ROSE®

Residuum Oil Supercritical Extraction

THE PROCESS

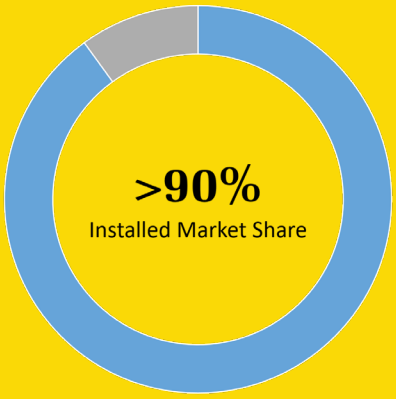
The Residuum Oil Supercritical Extraction (ROSE) process is the premier, preferred, market leading, Solvent Deasphalting technology (SDA) available today. This state-of-the-art process extracts high-quality deasphalted oil (DAO) from atmospheric and/or vacuum residues and other feedstock (i.e. thermally or catalytically cracked residue). Depending on solvent selection, DAO can be an excellent supplement to gas oil blend feedstock for catalytic cracking (FCC or RFCC), hydrocracking (including ebullated bed hydrocracking), or lube oil base stocks production.

The asphaltene product from the ROSE process has multiple dispositions, including in conversion processes such as delayed/flexi-coking, partial oxidation or gasification. It can also be solidified using KBR's Asphaltene Integrated Management Solution (AiMS™) process for sale as solid fuel, blended to fuel oil, supplement as pet-coke or used in the production of asphalt blending components.

ROSE technology is based on the use of a light, readily available hydrocarbon solvent to extract deasphalted oil from a feedstock containing asphaltenes. The solvent is separated from the DAO in the downstream DAO separator under supercritical conditions, then recovered and recycled back to the asphaltene separator. Solvent selection is based on the desired deasphalted oil purity and yield for a given feedstock. The ROSE unit is simple, mostly carbon steel and includes a deasphalted oil stripper and an asphaltene stripper for final recovery and recycling of dissolved solvent from the two effluent streams.

ROSE units can upgrade very heavy crudes, process residue from oil sand bitumen, and extract valuable products from thermally or catalytically cracked material.

ROSE®



Based on publicly known data on total number of supercritical units built

TECHNOLOGY BENEFITS

- Feed flexibility
- Higher yield with improved product quality
- Lower operating costs
- Lower capital costs
- Increased product flexibility
- Simpler operation
- Integrated energy efficiency
- Longer catalyst life of downstream catalytic units
- Significant reduction in asphaltene carryover with DAO
- Commercially proven experience with light, heavy, and mixed solvents
- Commercially proven experience with low to high capacity units
- Experience in design/ operation of two and three product ROSE units

SDA Leader for Over 40 Years

Commercially proven ROSE® leads the market with the largest installed base and extensive design and operating experience. Our track record of improving refinery margins gives licensees confidence in the quality, reliability and stability of this bottom-of-the-barrel technology. Key ROSE technology advantages offer the best investment value and minimize technical and reliability risks.

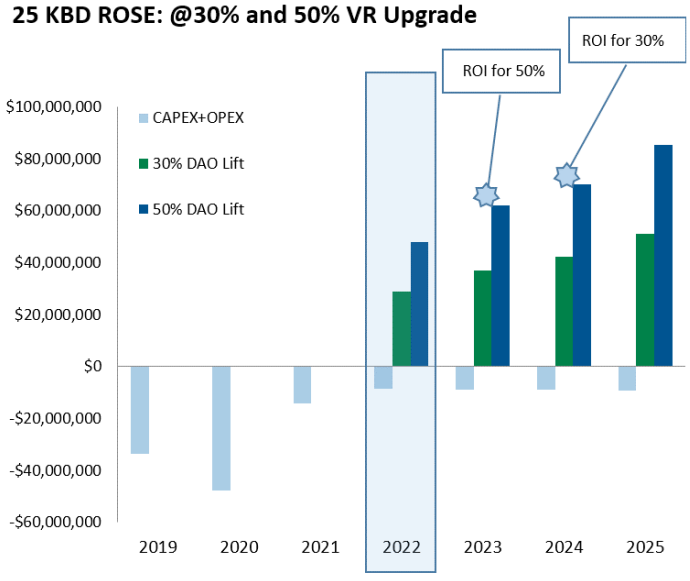
ATTRACTIVE ECONOMICS

- All economics on USGC basis
- Budgetary all-in TIC CAPEX for 25 kBPSD ROSE unit is approximately $75MM
- Budgetary ISBL TIC CAPEX for 25 kBPSD ROSE unit is approximately $50MM
- Low utilities (i.e. no catalysts)
- Pricing markers:
  - Assumed USGC HSFO (FO6)
  - HVGO (2% S)
- Conservative ROSE products pricing basis:
  - DAO at a $5/bbl discount to HVGO (2% S)
  - Asphaltene/pitch valued at $0/ton

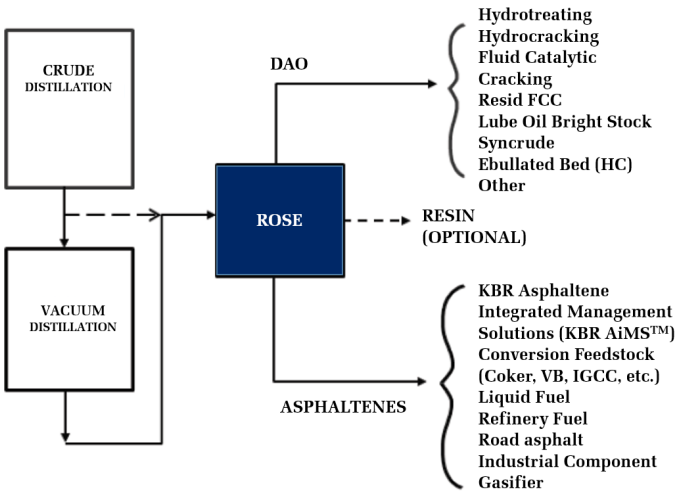
The many economic benefits of the ROSE process are the result of recovering the extraction solvent as a supercritical fluid. The recovered solvent is recycled through heat exchangers to recapture a major portion of the energy necessary to achieve supercritical solvent recovery. This significantly reduces capital and operating costs. Commercial ROSE units have demonstrated overall utilities savings of greater than 50 % compared to conventional solvent-extraction processes that use evaporation, compression and condensation. By eliminating the need to evaporate a major portion of the extraction solvent, the size and complexity of the ROSE unit is reduced. This, in turn, leads to reduced investment costs and further energy savings.

The relative simplicity of the ROSE process facilitates smooth start-up and operation and minimizes manpower operating requirements.

25 KBD ROSE: @30% and 50% VR Upgrade



ROSE TECHNOLOGY PROCESS ADVANTAGES



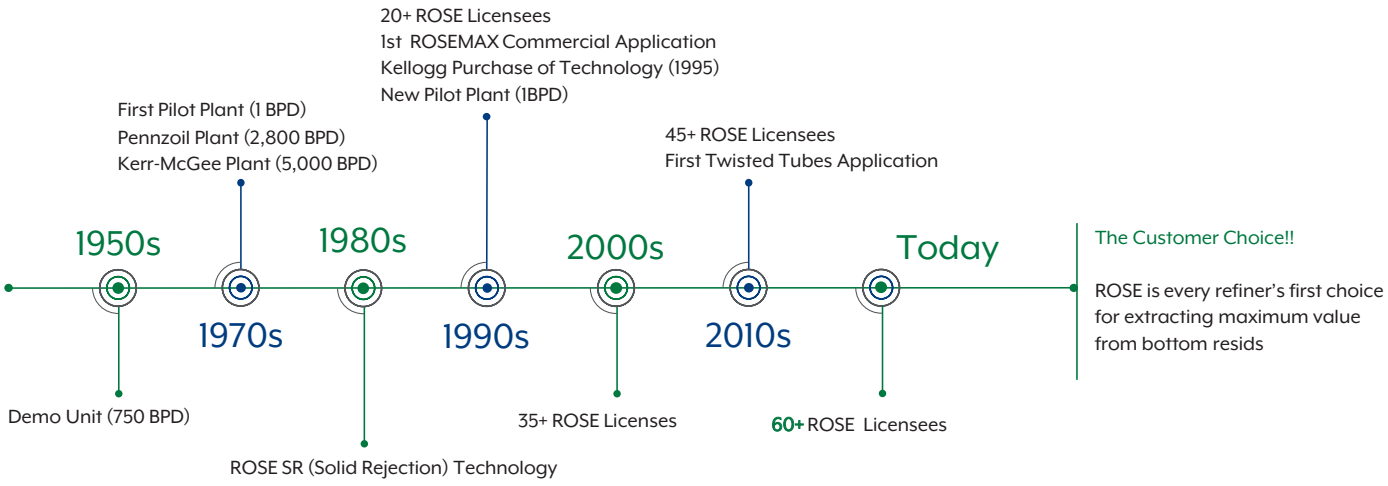
Feed flexibility
- AR
- VR
- AR/VR
- Cracked feed

Reputation
- Largest installed base
- High reliability

Cost-effective
- Energy efficient
- Low CAPEX and OPEX

Integrated Solution
- Multiple product outlets
- KBR Asphaltene Integrated Management Solution (AiMS™)

KBR HAS LICENSED 60+ ROSE UNITS WITH A COMBINED CAPACITY OF OVER 1.5 MILLION BPD.



REFINING EXPERIENCE

KBR delivers world-class results to the petroleum refining market. Our business as a process developer and licensor, in addition to our widely acclaimed project delivery capabilities, has resulted in licensing, designing, or constructing more than 60 greenfield refineries and well over 1000 refining units of every type and size globally.

Our licensed technologies are found in residue upgrading flow schemes, in more than half of the world's FCC units, and more than 100 hydroprocessing units. Our emphasis on heavy oil upgrading, improving the bottom-of-the-barrel material, producing clean fuels, and providing a wider range of operating flexibility to refiners makes KBR a clear partner in any refining challenge. From grassroots design to revamps, no job is too large or too small.

These references from the last decade illustrate the value of KBR's ROSE process technology.

Licensee	Capacity BPSD	Solvent	Product Destination
Riyadh Refinery, Mideast (new, 1Q2019)	15,000	Mix C_4	HCU/Road Asphalt
Confidential, N.E Asia (new, 2Q2018)	25,000	Mix C_5	RDS/Gasifier
ENAP, Chile (new, 1Q2018)	Conf.	Mix C_4	HCU/FCC/Coker
HPCL, India (new, 4Q2017)	24,000	C_5	HCU/Fuel Oil /Solid Fuel
Confidential, S.E Asia (new, 2Q2017)	64,000	Mix C_5	HCU/Fuel Oil
Confidential, Europe (1Q2017)	13,000	C_4/C_5	HDT/Gasifier
Hyundai Oilbank, Daesan, S. Korea	80,000	C_5	RDS-MHC/ Coker (Fuel Oil)
Confidential, US	4,500	C_4	HDT/Road Asphalt
Shell Pernis, Europe	Conf.	C_4	HDT/Gasifier/Fuel Oil
Confidential, Europe	12,500	C_4	HDT / Gasifier
JX Kashima, Japan	18,000	C_5/C_6	RDS/Fuel
Neste Oil, Europe	22,400	C_5/C_6	HCU/Solid Fuel
Holly Tulsa (conversion)	15,000	C_3	Lubes/Road Asphalt/Fuel Oil
Total Antwerp, Belgium	48,000	C_4	HDT/Fuel Oil/Road Asphalt
Luberef Aramco (conversion)	12,000	C_3	Lubes/Road Asphalt
HPCL Mumbai, India (conversion)	13,600	C_3	Lubes/Road Asphalt
Confidential Asia (conversion)	25,000	C_3	Lubes HCU/Road Asphalt
SRC, Iraq	47,000	C_5	HDT/Fuel Oil
Lotos Gdansk, Poland	51,000	C_4	HCU/Fuel Oil/Road Asphalt
IRPC Rayong, Thailand (20% exp)	13,200	C_3	Lubes/Road Asphalt
SK Ulsan, Korea	20,000	C_3	HDT/Road Asphalt
Pertamina, Indonesia	57,000	C_3	FCC/Coker
Holly Corp. Artesia 1, NM	30,000	C_4/iC_5	HCU/Fuel Oil
Holly Corp. Artesia 2, NM	30,000	C_4/iC_5	HCU/Fuel Oil
Ergon, MS	8,000	C_3	Confidential
JX Mizushima, Japan	20,000	C_5/C_6	RDS/Fuel
ENI Sannazzaro, Italy	15,500	iC_4	FCC/Gasifier
Confidential, China	15,700	C_3	Lubes HCU/Road Asphalt
Placid Oil, US (~50% expansion)	11,500	nC_4	FCC/Fuel Oil
Confidential, Europe	46,000	C_4/C_5	HCU/Gasifier
Husky Oil, Canada	61,000	C_4/C_5	HCU/Coker
NLP Canada	66,300	C_4/C_5	HCU/Gasifier
Holly Corp. Woods Cross, UT	11,625	iC_4/nC_4	FCC Feed Fuel Oil
Holly Corp. Artesia, N.M.	4,500	C_4	FCC Feed Asphalt
Confidential, Asia	54,000	C_4/C_5	HDT/FCC/Road Asphalt/Fuel Oil
Canada	25,000	C_5/C_6	HDT/Fuel Oil
Canada	25,000	C_5	HDT/Fuel Oil

*This is not a complete reference list

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