ISSN: 2639-7536

Case Report

Petroleum and Chemical Industry International

An Innovative Concept of ……. Power Generation from an Integrated Sources of Fuels in a Refinery

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Submitted: 2024, Jun 03; **Accepted**: 2024, Jun 24; **Published**: 2024, Jul 10

Citation: Brahma, D. (2024). An Innovative Concept of ……. Power Generation from an Integrated Sources of Fuels in a Refinery. *Petro Chem Indus Intern, 7*(3), 01-05.

Abstract

• This 2nd paper highlights the case study of Power Generation from an Integrated sources of Fuels in our Post Refinery Expansion scenario.
• It illustrates the beautiful concept & idea of the "Identification and Integration of the available sources of Fuels of Post Refinery Expansion & used them
• Power & Steam generations"
• Numaligarh Refinery Limited (NRL) was established as a Company on 22nd April 1993.
• It's present capacity is 3 MMTPA.
• NRL intends to expand its refining capacity to additional 6 MMTPA due to:
• projected demand growth of petroleum products in the country
• retain its profitability and competitiveness in the long run
• This mega project would also increase the power & steam demands to manifolds
• In view of this, an innovative idea and novel concept was devised to generate power & steam from the available sources of the existing & the upcoming new units in
• the post NRL expansion scenario.
• Now, the problem is …. how it would be possible ……. ???
• How the above scheme would be accomplished ……. ???

Let's see this beautiful 2nd idea and the new innovative scheme with beautiful illustrations of the scheme which would be the first of its kind in our NRL ……..

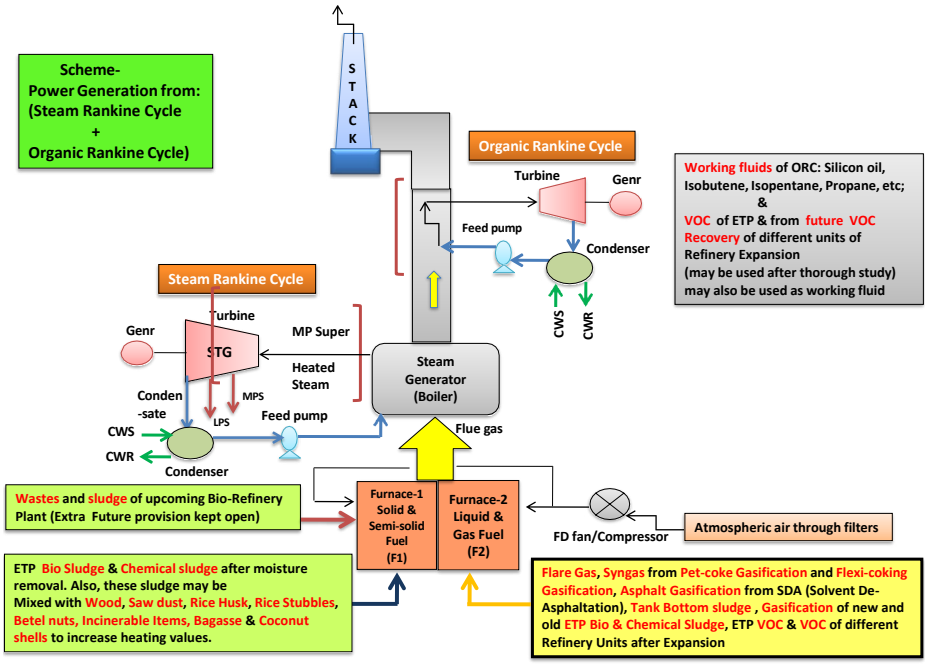

Figure 1: Power Generation from an Integrated Source of Fuels in Post Refinery Expansion

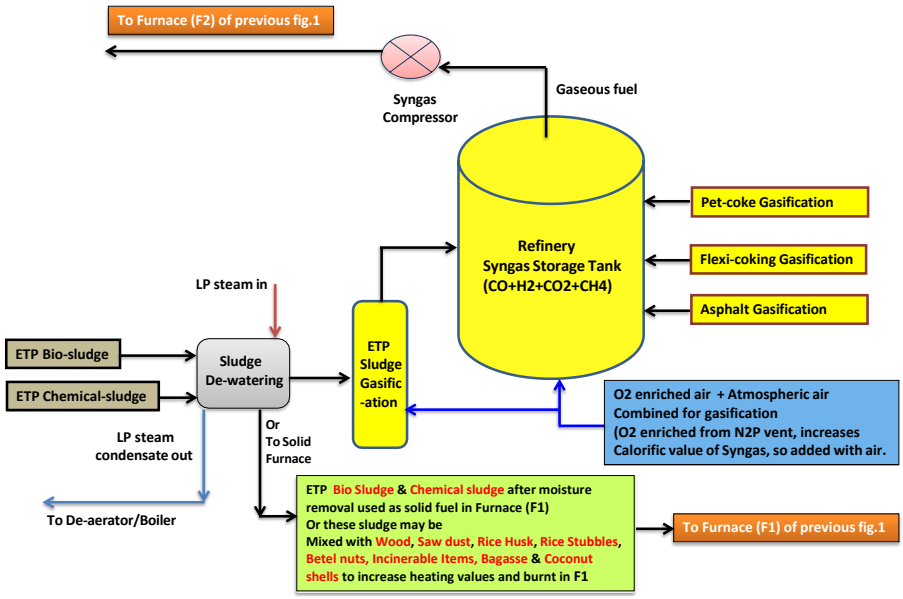

Figure 2: Generation of Syngas from Various Potential Sources in Post Refinery Expansion

1. Power Generation from an Integrated Sources of Fuels of Post Refinery Expansion

1.1 Brief Concept of Idea

• Setting up of a combination of Normal Steam Rankine Cycle and Organic Rankine Cycle

• Generation of Electricity from both these Thermodynamic cycles.

• Location: Preferably at old ETP (availability of floor space), better waste management & convert our ETP into A "Future Power-House Hub of our Refinery " along with the present Process Waste Treatment plant of the Refinery.

• Sources of Fuels: Following re-sources would be integrated into a Combination of Fuels in the Post Expansion of Refinery to generate useful outputs (Power & Steam):

(i) Syngas (Gaseous Fuel)

From Pet-coke Gasification and Flexi-coking Gasification (Syngas is a mixture of Hydrogen+CO+CO_2, & hence is a good source of Fuel).

(ii) Flare Gas (Gaseous Fuel)

In Post Expansion, the mass flow of the flare gas would be much more than the existing Refinery. So, there is a very good potential of it's recovery and use it as a source of combustion.

(iii) VOC of ETP (Gaseous Fuel)

As the ETP capacity would increase, hence it's potential of recovery of Volatile Organic Compound (VOC) would also increase. As VOC is recovered from the surface of the Oil surface of ETP, hence it would contain hydrocarbons in it. So, VOC could also be used as a probable source of Fuel for combustion. Also, VOC could be recovered from other units of the Refinery and combined with this ETP VOC. This would give an extra VOC mass flow.

(iv) Tank Bottom Sludge (Liquid Fuel)

Some portion of the tank bottom sludge could also be used as a source of fuel.

(v) ETP Bio and Chemical Sludge (Semi & Solid Fuel)

• Increase in ETP capacity, so the production of bio and chemical sludge.
• These sludge after removal of moisture could be used as a source of burning.
• To increase the heating values of these sludge, they may be mixed with the other sources like - Wood, Saw dust, Rice Husk, Rice Stubbles, Betel nuts byproducts, & Coconut shells which are readily available in our Refinery neighborhood.
• These sludge may also be mixed with the items which are burnt in our waste incinerator.
• Also, these sludge may also be used in the form of Syngas after Gasification.

(v) Bio-Refinery Wastes and Sludge (Semi & Solid Fuel)

• The wastes generated from our upcoming Bio-Refinery Plant would be utilized as a source of combustion as they contain good amount of heating values.

NB. (O_2 enriched air + Atmospheric air) are Combined for gasification (O_2 enriched of
N2P vent, increases the Heating Value or Calorific value of Syngas, so it is added with air.

Electricity would be produced through two nos. of Thermodynamic cycles: Normal Steam Rankine Cycle and Organic Rankine Cycle, which are explained below:

(a) Steam Rankine Cycle

• The Normal Steam Rankine Cycle will use superheated HP steam as working fluid. produced by the above-mentioned integrated sources of fuels available in our Post Expansion Refinery.
• These fuels are burnt in two different furnaces F1 & F2 as shown in the above diagram.
• F1: In 1st Furnace where the processed Solids & Semi-solids will be put into a combustion.
• F2: In 2nd Furnace where the Gaseous & Liquid Fuels will be put into a combustion.
• The Flue gas produced on combustion will generate Super-Heated High-Pressure Steam
• [HP Steam : 40 kg/cm2 (or ksc)/450 deg C].
• This HP steam will drive the Condensing-cum-Extraction Steam Turbine Generator (STG)
• This will generate Electrical Power in the Generator.
• The Turbine will also generate MP superheated steam (14 ksc/250 deg C) and LP superheated steam (4 ksc/180 deg C).
• MP & LP steam are supplied to the Refinery steam headers.
• Some portion of LP steam would be used to heat and remove the moisture from the ETP Bio and Chemical Sludge. Finally, it is converted into condensate and reused in Boiler.
• he final Turbine exhaust is then condensed in a surface condenser.
• The steam condensate is again sent back to the boiler.
• The cycle is repeated.

(b) Organic Rankine Cycle

• Further the heat of the flue gas is recovered at the downstream of the boiler.
• This recovered heat is used to drive an expansion Turbine to produce Electrical Power output through an Organic Rankine Cycle (ORC).
• Here the organic compound with high molecular mass and lower boiling point
• than water will be used to recover heat from this recovered flue gas at stack inlet.
• The working fluid is vaporized and then expanded in a vapor expansion turbine, that drives generator, producing electricity.
• The Flue gas is then finally goes into the atmosphere through the stack.
• Here, the working fluid may be silicon oil, iso-pentane, propane, etc.
• The Volatile Organic Compound (VOC) of ETP may also be used as a source of this fluid after further feasibility study of the composition and properties of the compound.
• We may recover VOC from other units of our Refinery which will act as a source of working fluid for this cycle.
• Also, these VOCs can be used as a source of gaseous fuel in Furnace F2 and in different furnaces of Refinery after further feasibility study of the composition and properties of the compound.

2. Advantages of the Schemes

• Huge potential of Power generation along with steam.
• Judicious use of the available resources which could be a good source of fuels for combustion like – Syngas, Flare Gas, VOC, Bio Refinery sludge and wastes, nearby areas available sources and finally the big advantage of using ETP Bio & Chemical sludge as fuel sources which are normally dumped in a secured landfill.
• Some sources of earning and livelihood for the nearby residing people.
• Use of nearby areas wastes as fuel sources - Wood, Saw dust, Rice Husk, Rice Stubbles, Betel nuts, Incinerable Items, sugarcane bagasse, Coconut shells
• ETP would be getting a whole new look – "Future Power-House Hub" of our Refinery along with the present Process waste treatment, a completely new concept in the view of the Refinery context.
• Better way of waste management at ETP.
• No more requirement of Incinerator.
• Both old and new ETP wastes could be utilized.

• Recovery and use of VOC of both old and new ETP. Bring into new angles of VOC recovery from other units of the Refinery.
• Reduce health hazards from VOC.
• The new Plants of Expansion Refinery and Flare system lie near to the new & old ETP, so, less transportation cost and easy set up.
• Wastes and sludge of Bio-Refinery would also be utilized.
• Helps to supply some amount of MP & LP steam required in the post Expansion Refinery units.
• Schemes Reduce Specific Energy Consumption of the Refinery.
• Lower Refinery's Energy cost.
• Could be replicated in other Refineries also for Power Generations after detailed
• feasibility study.

Calculation Details:

Refinery Flare Gas (HHV)		
Components	mol%	
CH4	43.6	
H2	5.54	
CO	0.186	
HHV	1806.576	
HHV	18.06	MJ/m3

Syngas (HHV)		
Components	mol%	
CH4	21.51	
H2	13.42	
CO	21	
HHV	1291.707	
HHV	12.92	MJ/m3

NRL Expansion Scenario							
Type	Source	Figure	Unit	MTPA	MTPD	m3PD	HHV (MJ/day)
Syngas	Petcoke	0.364	MMTPA	364000	997.2602741	1049747.657	13562739.73
Syngas	Asphalt (SDA)	0.755	MMTPA	755000	2068.493151	2177361.211	28131506.85
Flare Gas	Flare Gas	5	TPH		120	141176.4706	2549647.06
Syngas	ETP (Bio+Chemical sludge)	1070	TPY		2.931506849	3085.796683	39868.49
Syngas	VOC (ETP)	3000	NM3/Hr		72000	72000	36000.00
	Density of Flare Gas	0.85	kg/m3			Total Energy Available	44319762.13
	Density of Syngas	0.95	kg/m3				
	NB: VOC ETP HHV = 0.5 MJ/m3 (assumption)						

Calculation of Steam & Power Produced		
Taking Utility Boiler (UB) & Steam Turbine Generator (STG) at CPP as reference for calculation		
High Pressure Super-heated steam (HP Steam) at 40 kg/cm2 & 450 deg C		
Total NG fuel required to generate 1 TPH of HP steam in UB	88.00	SCM/H
NG Calorific Value	8472.00	kCal/SCM
Total Energy required to generate 1 TPH of HP steam	745536.00	kCal/H
Available Heat Energy from all the Fuels	10592423148.43	kCal/day
Available Heat Energy from all the Fuels	441350964.52	kCal/H
So, total HP steam generated by the available energy	591.99	TPH
Now, STG HP steam consumption at FSNL	7.00	TPH
STG HP steam consumption per MW	4.50	TPH
So, HP steam left for Power generation after FSNL	584.99	TPH
Finally, Power generated by 584.99 TPH HP steam	130.00	MWHr
Power generated in 1 day	3119.95	MW/Day
Savings per day	8361478.31	rupees/day
Savings per year	3051939581.97	rupees/year

Thus ……. “What is now proved was once only imagined.”– William Blake……. is rightly proved herewith.

This Innovative & Novel concept of Co-Generation Plant would indeed be a Game Changer in the Power sector of our future post NRL expansion configuration. It could be replicated in other Refineries also for Power Generations after detailed feasibility study.