2.0 PROJECT & PROCESS DESCRIPTION

Numaligarh Refinery processes Assam crude mix, which is highly paraffinic (8% on crude) and has high wax content. M/s NRL engaged M/s IIP, Dehradun, to carry out study for commercial production of paraffin and semi-microcrystalline wax. Accordingly, M/s IIP, Dehradun carried out probe runs on a number of sample feed stock provided by NRL, on lab scale. This was followed by bench scale experiments at IIP to determine the filterability of various stocks, achievable quality of product wax as well as optimum operating parameters. Having received the results from M/s IIP Dehradun, which were encouraging and promising both in the lab and bench scale study respectively, M/s NRL engaged the services of M/s EIL for preparing a Detailed Feasibility Report (DFR) for setting up a grass root De-waxing/ De-oiling Unit for the production of Paraffin and Semi-Microcrystalline Waxes (SMCW) at NRL, Numaligarh.

Following the DFR prepared by M/s EIL, M/s NRL proposes to set up 43,300 TPA of Type-1 Wax and 4500 TPA of Micro Crystalline Wax within existing refinery from MVGO and HVGO feed. As per earlier schedule, the project was to be mechanically completed in 49 months. But due to some advance action initiated, the revised schedule is of 42 months from the date of approval, out of which 2 months have been considered for commissioning activities.

This project is proposed to be implemented on Engineering Procurement & Construction Management (EPCM) basis wherein NRL shall engage consultants for process design, detailed engineering, procurement, inspection and expediting. Construction supervision at site and commissioning assistance, placement of orders and award of contracts shall be done by NRL. Time schedule of 42 months for implementation of project has been envisaged from the zero date i.e., the date of Go Ahead after receipt of process packages for units, viz., De-oiling and De-waxing Unit and Hydro Finishing Unit and connected utility offsite packages.

2.1 NUMALIGHRAH REFINERY

2.1.1 Configuration

The refinery configuration has been selected based on the following objectives:

a. Value addition for the product slate per unit of investment
b. Maximum production of middle distillates to meet the deficiencies in the country in general and North-eastern and northern regions in particular.

c. Minimum fuel oil production
d. Up-gradation of the residue to the maximum possible extent and with scope of manufacturing more products in future.
e. Quality of the products and proven / established technologies

Considering various alternatives, the Hydrocracker technology has been selected for the secondary processing unit for production of premium quality SKO/ATF & HSD.

2.2 PROPOSED PROJECT

The proposal relates to set up a grass-root De-waxing / De-oiling Unit for production of paraffin and SMCW at existing refinery. Following new units have been envisaged for the proposed project:

- De-waxing & De-oiling Unit
- Hydro-finishing Unit
- Slabbing & Washing Unit and
- Warehouse

2.2.1 Feed Characteristics

The feed obtained from Vacuum Distillation Unit for the proposed project have following characteristics:

Feed	TBP Cut (°C)	Feed Rate
MVGO	351.6-485.7	28.20 TPH
HVGO	344.-581.7	23.32 TPH

2.2.2 Product Details

The following products would be produced in blocked out mode:

Products	Type	Capacity	On-stream days
Paraffin Wax	I	43,300 TPA	260
Semi Microcrystalline Wax	A	4500 TPA	40

Alternatively,

Products	Type	Capacity	On-stream days
Paraffin Wax	I	50,000 TPA	300

2.2.3 Product Characteristics

The characteristic of the end product is as under:

Product	Type	M. Pt. (^oC)	Oil Content (Wt. %)	Specification
Paraffin Wax	I	61.0	0.1	BIS:4654-1593
Semi Micro-crystalline	A	67.0	0.3	BIS:13833-1993

(a) Paraffin Wax

Paraffin is the common name for the hydrocarbons with general formula C_nH_{2n+2} (Alkanes). It is mostly found as a white, odourless, tasteless, waxy solid, with a typical melting point between 47^0C to 64^0C and having a density of around 0.9 g/cm^3. It is insoluble in water, but soluble in ether, benzene and certain esters. Paraffin is unaffected by most common chemical reagents, but burns readily. It is an excellent electrical insulator, with an electrical resistivity of between 10^{13} and 10^{17} ohm meter.

Paraffin wax ($C_{25}H_{54}$) is an excellent material to store heat, having a specific heat capacity of 2.14-2.19 $Jg^{-1}K^{-1}$ and a heat of fusion of 200-220 Jg^{-1}. This property is exploited in modified dry wall for home building material. It is infused in the dry wall during manufacture so that, when installed, it melts during the day, absorbing heat, and solidifies again at night, releasing the heat. Paraffin wax is used in making Candles, Textiles, Cosmetic, Yarns, Plastic, Paper, Rope, Pencil, Waterproofing, Packaging and even in some food stuffs.

(b) Semi Microcrystalline Wax

Semi Microcrystalline Waxes are derived from the refining of heavy distillates from lubricant oil production by de-oiling petrolatum (petroleum jelly) as a part of the petroleum refining process. Depending on the end use and desired specification, the product then may have its odour removed and colour removed. This is usually done by means of a filtration method or by hydro-treating the wax material.

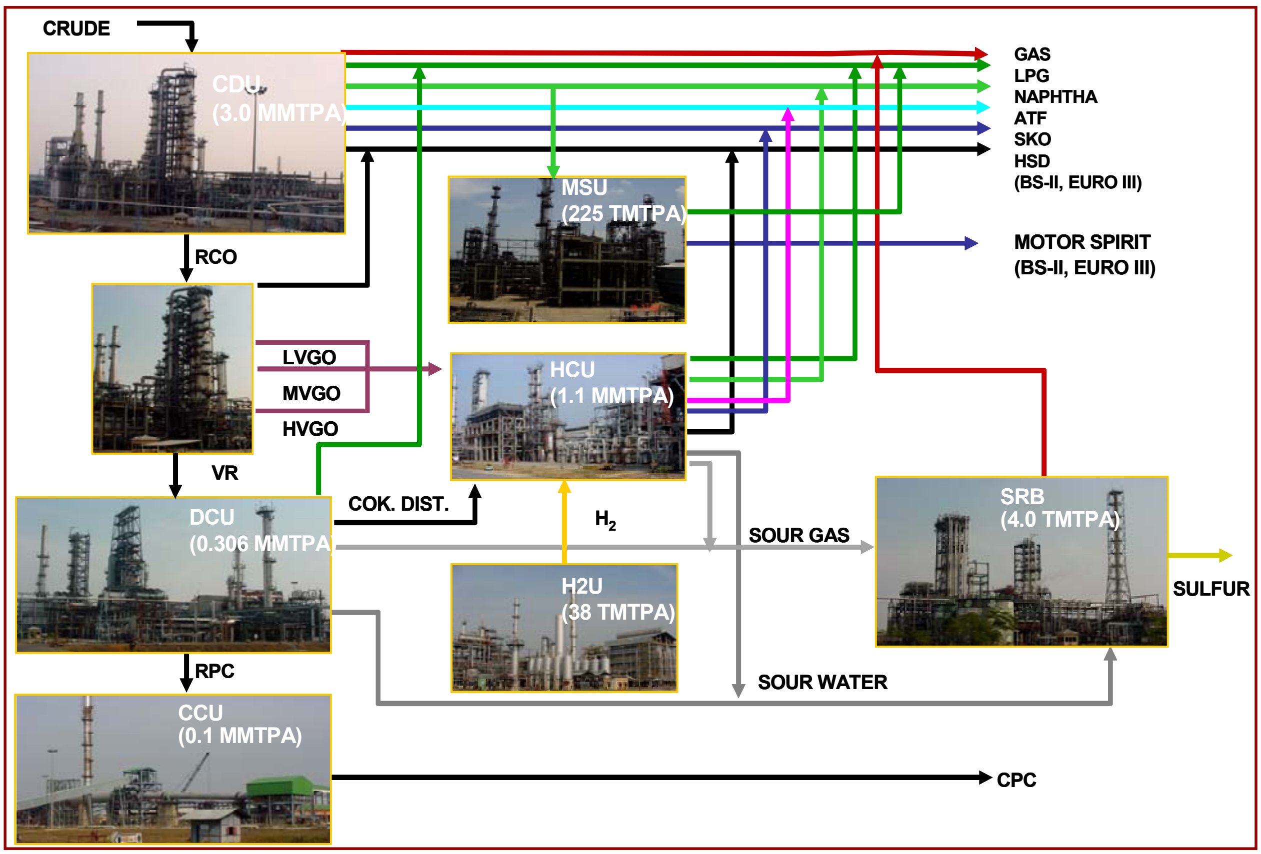
In contrast to the more familiar paraffin wax which contains mostly un-branched alkanes, microcrystalline wax contains a higher percentage of iso-paraffinic (branched) hydrocarbons and naphthenic hydrocarbons. It is characterized by the fineness of its crystals in contrast to the large crystals of paraffin wax. It is generally darker, more viscous, denser, tackier, and more elastic than paraffin wax and has a higher molecular weight and melting point. The elastic and adhesive characteristics of micro crystalline waxes are related to the non-straight chain components which they contain. Typical semi microcrystalline wax crystal structure is small and thin, making them more flexible than paraffin wax. It is commonly used in cosmetic formulations.

Microcrystalline waxes can generally be put in two categories: "Laminating Grades" and "Hardening Grades". The laminating grades typically have a melting point of 140-175^{0}F and needle penetration of 25 or above. The hardening grades ranges from about 175-200^{0}F and have a needle penetration of 25 or below. Colour in both grades can range from brown to white, depending on the degree of processing done at the refinery level.

2.3 PROCESS DESCRIPTION

2.3.1 Flow Diagram of NRL

A Flow Diagram of refinery is depicted below:



2.3.2 Process Description of Proposed Wax Project

The function of the de-waxing / de-oiling unit is to produce Paraffin and SMC Waxes from two different feed stocks in blocked out operation employing MIBK as the de-oiling solvent (> 98% purity, commercial grade).

The two designed feed stocks for the unit are:

(1) MVGO obtained from Vacuum Unit
(2) HVGO obtained from Vacuum Unit

Wax re-crystallization, such as wax sweating, separates wax into fractions and the process makes use of the different solubility of the wax fractions in a solvent such as ketone.

More generally, 3 main molecules are used in modern refinery technology:

1. Solvent de-waxing in which the feedstock is mixed with one or more solvents, then the mixture is cooled down to allow the formation of wax crystals, & the solid phase is separated from the liquid phase by filtration.
2. Urea de-waxing, in which urea forms adducts with straight-chain paraffin that was separated by filtration from the de-waxed oil.
3. Catalytic de-waxing, in which straight-chain paraffin hydrocarbons are selectively cracked on zeolite-type catalysts, and the lower boiling reaction products are separated from the de-waxed lubricating oil by fractionation.

The proposed wax plant has selected the process of solvent de-waxing by using Methyl Iso-butyl Ketone (MIBK) as solvent which would be recycled in the process.

The proposed wax plant shall have following main units:

I. De-waxing and de-oiling unit
II. Hydro-finishing Unit
III. Slabbing & Washing Unit and warehouse

(I) De-waxing and de-oiling unit

The De-waxing / De-oiling Unit of proposed wax project consists of following six sections:

a) Chilling Section
b) Filtration Section

c) De-waxed Oil Solvent Recovery Section
d) Slack Wax Solvent Recovery Section
e) Refrigeration Section
f) Inert Gas System

(a) Chilling Section

In Chilling Section, the feed obtained from storage is first heated above its cloud point in order to dissolve any precipitated waxes which may be present. The feed heating is done in the LP Steam Heater where the feed is heated to 70-80^{0}C. This is followed by controlled cooling and chilling of the feed in the subsequent exchangers. The feed cooling circuit consists of a feed cooler to cool the feed to nearly 55^{0}C using cooling water before feeding it to the DP Exchanger/ Chiller train. Feed temperature to DP Exchanger/ Chiller trains is maintained by a temperature controller, provided down-stream of feed cooler. Feed chilling up to filtration temperature (5^{0}C) is done in two parallel trains of DP scrapped surface exchangers followed by two parallel trains of chillers. Primary filtrate obtained from primary filters is used as the chilling medium in DP exchangers. Final feed chilling is done in DP chillers, which employ refrigerant for achieving the desired cooling. During feed chilling, dilution solvent is added at various points along the DP exchanger/ chiller trains to reduce the viscosity of the charge mix and hence the pressure drop in the chilling trains. The dilution temperature is kept nearly the same as the charge mix temperature at the injection point. Re-pulp filtrate is used as dilution solvent.

(b) Filtration Section

The wax crystals are separated from the chilled feed by primary filters. The re-pulp or secondary filter performs the second stage filtration in order to further reduce the oil content in wax to the desired level. The liquid to solid ratio of the feed to primary and secondary filters is adjusted by filtrate recirculation to promote easier filtration. The chilled charge mix obtained from DP exchangers and chillers flows to primary filter feed drum which is blanketed with inert gas. The feed to each individual primary filter flows by gravity from the drum. The vacuum produced by inert gas vacuum compressor draws the filtrate through the filter cloth and deposits the wax crystals on the filter cloth during the filtering of the cycle. The primary filtrate is pumped by the primary filtrate pump to the chilling section for cold recovery. The inert gas from primary filtrate receiver flows to the inert gas compressor through inert gas drip pot to eliminate any entrained liquid.

The wax cake formed on the filter cloth is washed with chilled solvent as it emerges from the liquid slurry. Following cake washing, the cake is dried by inert gas drawn through the filter cloth. The dry cake is then discharged with blow gas to rotating scroll conveyer which takes wax to wax boot. The dilution solvent is added to the boot for wax re-pulping. This serves two purposes. Firstly, it helps in washing additional oil from the wax and secondly it renders the slurry sufficiently fluid for pumping. The primary wax mix from primary filters is pumped by the respective primary filter boot pumps to the secondary filter. The slurry is diluted with recycled secondary filtrate in order to achieve the desired liquid to solid ratio. During filtration, the secondary filtrate obtained is collected in the secondary filtrate receiver where it is refrigerated from inert gas. The secondary filtrate is pumped by secondary filtrate pump to chilling section for incremental dilution and to the secondary filter feed for feed dilution.

The wax cake is washed, dried and collected in the secondary filter boot as is done in the primary filter. The wax mix drawn from the secondary filter boot is pumped by the filter boot pumps to slack wax solvent recovery section after being heated in the wax mix MP steam heater. A part of the heated wax mix is recycled back to the individual secondary filters boot to maintain the desired operating temperature and hence fluidity of wax slurry for pumping.

Provision has been kept in the design for cold backwashing of the primary as well as secondary filters. This will help in reducing the frequency of filter hot washing and hence filter down-time. Secondary filtrate drawn from secondary filtrate receiver is used for cold back-washing of the filters by cold back wash pumps. The cold back washing of the filters is done periodically and can be accomplished during normal running without interfering with filtration operation.

(c) De-waxed Oil Solvent Recovery Section

The de-waxed oil (DWO) solvent recovery section consists of three stages, flashing followed by steam stripping. The different stages are to be operated at the following conditions:

Stages	Operating Pressure (Kg/cm^2a)
Atm. Flash	1.34
MP Flash	2.8
HP Flash	4.2
Steam Stripping	1.2

The primary filtrate from feed mix chilling section is sent to DWO solvent recovery section to recover solvent from the de-oiled wax. Here the primary filtrate is first preheated by solvent vapours obtained from atmospheric and pressure flash columns in exchanger and followed by final heating in the LP steam heater before feeding to the atmospheric flash column, MP flash column and HP flash column, join after exchanging heat in exchangers and are sent to the Atmospheric Solvent Cooler where liquid solvent is cooled to 40^0C. The cooled solvent and water from solvent cooler is routed to solvent water separator drum where solvent and water are separated. The solvent flows to dry solvent receiver whereas the water containing equilibrium quantity of solvent is sent to Azeotrope Column after being heated by Azeotrope Colum Feed Bottom Exchanger. Solvent contained in Azeotrope Column is stripped off by steam and the solvent vapours along with steam and condensed in solvent condenser and routed to solvent water separator.

Fresh make-up solvent is pumped to dry solvent receiver drum by make-up solvent pump. Dry solvent is sent to chilling and filtration section by solvent dilution and reflux pump.

The de-waxed oil obtained from the bottom of atmospheric flash column is pumped by the DWO atmospheric flash bottom pump to DWO MP flash column after preheating in DWO mix/ HP flash vapour exchanger followed by DWO Mix/ Foots oil exchanger. The separated vapours from column top are also sent to atmospheric solvent cooler after exchanging heat with primary filtrate in exchanger. The bottom liquid from column is routed to DWO HP flash column through pump after preheating in DWEO mix heater. The HP flash column operates at 4.2 Kg/cm^2 a pressure. The liquid from HP flash bottom is fed to DWO stripper under its own pressure for final solvent stripping. The solvent vapours from HP flash column are sent to atmospheric solvent cooler after exchanging heat with MP flash column feed. Vapours from DWO stripper are routed to solvent condenser. In DWO stripper the last traces of the solvent are recovered by steam stripping. The de-waxed oil from the stripper bottom called Foots Oil is sent to storage tank through DWO stripper bottom pump after heat recovery and cooling in the DWO Mix/ Foots Oil exchanger and finally to Foots Oil Cooler respectively.

(d) Slack Wax Recovery Section

The slack wax solvent recovery section consists of single stage flashing followed by steam stripping. The different stages are to be operated at the following conditions:

	Operating Pressure (Kg/cm^2 a)
Flash Column	1.3
Steam Stripping	1.2

The wax mix after preheating in wax mix LP Steam is routed to wax mix surge vessel which is equipped with heating coil. The wax mix is pumped by wax flash column feed pump to slack wax flash column after pre-heating in a series of exchangers. The wax mix is first pre-heated by SW mix flash vapour exchanger and finally by MP steam in exchanger. The flashed solvent recovered from column top after heat recovery is routed to Atm. solvent cooler. The wax mix obtained from column bottom is fed by gravity to wax stripper. The last traces of solvent are recovered in the stripper by steam stripping. The wet solvent vapours from stripper top are routed to solvent cooler and then to solvent separator for further processing. The wax product obtained from stripper bottom is sent to storage through wax stripper bottom pump after being cooled in tempered water cooler.

In solvent water separator the wet solvent from various sources is collected and water & solvent phases are allowed to separate. The water rich phase is pumped to waste water stripper column through column feed pump. The stripped solvent vapours obtained from column top by steam stripping are condensed in solvent condenser and routed to solvent water separator drum. The waste water obtained from waste water stripper column bottom is routed to oily water sewer (OWS).

(e) Refrigeration Section

The typical refrigeration cycle serves as a utility to provide the chilling medium for the feed-stock and the solvent. Refrigerant R-22 is proposed to be used as refrigerant and is utilized for the following purposes:

a) Charge mix chilling in the DP chillers

b) Solvent chilling solvent chiller

c) Inert gas chilling in IG chiller

(f) Inert Gas Section

This section consists of the following facilities:

a) Inert Gas Generator

b) Inert Gas Holder

c) Inert Gas Compressor

The inert gas is primarily used for filtration and remains in circulation in a closed loop comprising of primary and secondary filters, Primary and Secondary Filtrate Receivers, Inert gas pot and inert gas vacuum compressor. Inert gas is also used for blanketing purposes in filters, solvent tanks etc. This prevents solvent losses as well as fire hazards by eliminating the contact of solvent with air.

(II) Hydro-finishing Unit (HDFU)

The objective of the hydro-finishing unit is to obtain a Type-I paraffin wax from the wax ex-MVGO, as per BIS 4654:1933.

This unit will also produce Type -A micro-crystalline wax (MCW) from wax ex-HVGO as per BIS 13833:1993.

Hydrogenation is performed under pressure, in a fixed bed reactor over a specific catalyst.

Products	Type	Drop Melting Point (^{0}C)	Specification
Paraffin Wax	I	45-75	BIS 4654:1933
Semi Microcrystalline Wax	A	65-70	BIS 13833:1993

(III) Slabbing & Washing Unit

Wax produced shall be taken to Slabbing & Washing unit where the final product will be made in the form of slab for subsequent weighing, packing and storage.

2.3.3 Product Streams

The product streams may be summarized as under:

Streams	Pressure, Kg/cm^{2}g		Temperature, ^{o}C		Destination
	O.P.	Mech. Design	O.P.	Mech. Design	
Paraffin Wax	4.0	14.0	80	150	OSBL Storage
Semi-MCW	4.0	14.0	80	150	OSBL Storage
Foots Oil	4.0	15.0	45	150	OSBL Storage

2.3.4 Storage Facilities

The following storage is envisaged within unit battery limit:

Name of Tank	No. x Cap.(m^3)	MOC	Design Temp. (^oC)
Slop Tanks	2 x 100	KCS+1.5 mm CA	150
Solvent Tank	2 x 100	KCS+1.5 mm CA	65
Finished Wax Product	4 x 500	KCS+1.5 mm CA	150
Semi MC Wax Product	2 x 250	KCS+1.5 mm CA	150
De-oiled Paraffin Wax	2 x 1500	KCS+1.5 mm CA	150
De-oiled Semi MCW	2 x 1500	KCS+1.5 mm CA	150
HVGO	1 x 1500	KCS+1.5 mm CA	150
MVGO	1 x 1500	KCS+1.5 mm CA	150

2.3.5 Utilities

i. Water Requirement

Additional water requirement for the proposed project is estimated about 60 m^3/hr. The existing infrastructure for water supply is adequate to meet the additional requirements.

ii. Cooling Water System

A new Cooling Tower of one cell with circulation rate of 1370 m^3/hr has been envisaged for the proposed project.

iii. Effluent Treatment Plant

The waste water generation from the proposed project is envisaged about 8.1 m^3/hr, which shall be added to the existing Effluent Treatment Plant (ETP) having a capacity of 220 m^3/hr. Present waste water generation from various processes at refinery, is about 110m^3/hr.

iv. Satellite Rack Room Building

A new Satellite Rack Room building shall be provided in the west side of De-waxing & De-oiling Unit to house the UPS system for instrumentation requirement.

v. Electrical Sub-Station

A new sub-station shall be provided in the west side of De-waxing & De-oiling Unit.

vi. Plot Area Requirement

Plot area required for various units/ facilities envisaged for the proposed project is as under:

Name of the Unit		Size of Plot area required
De-waxing & De-oiling Unit	:	76 M x 135 M
Hydro-finishing Unit	:	90 M x 60 M
Slabbing & Washing Unit and Warehouse	:	80 M x 40 M
Satellite Rack Room Building	:	32 M x 18 M
Sub-Station	:	48 M x 30 M

vii. Overall Plot Plan

The overall plot plan of the proposed project may be summarized as under:

- The proposed project is envisaged to be located on a plot of about 12.0 hectares area of land within existing Refinery.
- The new facilities proposed under the project have been located keeping in view the process sequence, safety and operation requirements space available and need for future expansion.
- All the facilities are proposed to be laid out in accordance with safety distance as per OISD: 118 and Petroleum Rules 2002 of PESO, Nagpur.

Plate – 2.1
Overall Plot Plan