INDIAN COAL RESOURCE: GASIFICATION STRATEGY



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OVERVIEW: INDIAN COAL RESOURCE & GASIFICATION STRATEGY

***** Coal Gasification Requirements?

- Worldwide Coal Gasification Technologies
- Coal Gasification Requirements
- Understanding the Indian Coal Resource
 - Gasification Potential Mapping of Coal
 - Criteria for selection of Gasification Technology

***** Govt. of India's Initiatives towards Coal Gasification:

- NITI Aayog Methanol Economy Roadmap
- Coal to Fertilizer (TFL); Methanol, SNG Plants at ECL, CCL, SECL & WCL

***** CSIR-CIMFR: Coal to Syngas & Methanol Program

• 1.5 TPD Oxy-Blown Pressurized Fluidized Bed Gasification Facility (TRL-6)





MISSION



- Ring-fence India from the import of crude (226.5 MMTPA), Natural Gas (21.69 MMTPA), petroleum products (33.35 MMTPA).
- > Judicious utilization of Indigenous energy resources.
- Reduction in carbon footprint.

POTENTIAL

326.50 Billion tonne of COAL Secure, Affordable & Sustainable energy resource.



OPPORTUNITY GASIFICATION

Clean Coal Technology towards Atma Nirbhar Bharat Abhiyan For Methanol, DME, Liquid Fuels, Fertilizers, DRI, Power, Thermal, etc.





GASIFICATION TECHNOLOGY



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COAL GASIFICATION REQUIREMENTS





Coal choice may be the least flexible factor due to economic, geographical and political reasons, so, it is necessary to adapt the gasification technology according to the available coal.



Understanding Indian Coal Resource

Physico-chemical properties of coal & Ash towards gasification. Gasifier suitability vis-à-vis Utilization strategy



GASIFICATION POTENTIAL MAPPING OF INDIAN COAL

CSIR-CIMFR & CMPDIL (under the aegis of NITI Aayog)

□ Coal characterization matrix in view of Physico-chemical properties of coal & Ash characteristics towards gasification.

□ Gasifier suitability vis-à-vis Utilization pattern & gasification strategy for gainful utilization of coal resource.



Gasification Potential Mapping of Indian Coal for MCL (18), CCL (7) & ECL(5) area has been completed & report submitted to *NITI Aayog in December 2019*.







INDIAN COAL RESOURCE



HIGH ASH CONTENT

Coal reserves (~73%) are of inferior grade non-cooking coals & Ash contents 35-50%



ASH TYPE

High Alumina & Silica, Refractory Nature with High AFT >1300 °C, Tcv >1400 °C



REACTIVITY

Moderate to high Gasification Reactivity



MECHANICAL STRENGTH

Moderate to High Cold & Hot Strength



CRITERIA FOR SELECTION OF GASIFICATION TECHNOLOGY





INDIAN COAL: GASIFICATION OPTIONS, GAPS & KEY ISSUES

	Gasification Option	Gaps and Key Issues
Option-1: Commercially Proven Gasification Technology	 Entrained Flow Gasifier (Shell) for low ash coal. High ash coal washing from 45% to 20% or Blending with low ash feed 	 Coal washing: Yield & Net loss CAPEX: & OPEX EFG tested up to 20% ash. High AFT Low thermal efficiency
	Moving Bed Gasifier (Lurgi FBDB) for low/medium ash coal High ash coal washing from 45% to 30% or Blending with low ash feed	 Coal washing: Yield & Net loss CAPEX & OPEX Selective feed particle size (>8mm) ~3% fuel loss in Tar, Liquids CAPEX for tar/liquid handling facility
Option-2: Developing Technology	Fluidized Bed Gasifier Low/medium/high ash coal	 Proven technology not available Lower carbon conversion Agglomeration /clinker formation







INDIAN COAL: GASIFIER SELECTION STRATEGY

TECHNO-ECONOMIC COMPARISON

with Respect to Indian Coal and commercial exploitation

Option-1: Commercially proven Entrained Flow or Moving Bed gasification technology

- Entrained Flow Gasifier (Shell) Demo Plants of CIL at TFL, Talcher, WCL (Wardha), SECL (Mahamaya), ECL (Sonpur Bazari, Dankuni)
- Moving Bed Gasifier (Lurgi) Experience at JSPL, Angul)

Option-2:IndigenouslyDevelopedFluidizedBedGasificationTechnology



• Pilot/Demo Scale PFBG at CSIR-CIMFR, BHEL, IITD-Thermax & EIL.





METHANOL ECONOMY: NITI AAYOG ROADMAP





CSIR-CIMFR: Coal to Syngas & Methanol Program

- Understanding Indian Coal Gasification Prospects & Suitability towards Gasification
- Development of Suitable Gasifier for High Ash Indian Coal
- Integration of 250 kg/day Syngas to Methanol Pilot Plant with 1.5 TPD PFBG Pilot Plant





CSIR-CIMFR MISSION



- Understanding Indian Coal Gasification Prospects & Suitability towards Gasification
- > Development of Suitable Gasifier for High Ash Indian Coal
- Integration of 250 kg/day Syngas to Methanol Pilot Plant with 1.5 TPD PFBG Pilot Plant





20 Kg/H Air Blown Pressurized Fluidized Bed Gasification Facility (TRL-5)



20 kg/h PFBG Specifications & Features

- Electrically heated alloy reactor installed in 2008-09
- Fuel Feed Rate : up to 20 kg/h
- ✤ Temperature: up to 1000 °C
- Pressure : up to 3 kg/cm²

AIR BLOWN PFBG ACHIEVEMENTS

- Addressed operational issues: fuel feeding, ash agglomerates, ash extraction
- Established operational philosophy to handle high ash coal in PFBG.
- Evaluated Gasification performance of high ash coal, Biomass & blends
- Copyright & Indian Patent (TRL-5).
- **Syngas Composition: (Vol.%)**
 - CO: 15-22, H₂: 15-20, CH₄: 1-2,
 - CO₂: 10-12, N₂: 48-55
- Heat Value: 1000-1200 kcal/Nm³
- Carbon Conversion : up to 93%
- Yield : 2.2-2.5 Nm³/kg of fuel





1.5 TPD OXY-BLOWN PRESSURIZED FLUIDIZED BED GASIFICATION FACILITY (TRL-6)



- CSIR-CIMFR design.
- Refractory Lined Gasifier
- Fuel Feed Rate : up to 1.5 TPD
- Gasifying Agents: Air/Oxygen & Steam
- Temperature: up to 1050 °C
- Pressure : up to 10 kg/cm²
- •Facility is dedicated to the nation on 17/11/2020

ACHIEVEMENTS:

- * Established operation for *High Ash Coal (MCL, Ash 42%) with 50% Oxygen* enriched Air & Steam.
- ✤ Syngas Composition: (Vol.%): CO: 23, H₂: 22, CH₄: 1.2, CO₂: 22,
- ✤ Carbon Conversion : >90%
- Syngas Yield: 1.2 1.5 Nm³/kg fuel





FLUIDISED BED GASIFICATION FACILITY





ACHIEVEMENTS

Parameter	Experiment-1	Experiment-2	Experimnet-3
Coal Flow Rate, kg/h	10-30	25-40	25-40
Air/O ₂ Flow Rate, kg/h	40-50	40-45	40-45
Oxygen Loading, %	21 (Airblown)	37	50
Steam Flow Rate, kg/h	10-13	15-20	15-20
Gasifier Temperature, °C	900-1050	900-1050	900-1050
Gasifier Pressure, atm	atm	atm	atm
Bed Height, mm	200-275	350-450	250-300
Ash withdrawal Rate, kg/h	Intermittent	15-20	15-20
Syngas Yield, kg/kg coal	2-2.5	1.2-1.5	1.2-1.5
Max. Syngas Composition, %	CO=11, H ₂ =12, CO ₂ =13 & CH ₄ =2	CO=19, H ₂ =16, CO ₂ =23 & CH ₄ =1.5	CO=23, H ₂ =22, CO ₂ =22 & CH ₄ =1.5
Max. Syngas CV, kcal/Nm ³	927	1225	1475
Carbon Conversion, %	>90	>90	>90





EXPERIMENT-3 GRAPHS



NEXT TARGETS

- Establish operation & <u>operational philosophy</u> for <u>Oxy-blown gasification of High Ash</u> <u>Indian Coal, Biomass & Blends.</u>
- > Syngas Composition (Vol.%):

CO: >27, H₂: >27, CH₄: 1.5, CO₂: <20, N₂: Balance

- > Achieve Carbon Conversion : >94%
- Understanding <u>Gasification Prospects</u> of Indian Coal/Biomass Resource and Generation of <u>Techno-economic Data</u> for commercial gasifier.
- Integration of Syngas micro-cleaning, conditioning and 250 kg/day Syngas to Methanol <u>Pilot Plant</u> with 1.5 TPD PFBG Pilot Plant.





CSIR-CIMFR Contribution

Indigenously developed 1.5 TPD PFBG Facility (TRL-6) is a milestone achievement as a part of "Methanol Economy Program" and an important step towards *"Atmanirbhar Bharat Abhiyan"* of Govt. of India.

Outcome:

- □ *Gasification potential & techno-economics* of high ash Indian coal vis-à-vis *utilization prospects* for downstream applications such as Methanol/chemicals, fertilizers, DRI, etc.
- Engineering Inputs for the *Development of Demo Scale PFBG* suitable for Indian High Ash Coal/Biomass resource.
- □ *Knowledge partner* for Gasification Programs of Govt. of India.





SUMMARIZED STRATEGY

□ <u>UNDERSTANDING COAL</u>: Gasification Potential Mapping of Indian Coal

• In view of Physico-chemical properties of coal & Ash towards gasification. Gasifier suitability vis-à-vis Utilization strategy for gainful utilization of coal resource.

□ <u>PILOT SCALE PFBG Plant integrated with Syngas to Methanol:</u> Indigenous Gasification Technology development an important step towards *"Atmanirbhar Bharat Abhiyan"* of Govt. of India.

- For <u>Techno-economic feasibility</u> of Indian Coal Gasification towards identified end uses & Confidence building in the area of gasification.
- Technical inputs for Demo Scale Gasification based Plants

□ <u>TECHNO-ECONOMIC COMPARISON of Gasification Technologies with Respect to Indian Coal</u>

- Commercially proven Entrained Flow Gasifier (Shell) Demo Plants of CIL at TFL, Talcher, WCL (Wardha), SECL (Mahamaya), ECL (Sonpur Bazari, Dankuni)
- Moving Bed Gasifier experience in (Lurgi) at JSPL, Angul
- Indigenously developed Pilot/Demo Scale PFBG at CSIR-CIMFR, BHEL, IITD-Thermax & EIL.

□ Coal to Methanol Commercial Plants 2030





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