solvents reject mainly asphaltenes and a part of resins depending upon the operating conditions of the process. The operating conditions are so selected that asphaltenes in the conversion feedstocks are reduced below 0.05 wt% because they carry catalyst poisons like metals, sulphur, nitrogen, etc. and are main source of coke formation/deposits leading to de-activation of catalysts. Nitrogen compounds neutralize the acidic function of the catalyst and metals more specifically influence the life of catalyst.

PRODUCT UTILISATION

As stated earlier, the DAO obtained through PDA is used for producing heavy viscosity lube oil called bright stock/cylinder stock. The DAO/DMO obtained through heavier solvent deasphalting forms the feedstock for FCC/HC units along with vacuum gas oil (VGO). DAO/DMO are blended with VGO in such proportions that the blend characteristics meet the feedstock requirements of downstream units like FCC/HC. Typical limitations\(^b\) of contamination in feed to above conversion units are given in Table-1. Generally the level of impurities i.e. Sulphur, nitrogen, metals and CCR in DAO/DMO is higher and therefore it is hydrotreated (HDT). The HDT processes aim to improve one or more properties depending upon the objective i.e. hydrodesulphurization (HDS), hydrodemetallisation (HDM) and hydrodenitrification (HDN). The HDT of DAO/DMO is comparatively much easier and economical than direct residue hydrotreating.

Asphalt/asphaltics obtained as SDA bottoms is utilized in several ways. It forms a component for making paving grade bitumen. It also serves as feed\(^c\) to partial oxidation units to make hydrogen rich gas. It may be blended with visbreaker feed\(^d\). Any remaining asphalt which cannot be disposed off, as above, can be blended with catalytic cycle oil/distilled fuel to make bunker fuel oil or finally can be used as refinery fuel.

Deasphalting process using propane or other solvents employs relatively larger S/F ratios hence in conventional units appreciable energy is consumed for solvent evaporation, compression and condensation for its recycle in the process. In an attempt to conserve energy (mainly utilities) and improve process economics, the solvent recovery mainly from solvent-DAO mixture is now increasingly being done under supercritical conditions of solvent. Under these conditions, the solvent loses solubility...
for oil (virtually insoluble) and a phase separation occurs. About 85% of associated solvent is thus separated forming upper phase and is utilized for heat exchange within the process before being recycled. The major benefits claimed in "ROSE" (Figure-2) and "DEMEX" processes following this approach are: utility savings of the order of about 40% and savings in capital investment for grassroots units, approximately form 15 to 25%. The relative cost of energy for above two techniques is compared below:

<table>
<thead>
<tr>
<th>Solvent recovery technique</th>
<th>Relative cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single effect evaporation</td>
<td>280</td>
</tr>
<tr>
<td>Double effect evaporation</td>
<td>170</td>
</tr>
<tr>
<td>Triple effect evaporation</td>
<td>150</td>
</tr>
<tr>
<td>&quot;ROSE&quot;</td>
<td>100</td>
</tr>
</tbody>
</table>

Owing to the above projected advantages, the new grassroots units are generally based on supercritical approach and the existing units are also increasingly being converted to this approach. Off late 8 of existing PDA units have been converted to ROSE scheme by M/s. Kerr McGee Corp, USA.

CONTRIBUTION OF DEASPHALTING PROCESS IN REFINING

In addition to above mentioned application of producing bright stock, the SDA has following emerging applications:

CRUDE OIL CONSUMPTION

The deasphalting unit, as stated before, also produces additional cracking feedstock which on conversion increases the overall availability of lighter and middle distillates from a given quantity of crude oil. This increase of desirable distillates is at the cost of less needed residue. Therefore instead of adding refining capacity in a refinery another option is to reduce crude run while producing a constant quantity of cracking unit feedstock. Figure-3 shows the relationship between UOP's DEMEX extraction level and relative crude requirements to produce a constant quality of conversion unit charge form light Arabian vacuum residue. At a DMO yield of 40 vol. %, the crude requirement with DEMEX is only 84%. At this extraction level, the VGO-DMO blend contaminant levels are not significantly affected by the DMO addition. At the highest extraction level, the crude requirement has been reduced to 73% of that without DEMEX.

PROCESSING OF HEAVIER CRUDES

Heavier solvent deasphalting mainly using pentane may soon find application in upgrading heavier crudes. The process separates asphaltenes, the least valuable components, from heavier crude oils. Such process units may be located in or near oil production fields. The deasphalted petroleum exhibits higher fluidity than the original crude and is then transported and refined in conventional ways. The separated asphaltenes can be burned to produce steam for steam flooding, etc.

FIG. 2 - ROSE PROCESS
BITUMEN MANUFACTURE FROM WAXY CRUDES

Short residues from waxy crudes do not make quality paving grade bitumen due to higher wax. SDA using propane or heavier solvents precipitate asphalt with much less wax content, suitable for fluxing with cutter stocks like lube oil extracts and/or asphaltene rich residual stocks, etc. to make desired penetration grade bitumen. However, this approach needs economic evaluation. The air blowing for asphaltene generation may or may not be needed in this scheme.

PRODUCTION OF LOW SULPHUR FUEL OILS

The ever increasing emphasis on cleaner environment forces the refiners to produce fuel oils which are quite low in sulphur. The desulphurization of DAO is easier and economical than short residue desulphurization directly and therefore adoption of desulphating process is picking up in the refineries to make quality fuel oil by blending desulphurized DAO with short residue.

PROCESS COMBINATIONS FOR RESIDUE REDUCTION

To maximise the conversion of vacuum residue into lighter products, various conversion processes like Visbreaking, Hydrovisbreaking and Asphaltene Bottom Cracking (ABC) are being considered for integration with SDA. In such combination processes, the residues are first thermally cracked with or without hydrogen and then subjected to solvent deasphalting. This approach reduces the asphalt production. In processes, like ABC-SDA of Chiyoda Chemical Engg. & Const. Co., Japan, the unreacted asphaltenes separated by SDA are recycled to asphaltene cracking step (Figure-4). The residue ultimately gets converted into DAO. The commercialization of this process is yet to take place.

CONCLUSIONS

1) In the present situation crude oil supplies to refineries keep changing and also refiners will have to process heavier crudes in future. Under such conditions one of the options with refiner is to use solvent deasphalting route to upgrade heavier crudes and residues for producing feedstocks for FCC/HC units to maximize middle distillates.

2) With increasing popularity of multigrade automotive crankcase oils, the proportion of bright stock, obtained from DAO is likely to decrease. This situation may provide spare capacity which can be effectively utilized to produce high quality feedstocks for downstream units. In many cases yield of DAO for these purposes can be increased by using C₄-C₆ solvents or their combinations.

3) Indian crude oils being waxy are not suitable for lubes and bitumen. The deasphalting step therefore can be applied to produce cracking feedstocks and asphalt having reduced wax content. The asphalt production alone from such crudes for bitumen making through PDA may not be economically attractive.

4) The approaches like use of solvent blends, supercritical solvent recovery and optimum utilization of products/by-products, etc. are commercially feasible and therefore should be adopted widely in view of currently high energy costs.

ACKNOWLEDGEMENT

The authors are grateful to the Director, IIP, Dehradun, for his kind permission to publish this paper.

REFERENCES

3) Literature on Residue Solvent Refining (RSR) Process by Lummus Crest.
4) Olson, R.K. & Gembiki, V.A., Oil & Gas Journal, 80,
THE ACADEMY OF ENVIRONMENTAL BIOLOGY

ANNOUNCEMENT FOR AWARDS 1994

(A) ARCHANA MEDAL

(B) 10TH JEB PRIZE (YOUNG SCIENTIST AWARD)

Nominations are invited from Members of AEB and through Heads of Universities/ITs, Research Institutes, Institutions and Learned Societies for the above Awards.

For Proforma of Nomination Forms and necessary information please write to:

Dr. R. C. Dalela
Secretary (HQ)

The Academy of Environmental Biology
771, Civil Lines (South), Muzaffarnagar - 251 001.
IS COMBUSTION YOUR BURNING PROBLEM?

Maximise Energy Savings and reduce Pollution through the latest Burner Technology from Credfeld Camtorc Ltd., U.K.

- Oil, Gas, Dual fuel combination of burners for Industrial Boilers
- Light up, Partial Load and Main Load burners for Thermal Power Plants (CEGB-UK approved)
- Flame Monitoring Systems based on Ultra Violet, Infra Red or Flicker Type
- Ignition Systems-Gas/Air Electric, High Energy or Carbon Arc Type
- Burner Management Systems in Relay logic, Solid State or Micro Processor Controls

Product Features
- Low Excess Air
- Low Steam Consumption
- Suitable for heavy fuels
- Low Emissions
- Modular Construction

Join some of the leading companies like Isgec, John Thompson, BHVP, Thermax, Walchandnagar Industries, Pudumjee Paper Mills, FACT, IPCL, etc. who have chosen Credfeld Burner Systems.

Jasubhai Credfeld Ltd.
D 222/2, TTC Industrial Area,
Shirwane, NEW BOMBAY - 400 706.
Phone: 7632496, 7632508
Telex: 0131 1263 JSGR IN,
Fax: 767079

WE UNDERSTAND COMBUSTION ..... BETTER