



IndianOil

R&D

The Power of Possibilities

Innovated in India
for the **World**

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From the Desk of Director (R&D)



It gives me immense pleasure to present to you this compilation that showcases the basket of technologies innovated & commercialized by IndianOil R&D across domains of refining, pipeline transportation, industrial biotechnology, etc.

What started way back in 1972 as a drive to indigenize the lubricant technology especially for defence forces, has now translated into creating a Superbrand and Masterbrand, namely SERVO, which holds leadership position in the midst of stiff competition from national and multinational players.

In the course of time, we have created formidable research infrastructure in the domain of refinery processes that has resulted in development of a sizeable basket of refinery technologies. IndianOil has developed & commercialized a large number of cutting-edge technologies for refinery processes and catalysts, for setting up greenfield and brownfield refineries. These world-class refining process & catalyst technologies boost product yields & performance and give refiners better flexibility & margins. INDMAX being our flagship refining technology, IndianOil R&D has a formidable portfolio of technologies for residue upgradation, product quality improvement, octane boosting, and sulphur reduction, as well as for production of petrochemical feedstock.

Our Pipeline research, commensurate with our growing footprint of cross-country pipeline network, has breached the highly guarded technology monopolies and innovated world-class inline inspection tools as well as drag reducing

agents. Keeping abreast with trends in sunrise energy domain, we have added state-of-the-art research infrastructure in the areas like petrochemicals and nanotechnology. We also have on offer cutting edge technologies in Hydrogen blending / dispensing as well as industrial bio-technology.

Living by the credo of Innovation, IndianOil's core corporate value, IndianOil R&D has breached the 1550-patent filing mark. With a dream to power India's technological self-reliance, IndianOil is keen to see you reap the rewards from these world-class technologies. We are driven by innovation & a desire to make our world a cleaner place. We'll happy to power your journey!

A handwritten signature in black ink, appearing to read 'Dr. SSV Ramakumar' with a stylized flourish at the end.

-Dr. SSV Ramakumar

About IndianOil

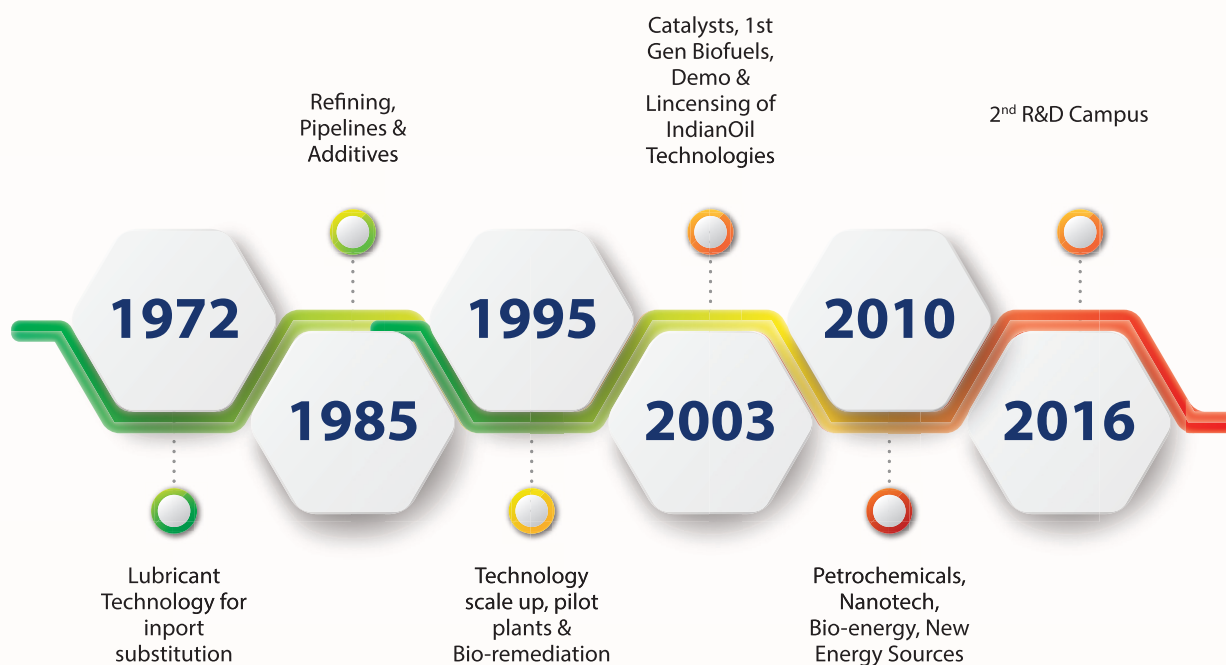
IndianOil is India's flagship national oil company with business interests straddling the entire hydrocarbon value chain - from refining, pipeline transportation and marketing of petroleum products to exploration & production of crude oil & gas as well as marketing of natural gas and petrochemicals. India's highest ranked Energy PSU in Fortune 500 list (Rank 212), IndianOil recorded Revenue from Operations of ₹7,28,460 crores and a net profit ₹ 24,184 crores for the financial year 2021-22.

About IndianOil R&D

IndianOil's sprawling R&D Centre near the National Capital is one of Asia's finest in downstream petroleum research, development and commercial deployment. Since inception in 1972, IndianOil R&D has been developing world-class technology, refining process solutions and innovative products. With five decades of pioneering work in lubricants formulation, refinery processes and pipeline transportation, IndianOil R&D has over 1500 patents.

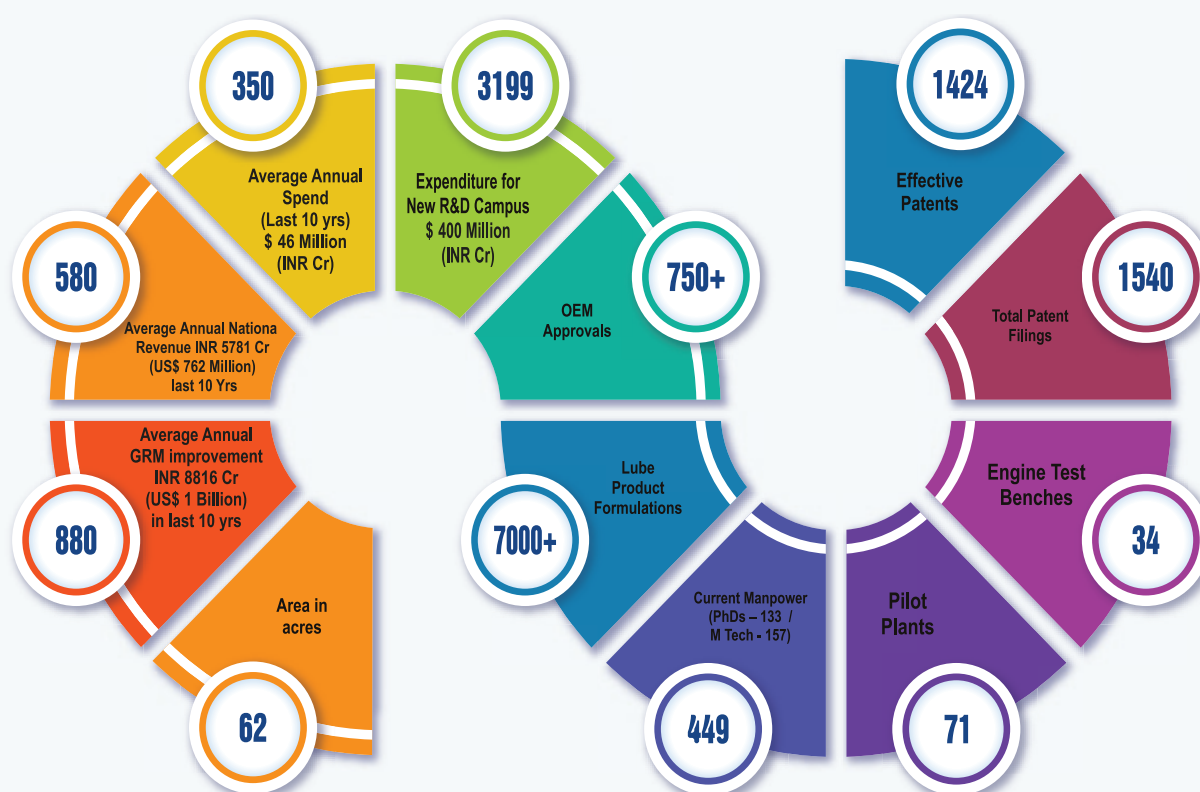
Evolution of R & D

Year of Inception - 1972



With a patent filing rate of nearly two per week, it enjoys the highest technology commercialisation rates in the world. World-class modern analytical laboratories at IndianOil R&D are equipped with more than 50 state-of-the-art spectroscopic, chromatographic and microscopic equipment to analyze all kinds of petroleum products.

IndianOil R&D at a Glance

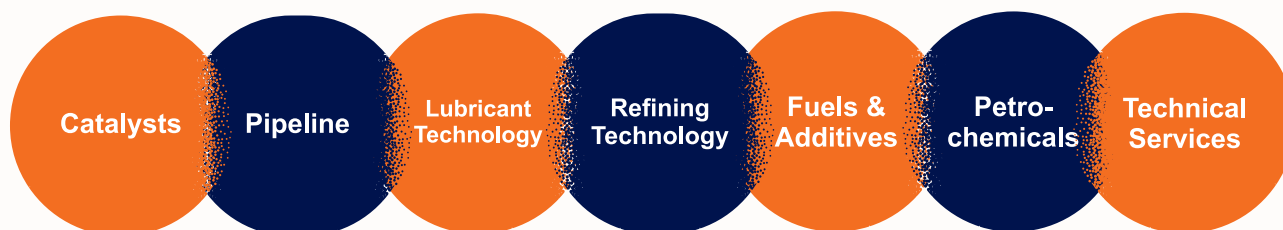


The cutting-edge research in tribology is showcased by IndianOil's *SERVO*® product line comprising more than 7,000 lubricant & grease formulations and over 800 active grades to suit virtually every conceivable application. In addition, the Centre has also developed several refinery process technologies and catalysts especially suited to Indian conditions. The Centre's basket of technologies and research work includes alternative energy programmes in Bio-energy, Solar energy, Hydrogen H-CNG blends, Synthetic fuels and shale oil. It is also focussing on cutting-edge research in nanotechnology, Petrochemicals & Polymers, Coal Gasification/Liquefaction and gas-to-liquid technologies. IndianOil R&D is also nurturing an ecosystem conducive for innovations in the domestic hydrocarbons sector through a Start-up Fund.

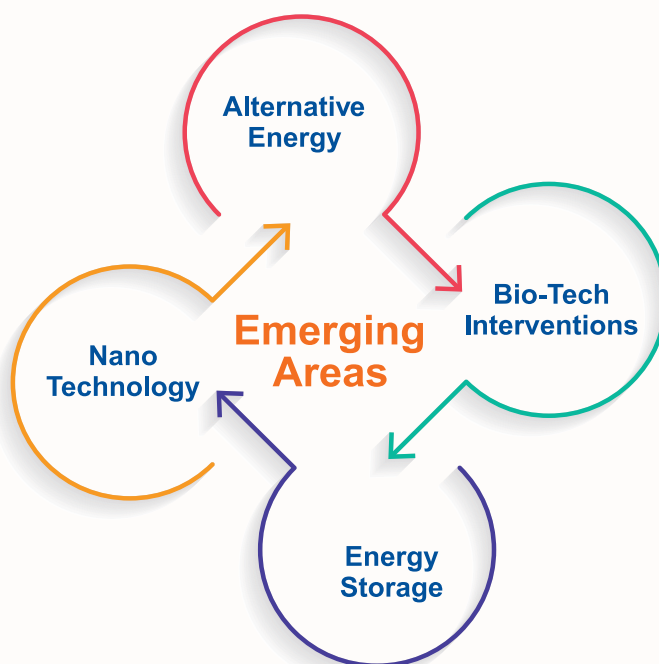
For more details, please visit <https://iocl.com/pages/r-and-d-centre>

Key Research Areas

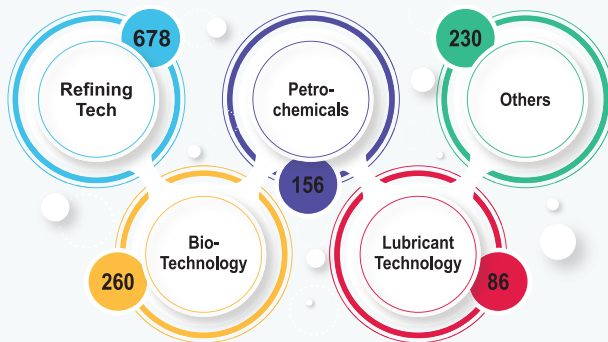
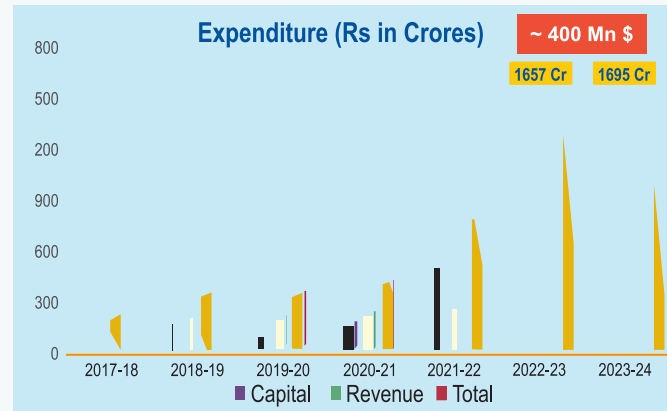
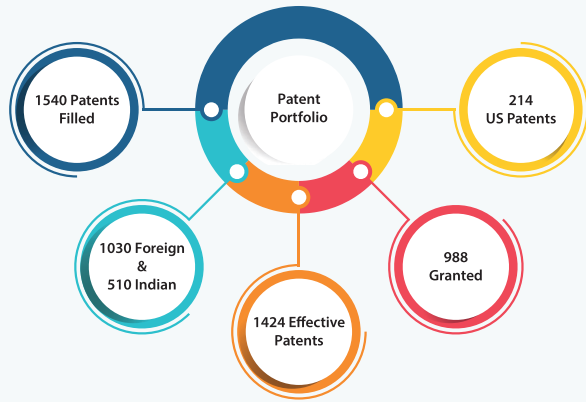
CORE AREAS



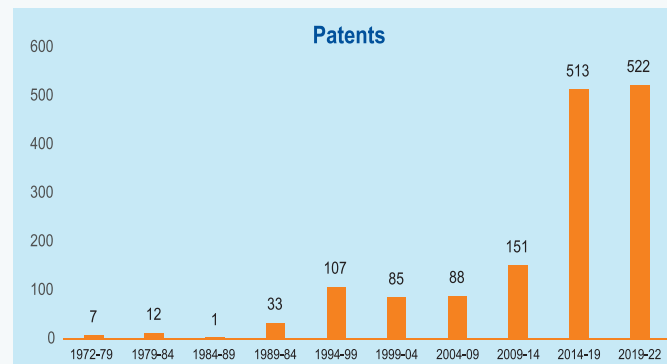
Emerging Areas



R&D Intensity-Key Indicators



*(as of July 2022)





INDMAX Technology
Light Olefins Maximization

INDMAX Technology

Higher yields of Light Olefins/LPG & High Octane Gasoline From Heavy Hydrocarbon Streams

Demand for propylene is continuously increasing and it is envisaged that propylene market share will grow fast. Production of propylene from conventional sources can no longer meet the demand in such a scenario. On the other hand, the demand of heavy distillate (fuel oil) is decreasing. Therefore, the biggest challenge for refiners is to upgrade the residual streams/ bottom-of-the-barrel to lighter & valuable products for improving Refinery profit margin.

INDMAX, a flagship technology developed by IndianOil R&D, helps refiners to produce higher yields of light olefins / LPG and high-octane gasoline from various resid / non-resid feedstocks. Due to its capability in achieving higher conversion along with selectivity towards lighter olefins, implementation of this technology enables seamless integration of refinery with petrochemicals complex.

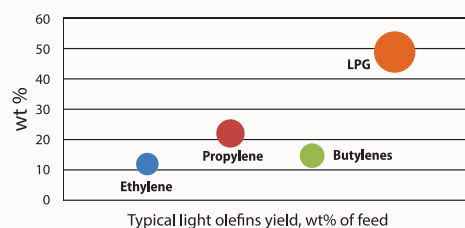
INDMAX employs circulating fluidized bed Riser - Stripper - Regenerator configuration similar to conventional FCC technology with single-stage full combustion Regenerator system. The catalyst system, operating conditions and hardware components employed in INDMAX process are customized to yield desired products and the process is different from the conventional FCC technology.

Currently, INDMAX technology is licensed worldwide by Lummus Technology LLC, USA in collaboration with IndianOil.



Salient Features

- INDMAX technology employs proprietary catalyst system with higher metal tolerance, higher selectivity towards light olefins and lower dry gas yield.
- Higher conversion and better heat balance is achieved through highly efficient hardware components such as Micro-Jet™ Feed injector, ModGrid® stripper internal, Direct-coupled cyclone separator, MSO™ distributor, etc.
- With the combined effect of INDMAX Catalyst and hardware design, the unit is designed with single-stage full burn Regenerator for high CCR feedstocks up to 6 wt% without catalyst cooler.





Major Benefits

- Gasoline from INDMAX unit has a higher octane number (RON > 95) as compared to conventional FCC.
- Extraction of Toluene & Xylene from gasoline helps improve refining margin.
- Capable of handling wide range of feedstock as well as operation in different modes to maximize propylene or gasoline yield depending on demand.
- Robust and high performing design of INDMAX unit based on proven experience of more than three decades in research, technical services, revamp, troubleshooting, optimization, etc. along with wide operating experience of Catalytic Cracking units.
- Equipped with Pilot plant facilities, advance testing & catalyst evaluation facilities.

Commercial Experience

Commissioned Units

- 100 KTA unit commissioned in 2003 in one of the Indian refineries, which was subsequently revamped to 150 KTA in 2016
- A mega scale unit of 4.17 MMTPA for production of propylene as feedstock to petrochemicals complex commissioned in 2015 in India
- A grassroots unit of 0.74 MMTPA capacity with residue feed with CCR ~ 4 wt% commissioned in 2020 and Performance Guaranteed Test Run (PGTR) of the Unit successfully completed in December, 2021 in one of the Indian refineries to eliminate black oil production and improve LPG and distillate yields.

Upcoming Units

- Four grassroots units of 2-3 MMTPA capacities, handling feeds ranging from hydrotreated VGO to residual feed (CCR ~ 5wt %), are under various stages of implementation in different Indian refineries. The prime objective of all these units is maximization of propylene as feedstock to petrochemical complex.
- Revamp of two-stage RFCC unit to 1.7 MMTPA unit with propylene maximization is under progress in one of the Indian refineries.
- Revamp of FCC unit to 0.66 MMTPA for propylene maximization is under progress in one refinery in Europe
- Cumulative capacity of licensed INDMAX units is 17.2 MMTPA (345 KBPSD).





indLPet
LCO Upgradation Process

indLPet®

Production of Petrochemical Feedstock (Alkylated Benzenes) from LCO

The installed capacity of Fluid Catalytic Cracking (FCC) units in India as well as Asia Pacific region is increasing due to increasing production of Petrochemical feedstocks. This results in production of higher quantity of Light Cycle Oil (LCO) stream.

As on today, LCO stream is routed to HSD pool after processing in Diesel Hydrotreating (DHDT) unit for reduction of sulphur and associated improvement in Cetane. Due to higher concentration of aromatics, the improvement in Cetane of LCO stream on standalone basis is much lower than other diesel range streams (Straight Run Gasoil, Coker Gasoil, etc.) even at higher pressure and with higher chemical hydrogen consumption.

Considering this, indLPet technology has been developed by IndianOil R&D for conversion of LCO from FCC / INDMAX units to aromatic rich naphtha suitable for processing in Aromatics Complex producing BTX. In case of non-availability of Aromatics Complex, the technology can be employed for production of high octane gasoline stream of RON in the range of 95-97.

With changing global energy scenario and focus shifting towards crude-to-chemical (CTC) configuration, indLPet® technology will integrate refinery and petrochemical complex. This technology will play a major role for increasing overall petrochemical yield in future CTC configurations.

Salient Features

- Simplified configuration similar to conventional DHDS/DHDT
- Low operating pressure (40-60 kg/cm²g)
- CAPEX is comparable to DHDS unit
- Process can handle wide range of LCO feedstock with total aromatics in the range of 70 - 98 wt %
- Flexibility of operation in different modes to produce either petrochemical feedstock or high octane gasoline depending on client's requirement
- Proprietary catalyst with attractive run length



indLPet
LCO Upgradation Process

Major Benefits

- Possible to revamp existing DHDS/DHDT units
- Production of high aromatics Naphtha suitable for routing to Aromatics Complex for production of BTX or direct blending into MS pool without further treatment
- Unloading of LCO from existing DHDT units thus improving catalyst run length and overall unit performance
- Highly attractive in refineries with petrochemical integration, especially in 'Crude-to-Chemicals' configuration

Commercial Experience

- Wide operating experience with commercial Hydroprocessing units
- BDEP prepared for revamp of DHDS to indLPet in one of the Indian refineries



Delayed Coking

Conversion of Residue to Distillates

Globally, crudes are becoming heavier, yielding higher amount of residues and shrinking refinery margins. Delayed Coking is a severe thermal cracking process for converting low value heavier residue to lighter products with rejection of metals and Conradson carbon into coke. The ability of this technology to convert heaviest residue streams provide the much-needed flexibility to refiners to process a wide variety of crude oil and therefore, is the most widely used process all over the world.

IndianOil and Engineers India Ltd. (EIL) have jointly licensed the Delayed Coker technology by synergizing individual technological strengths. IndianOil R&D has the capability to estimate product yields, process conditions and product properties based on its state-of-the-art pilot plant and process simulators. EIL has global experience of process design and engineering for both open-art and licensed units.



Salient Features

- Minimization of shot Coke formation by optimising process parameters
- Design of Coke drum cycle from 16-24 hours
- 'Pit & Pad' combination for Coke handling, minimizing drum structure height
- Automatic top and bottom un-heading valve for operator safety
- Closed blow-down to minimize air pollution, water re-use (Maze system) & hydrocarbon recovery during drum cooling.
- Efficient fired heater design ensuring:
 - ▶ Reduction in ratio of peak flux to average flux in radiant section by ~ 30%
 - ▶ Uniform heat distribution
 - ▶ Lower heat transfer area
 - ▶ Shorter residence time and lower pressure drop
- Processing of Refinery waste sludge in Coker for its disposal

Major Benefits

- Safe, reliable and well-proven technology
- Conversion of low-value residue to distillates with moderate capital investment
- Processing of a wide range of feedstocks - offers flexibility to enhance refinery margin through processing cheaper crudes
- Design of Fuel as well as Anode grade Cokers depending on feed quality

Commercial Experience

Commissioned Units

- Wide operating experience with commercial Delayed Coker units
- Technical support and troubleshooting expertise
- Revamp of Delayed Coker of 0.6 MMTPA in one of the Indian refineries (Coke reduction by ~ 4 wt% with corresponding distillate yield improvement and energy savings in the range of 30-40%)

Upcoming units

- Revamp of 0.5 MMTPA DCU unit by 130% in one of the Indian refineries by 2023-24





Ind-Coker^{AT}
Minimizing coke yield

Ind-Coker^{AT}

Residue Upgradation with Lower Coke Yield

Refineries all over the world are increasingly processing heavier crudes for maximization of refinery margins. As a result of this, Delayed Coking Units have gained importance for bottom-of-the-barrel upgradation to improve profitability. However, high yield of low grade Coke from the Delayed Coking is a bottleneck in improving the refinery margin further.

To enhance profitability in thermal cracking process, IndianOil R&D has developed Ind-Coker^{AT} technology, for residue upgradation with lower Coke make & superior distillate yields in comparison to the conventional Delayed Coker technology. Apart from significant improvement in the refining margins, ease of integration with existing Delayed Coker unit and its implementation with minimum investment provide an additional advantage.

Salient Features

- Technology can be implemented in existing Delayed Coker Unit as well as grassroots unit
- Operational flexibility due to Dual mode operation (either Ind-Coker^{AT} or Coker mode)
- Refinery waste sludge can be processed for disposal

Major Benefits

- Reduction in Coke yield and increase in distillate yield compared to conventional Delayed Coker Unit
- Higher conversion of low-value residues to distillates with minimum capital investment
- Processing of wide range of feedstocks: Offers flexibility to enhance refinery margin by processing cheaper crudes

Commercial Experience

- Wide operating experience with commercial Delayed Coker Units
- Technical support and troubleshooting expertise
- Commercially demonstrated in 3 MMTPA DCU in one of the IndianOil refineries (Coke yield reduction by ~ 5 wt% with corresponding middle distillate yield increase by ~ 4 wt%)
- Preparation of BDEP for revamp of existing DCU to Ind-Coker^{AT} in one of the IndianOil refineries under progress





indeDiesel
Ultra Low Sulfur Process

indeDiesel®

Production of Ultra-low Sulphur Diesel

Introduction of Ultra-low Sulphur Diesel (ULSD) necessitated quantum improvement in performance of Diesel Hydrotreating technology. indeDiesel is a commercially proven technology for meeting BS-VI/Euro-VI diesel specifications. The technology offers flexibility to upgrade middle range straight run distillates, light coker gas oil stream and light cycle oil from Catalytic Cracking units to ultra low sulphur, high cetane diesel suitable for meeting ULSD specifications.

Salient Features

- Superior reactor design with improved hydrodynamics
- Efficient reactor internals for enhanced catalyst life
- Optimized feed preheat scheme & reactor configuration offering cost-effective designs considering both capital and operating costs
- Employs improved high active hydrotreating catalyst developed by IndianOil
- Customized process design and flow schemes depending on the feed characteristics and process objective

Major Benefits

- Can handle high Sulphur feed meeting the diesel Sulphur Specification (≤ 8 ppmw)
- Design capability to process a wide range of cracked components (10% to 80%)
- Flexibility to produce Jet fuel
- Cetane improvement in diesel over combined feed can be customised to ≥ 12 Cetane units
- Technical support for optimization of unit performance and trouble-shooting studies
- Revamp for capacity augmentation & product quality improvement





indeDiesel
Ultra Low Sulfur Process

Commercial Experience

Commissioned Units

- Two grassroots units, each of 1.2 MMTPA, are in operation producing BS-VI diesel (Sulphur <10 ppmw & Cetane number > 51) since commissioning in 2011 and 2020 respectively
- Successfully revamped three large capacity units in Indian refineries and in operation for production of BS-VI quality diesel
 - ▶ DHDT unit by 130% to 2.86 MMTPA
 - ▶ DHDS unit by 124% to 2.20 MMTPA
 - ▶ DHDT unit by 130% to 1.6 MMTPA

Upcoming Units

- A grassroots unit of 1.2 MMTPA capacity scheduled for commissioning in 2023-24 in India





indeHex
Food & Polymer Grade Hexane Process

indeHex®

Production of Polymer/Food Grade Hexane

Polymer/Food Grade Hexane (PGH/FGH) specifications are becoming stringent especially w.r.t. benzene content and the fact that conventional clay treatment process has been replaced by hydrogenation process. To enable refiners to meet this specific requirement, IndianOil R&D has developed indeHex® technology for production of Polymer/Food Grade Hexane (PGH/FGH).

Salient Features

- indeHex® process is a catalytic process which converts Benzene to Cyclohexane & Olefins to Alkanes
- Offers flexibility of producing PGH/FGH from either straight-run or side stream of Naphtha Hydrotreater Unit
- Low Severity operation
- Very low hydrogen consumption
- Product yield above 99.5%

Major Benefits

- indeHex® process helps reduce Benzene below 10 ppmv in Hexane
- It can replace conventional clay treatment process for benzene reduction
- Production of value-added product from Naphtha stream

Commercial Experience

- 28 KTA grassroots unit commissioned in 2001 in one of the Indian refineries
- 20 KTA unit commissioned in 2012 in another refinery in India





indSelect^G
Selective Gasoline Desulphurization

indSelect^G

Desulphurisation of Cracked Gasoline with minimum Octane loss

Production of gasoline meeting stringent specifications of BS-VI/Euro-VI at low cost is a challenge for refineries. indSelect^G is selective hydrotreating technology developed by IndianOil R&D with catalyst developed in-house for cracked gasoline desulphurisation keeping Octane loss minimum. This process is mainly for upgradation of full range (C5-210°C) FCC / light Coker gasoline (C5-90°C) with respect to sulphur meeting the specifications of BS-VI standards. Light cracked gasoline with boiling fraction from C5 to 60-70°C, which is enriched in olefins (Octane rich) and lean in sulphur, can be directly routed to MS pool for blending. Heavy gasoline is selectively desulphurised before sending it to MS pool.

Salient Features

- Customised Catalysts developed by IndianOil R&D
- Low severity operation
- Accepts wide range of feedstock (full range gasoline from FCC, Visbreaker and Delayed Coker)

Major Benefits

- Reduces sulphur content <10 ppmw
- Low hydrogen consumption
- Suitable for upgradation of full range FCC & light Coker gasoline streams to BS-VI/Euro-VI compliant MS
- Direct blending of high RON & low Sulphur light cracked gasoline stream into gasoline pool

Commercial Experience

- 80 KTA grassroots unit commissioned in July, 2022 in one of the Indian refineries





Octamax

C4 to High-octane Gasoline

Octamax®

Production of Gasoline Component of very high Octane

Production of clean fuels meeting stringent BS-VI/Euro-VI specifications while enhancing valuable products per barrel of crude oil continue to play a major role in sustaining refinery margins. Deep desulphurisation of cracked gasoline streams, as necessary for meeting sulphur specification in gasoline pool, leads to reduction in octane number. Hence, processes producing high RON, low RVP, low aromatic gasoline blending stream is essential. Octamax technology developed by IndianOil R&D enables refiners to produce high octane stream from cracked C_4 streams thus providing greater flexibility in achieving BS-VI/Euro-VI MS specifications. Since the blending RON of Octamax product is very high, even higher than the conventional Alkylate, it helps in increasing gasoline production through blending of low Octane naphtha.



Salient Features

- Produces gasoline blending stream with high blending RON(>120) and low RVP flexibility to maintain gasoline specifications in various adverse scenarios
- Accepts wide range of cracked feedstocks (C_4 stream from Catalytic as well as Ethylene Crackers)
- Feed pre-treatment is optional depending on level of impurities in C_4 stream
- Employs a simplified process scheme while maximizing conversion to high octane components



Octamax

C4 to High-octane Gasoline

Major Benefits

- Cost-effective technology - lower Capex & Opex by design optimisation
- Environment friendly - Does not require handling of any toxic material compared to other similar technologies
- Low carbon footprint due to moderate process conditions
- Provides high degree of flexibility to augment gasoline quality and quantity
- Direct blending of product into gasoline pool without any further treatment

Commercial Experience

Commissioned Units

- A grassroots Octamax unit of 55 KTA capacity (product rate basis) commissioned in 2018 in one of the Indian refineries producing Gasoline stream with blending RON >120

Upcoming Units

- One grassroots unit of 110 KTA capacity (product rate basis) in an upcoming refinery complex in India - scheduled for commissioning by 2026
- Third unit of 102 KTA - under implementation, commissioning by 2025
- Feasibility study in progress for one grassroots unit





AmyleMax

C5+ Olefins to High-Octane Gasoline

AmyleMax®

Enhancing Octane of Light Olefinic Gasoline

One of the major challenges in sustaining refinery margin is production of clean fuels meeting prevailing specifications at low cost. Etherification route producing Tertiary-Amyl-Methyl-Ether (TAME) or Tertiary-Amyl-Ethyl-Ether (TAEE) is an attractive option for higher Octane requirements of BS-VI/Euro-VI gasoline.

AmyleMax, a catalytic etherification technology developed by IndianOil R&D for producing high Octane mixed ethers stream (C5-90°C) cut from cracked Naphtha (ex-Desulphurisation unit)/ Naphtha cracker streams, is a need-of-the-hour technology. Through enhancement of RON of Light Cracked Naphtha, AmyleMax technology provides flexibility to the Refiners to either increase gasoline production by blending low octane naphtha or produce premium grade gasoline with higher octane.

Salient Features

- RON improvement up to 4 units in mixed ether product as compared to feed
- Reduction of olefins
- Negligible methanol carryover in product
- No significant change in sulphur





AmyleMax

C5 + Olefins to High-Octane Gasoline

Major Benefits

- Able to process full range light gasoline cut without further splitting into narrower cut
- No requirement of additional feed pre-treatment
- Cost-effective solution requiring lower capital investment through a simple fixed bed reactor
- Simplified process with low Capex/Opex
- Low specific energy consumption and area footprint
- Direct blending of high octane product into gasoline pool

Commercial Experience

- Successfully demonstrated in 42 KTA revamp unit in 2019 in one of the Indian refineries
- Feasibility study in progress for two refineries





indDSN®

Production of Ultra-low Sulphur Naphtha Stream

indDSN® is a process technology for treating Naphtha stream to achieve product stream containing ultra-low sulphur (≤ 0.5 ppmw). In addition to sulphur removal, the process is also able to remove nitrogen and saturate olefins. Further, as required in refinery operation, the technology has the capability to process lighter as well as full range Naphtha. Thus, the technology is suitable for treating Naphtha range streams upstream of Isomerisation and Catalytic Reforming Units for production of gasoline components.

Salient Features

- Production of Naphtha stream having ultra-low Sulphur (≤ 0.5 ppmw) as required for Isomerisation or Catalytic Reforming Units
- Impurities such as metals and nitrogen are removed and olefins are saturated
- Customised Catalyst and efficient reactor internals developed by IndianOil R&D

Major Benefits

- Capable of handling wide range of Naphtha streams
- Low hydrogen consumption
- Flexibility to use reformer off-gas instead of pure hydrogen

Commercial Experience

- 235 KTA grassroots unit successfully commissioned in one of the Indian refineries in May 2021
- Development of BDEP for revamp of two NHT units in IndianOil refineries employing indDSN technology under progress





indDSK
Kero Deep Desulfurization

indDSK®

Production of Ultra-clean Kerosene

In the scenario of BS-VI/Euro-VI fuel specifications, there is a requirement of ultra clean Pipeline Compatible Kerosene (PCK) as an interface plug for a multi-product pipeline having ≤ 10 ppmw sulphur. PCK is also suitable as blending material in BS-VI/Euro-VI diesel pool of refineries. To enable refiners to meet this specific requirement, IndianOil R&D has developed indDSK® technology to produce ultra-clean Pipeline Compatible Kerosene (PCK).

Salient Features

- Low severity hydrodesulphurisation process - optimised for kerosene range
- Negligible hydrogen consumption and product yield above 99.5%
- Product meets all critical properties such as Acidity, Colour, Flash Point, etc.
- Customised Catalysts and efficient reactor internals developed by IndianOil R&D
- Capability to produce ATF with addition of minor hardware at downstream of the Reactor.

Major Benefits

- Can handle feedstock up to ~ 4000 ppmw sulphur
- Flexibility to use reformer off-gas instead of pure hydrogen
- Significant colour improvement meeting Saybolt specification
- Blending of PCK can also be done in BS-VI/Euro-VI diesel pool

Commercial Experience

- 300 KTA grassroots unit-to be commissioned in one of the Indian refineries by 2022-23



**INDAdept**
Deep Desulphurization Technology

INDAdept®

Adsorption Technology for Deep Desulphurisation of Cracked Gasoline

IndianOil R&D has developed INDAdept process and proprietary adsorbent to reduce sulphur from cracked gasoline feedstocks to meet BS-VI/Euro-VI sulphur specifications. The technology comprises of two fixed bed reactors operated in swing mode of adsorption and regeneration, for deep desulphurisation of gasoline under optimised operating conditions. In this process, sulphur in gasoline is removed by Reactive Adsorption mechanism. After reaching the Sulphur-breakthrough point, the adsorbent is regenerated under controlled conditions with lean air (1% O₂ in N₂) by oxidation of adsorbed Sulphur and Coke followed by activation with nitrogen - hydrogen mixture.

Salient Features

- Reactive adsorption based process technology for production of low sulphur gasoline component meeting BS-VI/Euro - VI sulphur specification
- Process comprises of two fixed bed reactors operated in swing mode of adsorption & regeneration

Major Benefits

- Capable of handling heavy cut of cracked gasoline feedstock like FCC Gasoline and Coker Gasoline
- Reduces Sulphur content to < 10 ppmw
- Low hydrogen consumption in the range of 0.20 to 0.30 wt% of feed
- Uses low-cost proprietary adsorbent

Commercial Experience

- 35 KTA grassroots unit commissioned in 2017 in one of the Indian refineries





indJet
ATF Hydrotreating

indJet®

Selective Removal of Mercaptan Sulphur from ATF

A viation Turbine Fuel (ATF) is one of the major petroleum products from a petroleum refinery. Global demand for aviation fuel has been continuously increasing owing to rise in airline passenger traffic and increasing demand for air cargo transportation. In India, the growth in air travel is expected to rise in coming years. Envisaging the growth potential and strategically important nature of the fuel, indJet® technology has been developed for production of ATF of emerging specifications.

indJet® is a low severity hydrotreating technology, which selectively removes mercaptan sulphur from ATF feed stream with minimal removal of other sulphur compounds. indJet® is an eco-friendly technology as it does not involve commonly used hazardous caustic as process chemical.

Salient Features

- Low severity operation
- Selectively removes mercaptan sulphur to < 10 ppm (well below the norm of < 30 ppm)
- Significant colour improvement meeting Saybolt specification
- Customized catalysts and efficient reactor internals developed by IndianOil R&D
- Flexibility to use reformer off-gas instead of pure hydrogen
- Possible to revamp existing caustic-based units keeping same post-treatment vessels for salt dryer and clay treatment
- Process can be extended for production of PCK (Pipeline Compatible Kerosene)

Commercial Experience

- 400 KTA grassroots unit for production of ATF and PCK commissioned in July, 2022 in one of the Indian refineries

Major Benefits

- Negligible hydrogen consumption (< 0.1 wt%)
- No requirement of Make-Up Compressor (MUC) and Recycle Gas Compressor (RGC), reducing the Capex/Opex
- Capable to process feedstock with higher mercaptan sulphur
- Processing of high TAN feedstock
- Eco-friendly as it does not use of any hazardous chemical
- Cost-effective solution for production of low sulphur ATF in case of enforcement of stringent regulations





IBG-Plus
Single Stage Biomethanation

IBG-Plus

Single-Stage Biomethanation Technology

The global economic development in the 20th century has led to extensive use of fossil fuels thus causing enormous emissions of greenhouse gases such as carbon dioxide. Organic wastes also generate large amount of methane as they decompose. Increase in concentration of both carbon dioxide and methane in the atmosphere causes global warming. Therefore, there is a thrust globally on reduction of fossil usage fuels and increasing the organic waste conversion to fuels.

IndianOil R&D has developed a single-stage anaerobic digestion technology, IBG-Plus, for conversion of all types of organic waste to biogas through use of enviro-tolerant inoculants and an innovative biodigester design. This technology is feed agnostic and suitable for any kind of organic waste containing biodegradable material. IBG-Plus technology has been validated for almost all types of organic wastes including agricultural residues like paddy straw, wheat straw, bagasse, etc. The IBG-Plus technology employs feedstock pre-treatment followed by digestion in presence of proprietary inoculant leading to low Hydraulic Residence Time (HRT) and high biogas yield.



Salient Features

- High biogas yield with higher methane content (> 70%)
- In situ conversion of CO₂ to Methane
- Proprietary enviro-tolerant, feed agnostic inoculants work efficiently at wide range of temperature and salinity
- Waste to biogas conversion efficiency is 1.5 times higher than conventional technologies



IBG-Plus

Single Stage Biomethanation

Major Benefits

- Low HRT and low CAPEX due to reduced reactor size
- Low purification cost & less footprint area
- Generated manure can be utilised as bio-fertilizer



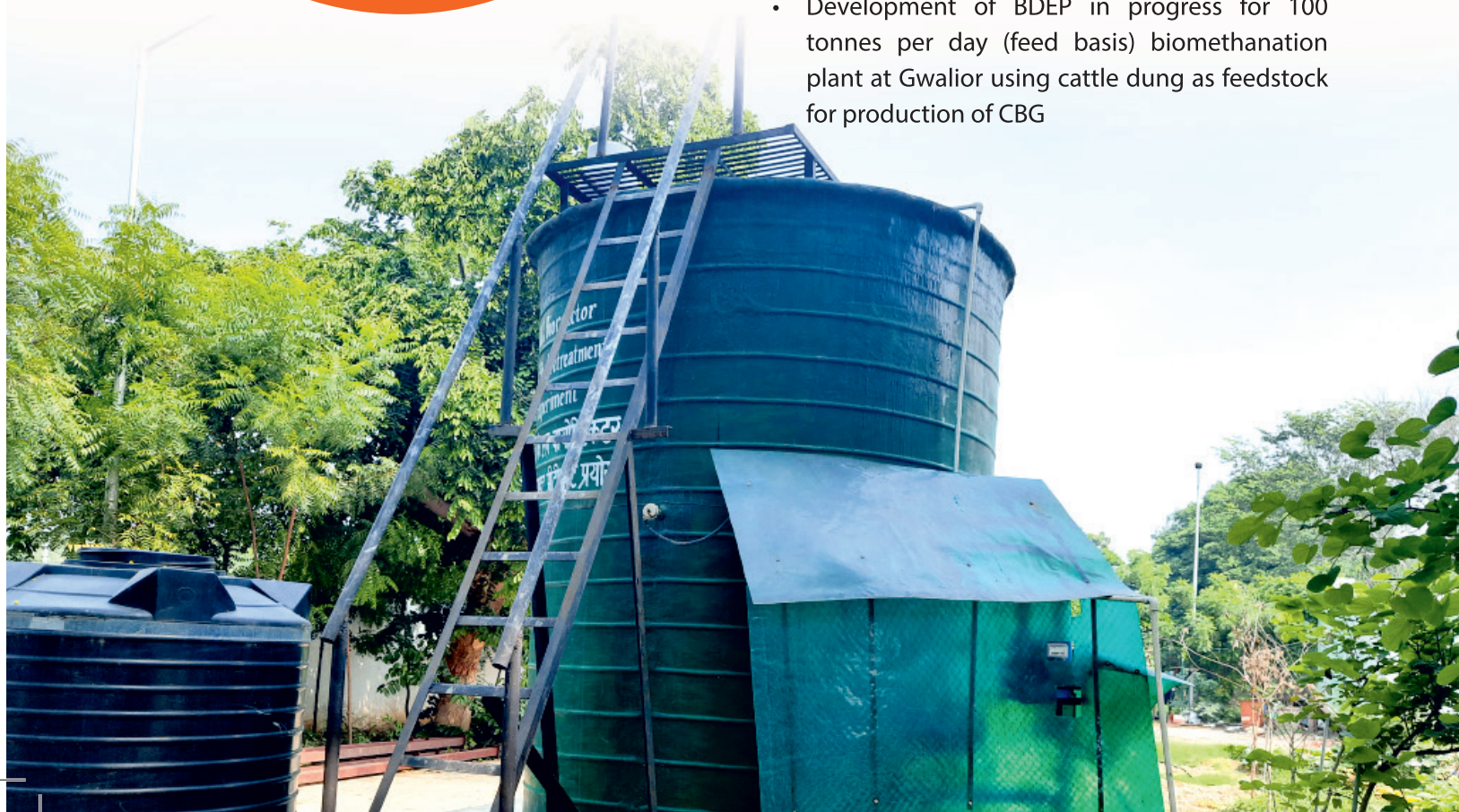
Commercial Experience

Commissioned Units

- IBG-Plus technology has been successfully piloted at IndianOil R&D
- Successfully implemented at following locations through use of proprietary microbial inoculant
 - Single-stage biomethanation plant of 5 tonnes per day at Varanasi, Uttar Pradesh
 - 240 tonnes per day biomethanation plant at Namakkal, Tamil Nadu based on press mud, chicken litter and MSW, resulting in higher biogas yield (~30%) with higher methane content (~15%) in the biogas

Upcoming Units

- 200 tonnes per day (feed basis) biomethanation plant at Gorakhpur, UP based on IBG-Plus technology using paddy straw as feedstock for production of Compressed Bio Gas (CBG) - commissioning scheduled in 2022-23
- Development of BDEP in progress for 100 tonnes per day (feed basis) biomethanation plant at Gwalior using cattle dung as feedstock for production of CBG





IBG-Max
Two Stage Biomethanation

IBG-Max

Two-Stage Biomethanation Technology

The global economic development in the 20th century has led to extensive use of fossil fuels thus causing enormous emissions of greenhouse gases such as carbon dioxide. Organic wastes also generate large amounts of methane as they decompose. Increase in concentration of both carbon dioxide and methane in the atmosphere causes global warming. Therefore, there is a thrust globally on reduction of fossil fuels usage and increasing conversion of organic waste to fuels.

IndianOil R&D has developed a two-stage anaerobic digestion technology, IBG-Max, for conversion of all types of organic waste (except agricultural residues) to biogas through the usage of proprietary inoculants and innovative biodigester design.

IBG-Max technology has been validated for most of the organic wastes such as food waste (both pre-cooked and leftovers) from various sources like food processing industries, households and hospitality sector, animal waste (cattle dung and poultry droppings, etc.), dairy waste, organic fraction of Municipal Solid Waste (MSW), Press Mud, STP waste water/sludge etc. The technology employs extraction of biodegradable organic fraction from waste as acid intermediates using optimised microbes in the first stage; while in the second stage, the acid intermediates from the first stage are converted into biogas using proprietary inoculants.



Salient Features

- High biogas yield with higher methane content (> 80%)
- In situ conversion of CO₂ to methane
- Proprietary enviro-tolerant, feed agnostic inoculants work efficiently at wide range of temperature and salinity
- Waste to biogas conversion efficiency is 1.5-2.0 times higher than conventional technologies



IBG-Max

Two Stage Biomethanation

Major Benefits

- Low HRT and low Capex due to low-capacity reactors
- Low purification cost & less footprint area
- Generated manure can be utilised as bio-fertiliser

Commercial Experience

Commissioned Units

- A 5 tonnes per day biomethanation plant based on IBG-Max technology is operational at IndianOil's R&D Centre at Faridabad, using MSW as feedstock, meeting biogas yield and methane content against design value
- 100 tonnes per day biomethanation plant at Jaipur, Rajasthan based on two stage IBG-Max technology using cattle dung as feedstock commissioned in July, 2022 producing Compressed Bio Gas (CBG) meeting IS specification

Upcoming Units

- Setting up of plant with capacity to process 135 tonnes per day of cattle dung is under process at Shri Mataji Gaushala, Barsana, Uttar Pradesh





INDEcoP2F
Plastics to Fuel Technology

INDEcoP2F®

Co-processing Waste Plastic in Delayed Coker

Plastic pollution has become one of the most serious environmental issues, as consumption of disposable plastic products is rapidly increasing worldwide. Conventional disposal methods such as landfill and incineration contribute to more pollution. Considering these challenges in handling waste plastic, IndianOil R&D developed a need-of-the-hour eco-friendly technology, INDEcoP2F®, for co-processing of waste plastics in Delayed Coker unit to convert to fuels.

The technology is commercially demonstrated in one of the IndianOil refineries by co-processing about 1.5 wt% waste plastic in Delayed Coker Unit (DCU). The technology has the capability to achieve conversion of ~ 95 wt% of waste plastic to fuel, thus improving refinery margin.



Salient Features

- Employs patented process configuration for waste plastic injection
- Sustainable operation of Delayed Coker unit (DCU), no impact on furnace operation
- No requirement of reduction in feed throughput
- Insignificant impact on product quality
- Robust design capable of operating DCU in waste plastic processing mode and conventional mode



INDEcoP2F

Plastics to Fuel Technology

Major Benefits

- Ability to handle waste plastic - PE/PP and metal additised multi-layered packaging (MLP)
- High conversion of waste plastic to fuel (>95 wt%)
- Improvement in GRM and enables circular economy of plastic
- Contribution towards plastic neutrality and waste plastic disposal management
- Easily implemented in existing Delayed Coker Unit with minimum downtime

Commercial Experience

- Successfully demonstrated co-processing of 0.5-1.3 wt% metal-additised MLP waste plastic in 170 KTA DCU in one of the IndianOil refineries.
- 95 wt% waste plastic converted to fuel.
- No significant changes in the quality of Coke as well as liquid products.



Drag Reducing Agents

Innovative Solution for Improving Pipeline Flow & Efficiency



XtraFlo-C

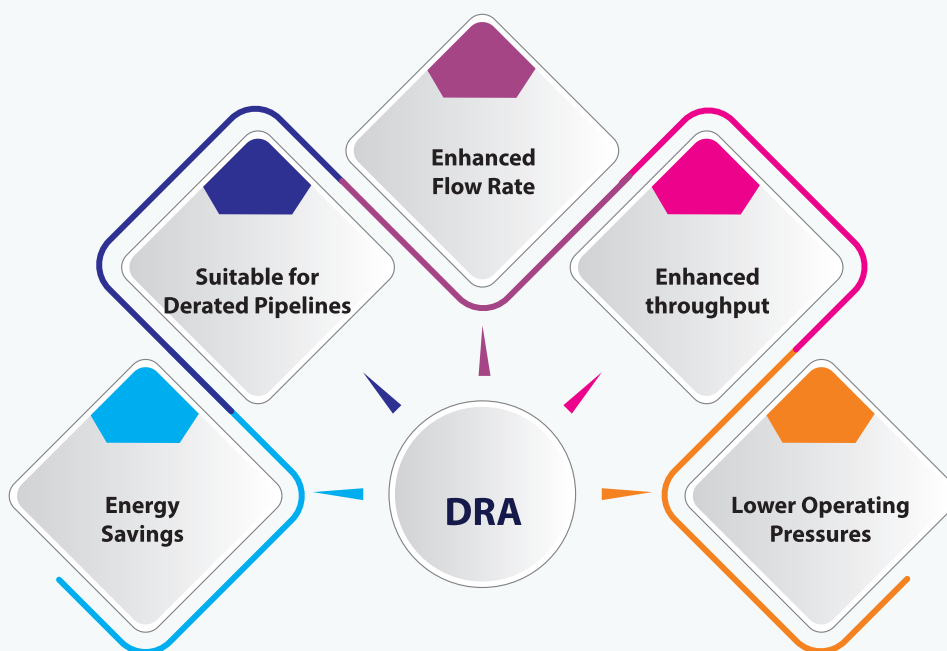
IMPROVING PIPELINE FLOW AND EFFICIENCY



XtraFlo-P

IMPROVING PIPELINE FLOW AND EFFICIENCY

Customised Chemistry for Crude Oil and Products Transportation



XtraFlo

IMPROVING PIPELINE FLOW AND EFFICIENCY

Solution to boost the flow of crude oil and petroleum products in pipelines

Amalgamation of novel patented process and catalyst

Designed to meet stringent performance requirements of the customers for varied fluids and pipeline dynamics

Commercially proven product, being supplied to multiple consumers

Product is gaining widespread global acceptability

Proven to provide superior drag reduction over other incumbent commercial products

The technology has been licensed for commercial production to Dorf Ketel Chemicals Indian Pvt. Ltd., a multinational chemical manufacturer for manufacturing and worldwide supply

DORF KETEL

State-of-the-art production facility under operation at port, suited for supply across the globe



Compact Reforming Technology for Hydrogen

HCNG is the first intermediate step towards “Hydrogen Economy” and “Cleaner Environment” for urban areas.

IndianOil R&D has developed and patented a single-step compact reformer technology whereby H-CNG blends can be produced in situ directly from CNG with reduced complexity & safety hazards of separate hydrogen production, compression & storage. Through this technology, HCNG production process is flexible (in terms of controlling percentage of hydrogen in HCNG blends) and robust, allowing production of HCNG in less severe conditions as compared to conventional reforming processes associated with hydrogen production. Trials conducted at the International Centre for Automotive Technology (ICAT – an automotive testing and research centre located at Manesar near New Delhi) on buses running on HCNG showed a drastic reduction in mass emissions (in gm/km) - 77% in CO, 68% in total hydrocarbons and 53% in NO_x – as compared to buses running on CNG near New Delhi.

Salient Features

- The Compact Reforming Technology yields higher quantity of HCNG mixture by 3-4% (by weight) as compared to the input quantity of CNG.
- HCNG product mixture can be directly used as automobile fuel after compression upto 200 bar.

Major Benefits

- It eliminates the need for separate production, its compression and storage of pure Hydrogen.
- Process operates at mild operating conditions, thereby allowing use of relatively simpler and less expensive metallurgy. It employs a simpler fixed bed reactor.
- CO is not present in reactor effluent and does not need further shift conversion.
- The process is capable of producing H-CNG mixture of desired composition for direct dispensing into vehicles as automobile fuel.



Commercial Experience

- A compact reformer unit of 4 tonnes per day was set up in New Delhi to produce HCNG for field evaluation in a fleet of 50 Bharat Stage-IV compliant commercial CNG vehicles. The HCNG plant was started in mid-Oct 2020 and wide-scale demonstration trials were completed in April 2021. During this period, HCNG product quality was demonstrated at all capacities.

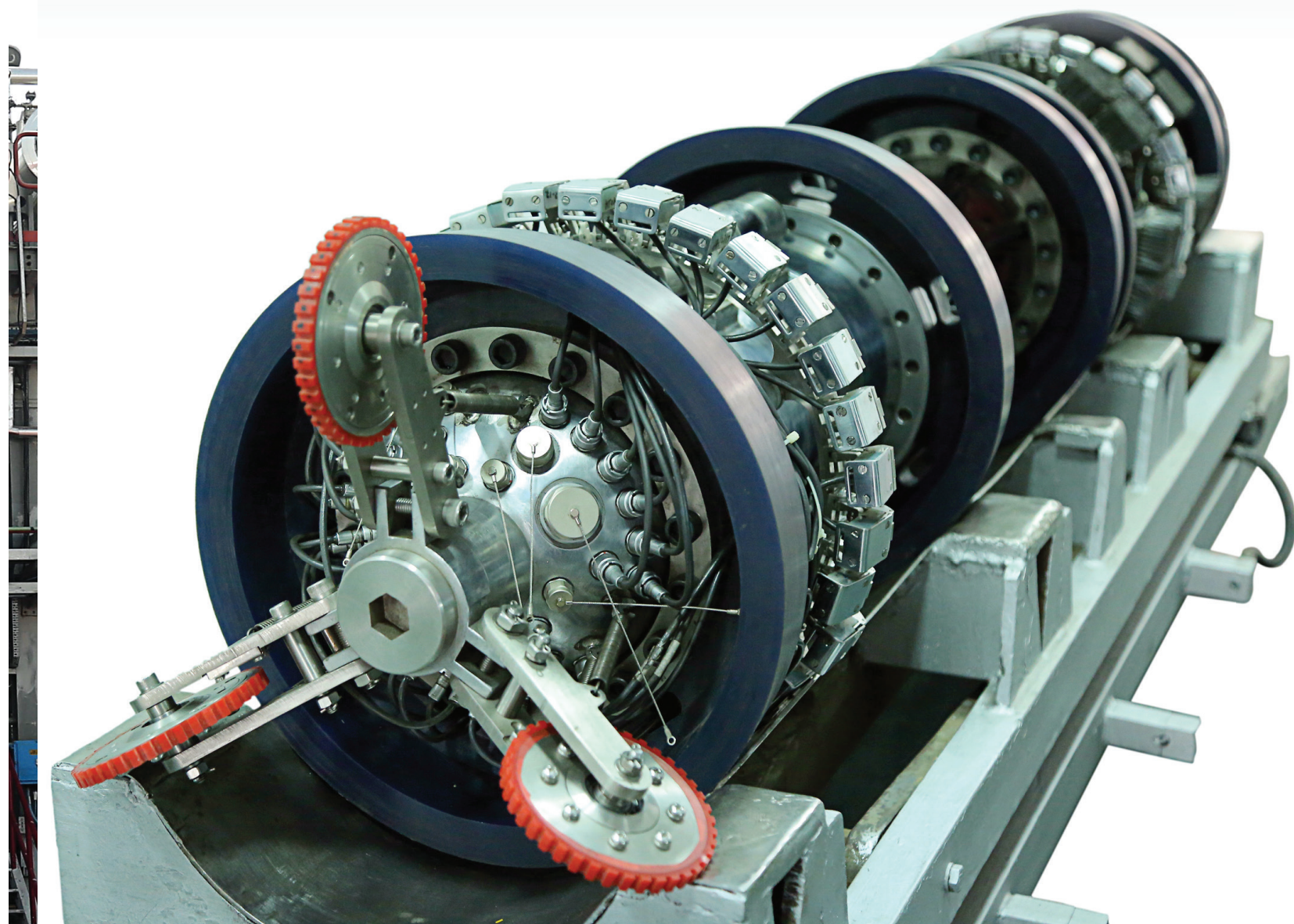


INDScan® Tools & Technology

for Inline Inspection of Oil & Gas Cross-Country Pipelines

Reliability and integrity of vast and spread-out pipeline networks of oil & gas industry need periodic assessment. This can be done using Instrumented Pipeline Inspection Gauge (IPIG) to assure economical and environmentally safe transportation of petroleum products. IPIG is a non-intrusive and non-destructive inspection technology available only with select developed nations to assess the health & integrity of cross-country oil & gas transporting pipelines.

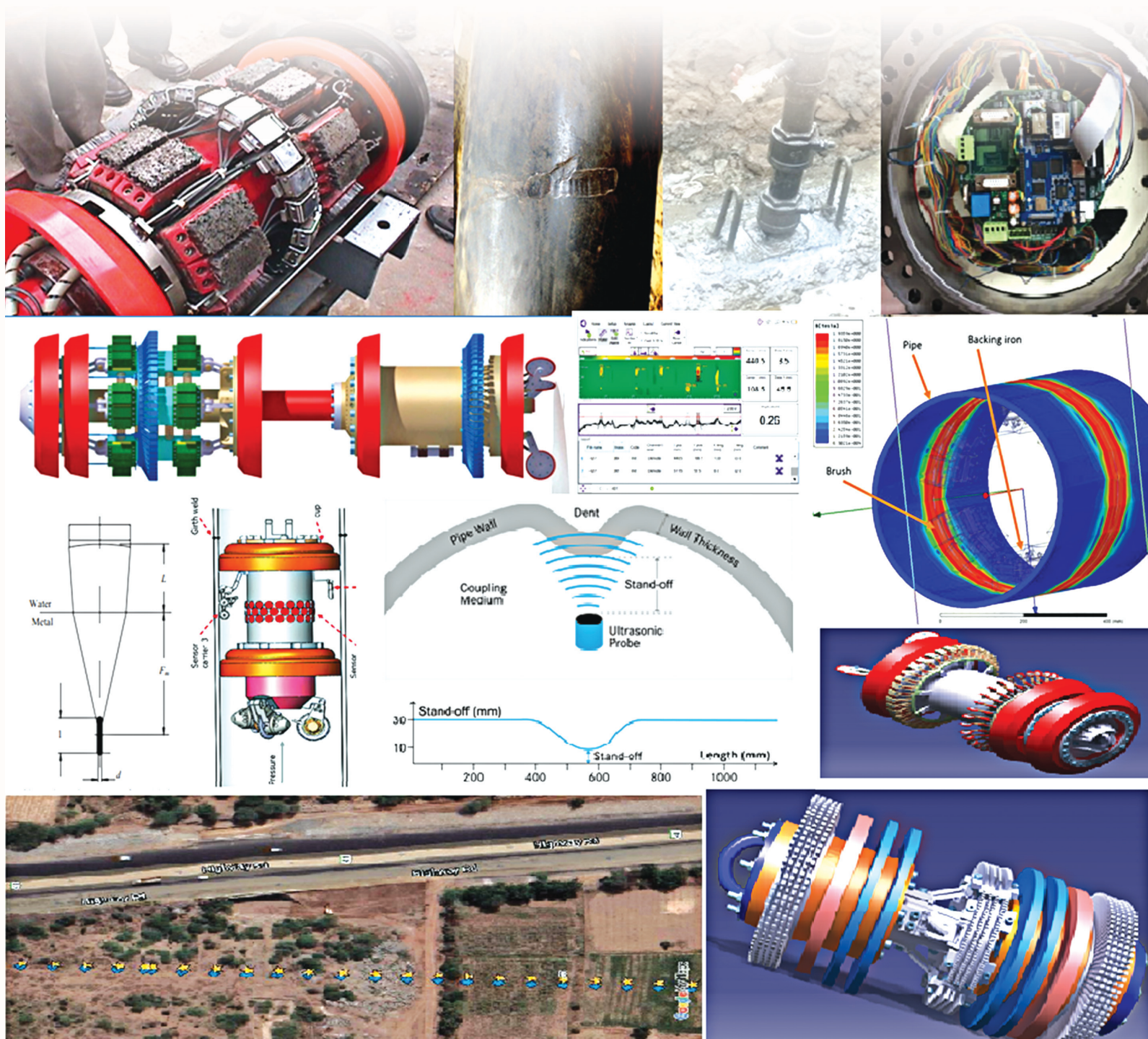
IndianOil R&D has teamed up with Bhabha Atomic Research Centre (BARC) to develop and deploy Magnetic Flux Leakage (MFL) based INDScan® series of IPIG tools for inline inspection (ILI) of cross-country pipelines. The indigenous development of IPIG technology & tools have been carried out from the fundamentals and all sizes of IPIGs are available for inline inspection of cross-country pipelines.



Major Benefits & Commercial Experience

The INDScan® series of ILI tools are high resolution tools backed by AI-ML based software for data analysis. The indigenous IPIG tools are being successfully used in the field for inline inspection (ILI) of cross-country petroleum pipelines. So far, a cumulative length of over 10,000 km of inline inspection has been carried out in pipelines using the indigenous INDScan® series of tools.

INDScan® tools have been proven to detect pipeline anomalies and corrosion defects accurately and precisely. In addition, these IPIG tools have also been successful in detecting many third-party interventions & pilferage in the pipelines. Inline inspection services, using INDScan® tools, have also been deployed to other Indian hydrocarbon companies.



Bioremediation Technology for oily sludge treatment

Environment-friendly and low-cost biotechnologies for Oily Sludge Remediation

Management of oily sludge is one of the major problems being faced by refiners worldwide. Oily sludge is hazardous waste which causes enormous environmental pollution.

IndianOil R&D has developed environment-friendly and low-cost bio-technologies for oily sludge remediation. These technologies provides an environment-friendly solution for disposal of oily sludge generated in refineries, pipelines and marketing locations during crude oil /product storage and transportation.

The technology has two formats and both have been widely applied on commercial scale successfully.

- i. Land-farming based bioremediation: Bioremediation of sludge is carried out after mixing it with soil.
- ii. Confined Bioreactor bioremediation: Bioremediation of sludge carried is out in separate bioreactor in aqueous media.

The land-farming based bioremediation technology combines bio-augmentation and bio-stimulation strategies for environmentally safe and cost-effective disposal of various types of oily sludge, hydrocarbon waste and treatment of oil contaminated soil. It uses a selective aerobic microbial blend of potential isolates that are specifically adapted to degrade various types of hydrocarbons in soil and water.

The microorganisms break down or degrade, hazardous substances into non-toxic substances such as carbon dioxide and water. IndianOil R&D also has a proprietary nutrient recipe (microbe adjuvant) to hasten the break-down of hydrocarbon contaminants. The technology needs only watering and tilling intermittently once the bacteria are dosed, and no other inputs required. It takes approx. 3-6 months for complete bioremediation of hydrocarbon waste loaded at 10-15%.



Land-farming based Bioremediation

Salient Features

- Uses "natural isolates" - Not "genetically modified".
- Safe to handle, no disease causing organisms.
- Has excellent capability to degrade wide range of hydrocarbon contaminants like saturated and unsaturated alkanes, mono and polycyclic aromatic hydrocarbons (PAHs) including organosulphur compounds
- High salt tolerance

The bioremediation technology has been recommended by CPCB, a statutory organization in India for safe disposal of oily sludge. This technology has also been widely recognized with several technology awards.

Commercial Experience

- This technology has been effectively employed over the last two decades for:
 - ▶ Disposal of oily sludge generated in oil refineries in crude oil tank bottoms and in product storage tanks in pipeline & marketing installations.
 - ▶ Treatment of drill cuttings and oil spills at oil exploration sites
 - ▶ Treatment of oil spills on land
 - ▶ Oil contaminated soil/site restoration
- It has also been implemented for disposal of tar ball during Oil Spills in Mumbai, Paradip and Chennai.
- Deployed by ADNOC for bioremediation of 200 tonnes oil sludge from drill cutting industry.

Confined Bioremediation (CBR) Technology

This is a bio-reactor based ex situ technique for treatment of oily sludge and oil-contaminated soil with a total treatment time of 3-4 weeks. This technology is IPR-protected. In this, an aqueous slurry is created by combining soil, sediment or sludge with water and other additives. The slurry is mixed to keep solids suspended and microorganisms in contact with soil contaminants. Upon completion of the process, the slurry is de-watered and the treated soil is disposed off.

This can be operated as a semi-continuous and continuous batch in an aerobic, anaerobic or mixed process.

- Sludge is treated in aqueous suspension, typically 10 to 30% w/v under controlled environmental conditions by providing optimized bacteria, nutrients, continuous aeration and agitation.
- This leads to several process advantages

Major Benefits

- ▶ Increased mass transfer rates and increased contact microorganisms / pollutant/nutrients
- ▶ Increased rates of pollutant biodegradation compared to in situ bioremediation or ad-situ solid phase biotreatment
- ▶ Shorter treatment times
- ▶ Control and optimization of several environmental parameters such as temperature, pH, etc.
- ▶ Increased pollutant desorption and availability through addition of surfactants and solvents

Commercial Experience

- Successfully implemented on commercial scale in IndianOil refineries located at Panipat, Gujarat, Bongaigaon, Barauni, Guwahati, etc.



Bio-inoculant Technology for Effluent Treatment Plants

Environment-friendly and low-cost biotechnologies

Petroleum refining produces a large quantity of wastewater in its operation. As per a conservative estimate, water use of a refinery is around 1-1.3 times of crude oil volume processed. Wastewater produced in petroleum refineries is treated in the Effluent Treatment Plants (ETPs) using physico-chemical and biological processes. Physico-chemical methods are energy intensive processes and are unable to recover all oil contaminants economically.

Biological processes reduce the oil and grease content by catabolic capacities of microbes. The extent of degradation depends on presence of required catabolic gene pool as well as their numbers. Effluent treatment plants are usually unable to completely degrade the wastewater being treated in the biological unit due to deficiency of microbes with required metabolic characteristics. By providing the microbes with required catabolic potential in adequate numbers, the overall efficiency of the treatment system can be improved.

IndianOil R&D has developed "Bio-inoculant Technology" which can enhance the degradation efficiency of microbes in the system. This innovative product ensure compliance with MINAS standards without need for any ETP revamp/modification.



Technology Description

The technology includes a mixture of selected microbes and optimized nutrients. It is dosed in aeration tank/ biological section of ETP in the aeration chamber system. The microbes included in the product are highly robust with a strong cell envelope and high tolerance to high levels of hydrocarbons, which allow them to thrive in the variable hydrocarbon contaminated environment, temperature, wide range of pH, osmotic and shock load conditions. This novel bio-inoculant has the ability to degrade oil and grease, phenol, sulphides in presence of heavy metals like Cr, V, Ni, Hg and cyanides and reduce them to the extent to meet the MINAS standards.

Salient Features

- Efficient, cost-effective, simplified, easy-to-adopt solution to enhance ETP efficiency for multiple contaminants
- Effectively removes multiple contaminants
- The product has enviro-tolerant and long lasting characteristics:
- It improves Mixed Liquor Suspended Solids (MLSS).
- Degradation of contaminants in aeration tank at lower stirring - saves energy
- Tolerant to shock loading of contaminants in ETP
- Effective and able to withstand extreme seasonal variations without compromising the performance.
- Totally indigenous and highly cost-effective
- Compatible with microbes in activated sludge

Commercial Experience

- This bio-inoculant technology has been successfully deployed across IndianOil refineries for the last 10 years to ensure compliance with new MINAS standards without altering the existing refinery ETP configuration.



LUBRICANT TECHNOLOGY BASKET



7000 Product Formulations
800 Commercial Grades | 750 OEM Approvals
Only Lube Superbrand & Masterbrand of India
Market leader among 40 major players



Petrochemicals & Polymers

- ZN Catalysts • Drag Reducing Agents
- Poly Alpha Olefins • Additives
- New Grade Development • Specialty Polymers
- Petrochemical Processes & Catalysis
- Waste Plastic Valorization

Nano Technology

- Nanocut: High therm Metal-cutting LPG
- Multi-Metal Nano-dispersions for Boiler Fuels
- XtraTej Differentiated LPG
- New Generation Catalyst & absorbent
- IndianOil XtraGuard surface disinfectant

ALTERNATIVE & RENEWABLE ENERGY





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