



Kinetics Process Improvements, Inc.

Independent Consultants & Engineers

Serving to Improve, Decarbonize & De-bottleneck

- **Ammonia Plants** (Integration with $\text{gH}_2\text{L}^{\text{TM}}$ fCI m[Yb'9 bf]W a YbH'
- **Methanol Plants** (Electrification)
- **Primary Reformers** (Tech-Evaluations)
- **CO₂ Removal Systems** (Green-Blue Ammonia & Methanol Plant Studies)
- **Decarbonization Solutions**

- Technology Evaluation
- Project Cost Estimate
- Risk Assessment
- Due Dilligence
- Economic Evaluation

PROJECT FEASIBILITIES

REVAMP STUDIES

- Capacity/Efficiency Improvements
- Plant Energy Audits
- Reformer Re-ratings
- MICTM Revamp without major compressor upgrades
- Synloop Optimizer

- Process & Technology
- Equipment:
 - Monitoring Techniques
 - Reliability Reviews
- Plant Modeling

CUSTOM PROCESS TRAINING

PROCESS DESIGN & ENGINEERING

- Basic Engineering Pkg
- Pilot Scale Up
- Process Simulations
- Converter Modeling

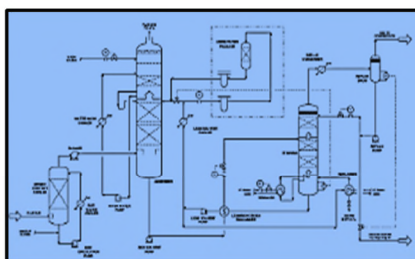


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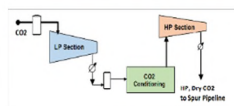
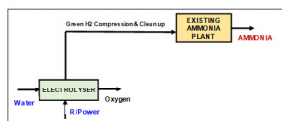
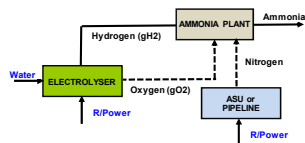
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Phone: 281-773-1629 • Fax: 832-565-9360

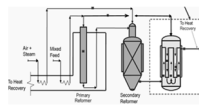
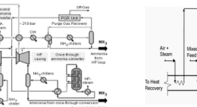
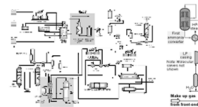
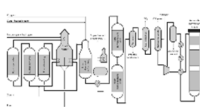
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GREEN AMMONIA PLANT STUDIES

INTEGRATION STUDIES- gH₂ & gO₂CO₂ COMPRESSION & DEHYDRATION

TECHNOLOGY EVALUATION-RISK ASSESSMENT-MITIGATION



OWNER'S ENGINEERS FOR EVALUATING & EXECUTING DECARBONIZATION SOLUTIONS-STUDIES

SINCE 2005

Consulting to Decarbonize [Blue-Green Options]

by KPI Consulting, Houston

*KPI has provided project development management and consulting services for over a dozen projects. KPI led the successful development of Four large projects as "Owner's Engineers" including a major Propylene derivatives complex in Saudi & ongoing green & Blue Ammonia plants at USGC. Our breadth of technology expertise coupled with our **experience in various Decarbonization options** provide the value addition for the new projects as well as upgrading the existing facilities.*

Expertise

- Ammonia Tech & Economics
- Methanol Tech & Economics
- H₂ Production Tech & Economics
- OTF H₂ Cost & Economic Analysis
- SMR & ATR Syngas Technologies
- CO₂ Capture Technologies (Pre & Post)
- CO₂ Compression & Dehydration
- gH₂/bH₂ Integration Studies
- O₂ Enrichment studies
- Green-Blue H₂ & NH₃ Evaluation
- Ethylene & PDH Technologies
- Strategic Project Planning
- Project definition & management
- Project Configuration Evaluations
- Technology & Risk Evaluation
- Due diligence- overall project
- Project Cost Estimates & Economics
- Project Pre-Feasibility
- Licensing/BEP Agreements reviews
- Project Execution support
- Critical Technical Reviews
- Simulation modeling

Resources

- Team of SME's- Houston office
- Working relations with Licensors
- Working relations Equipment Suppliers
- Proven modeling & sizing tools
- Cost data base (updated regularly)

Projects/Studies Handled

- Green-Blue H₂/NH₃/MeOH Studies
- O₂ Enrichment Studies
- g/bH₂-NH₃ Integration Studies
- Electric Pre-reformer
- CO₂ Capture Feasibility Study
- CO₂ Compression & Dehydration
- New Decarb Tech options studies
- Ammonia plant studies
- Methanol & value chain Studies
- Pet coke to Chemicals Studies
- Propane Dehydro (PDH) project
- Ethylene & value chain study
- Propylene value chain Project
- Oxo-Alcohol & derivatives project
- Acrylic Acid & derivatives project

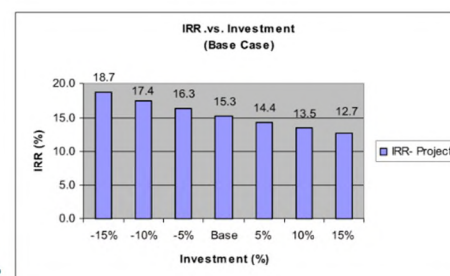
References

SABIC, Advance Petrochemicals, Saudi Chevron, Tasnee, Chemanol, Methanol Holdings, Modi Group, D7 Petrochem, YCI, CFI, Nutrien, Yara, OCI, Dyno Nobel, CSBP Chemanol, Statoil, PPGPL, USGC

Completed several Green & Blue Ammonia and gH₂/gO₂ integration studies as well as CO₂ Capture, Compression and Dehydration with total Cost Estimates

Decarbonization Consulting Advisory & Engg. Studies

*Project Definition & Planning
Project Configurations
Technology Assessment
Project Risks & mitigation
Project Pre-feasibility
Project Cost Estimates
Design & Engg. Management
Critical Technical Reviews*



KPI Consulting

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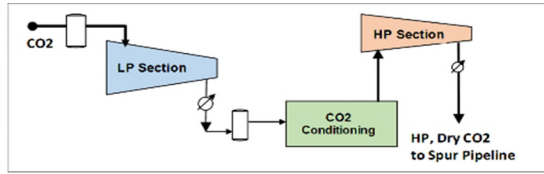
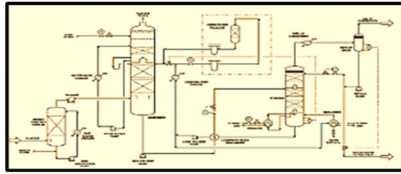
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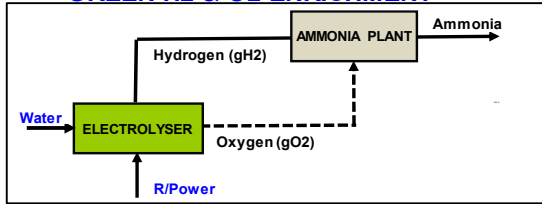
"Completed over a dozen Engineering studies and six successful upgrades of pre-combustion CO₂ capture units"

CO₂ CAPTURE, DEHYDRATION & COMPRESSION STUDIES

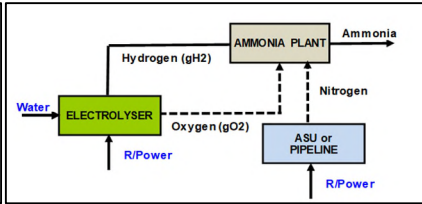


INTEGRATION STUDIES

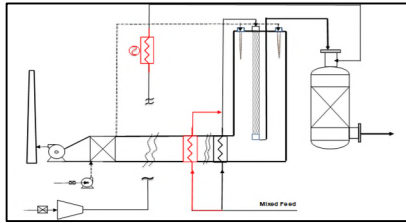
GREEN H₂ & O₂ ENRICHMENT



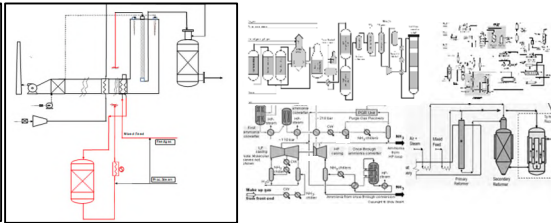
GREEN AMMONIA PLANT STUDIES



STUDY TO RECONFIGURE & ELECTRIFY FOR REDUCED FIRING



ATR & CO₂ REDUCTION TECHNOLOGY EVALUATION



COMPLETED SEVERAL DECARBONIZATION & CCS ENGINEERING STUDIES WITH COST ESTIMATES

Decarbonization Pathways & Solutions

by Kinetics Process Improvements, Houston

KPI-Houston is an Independent Process Technology & Consulting for in-depth analysis Studies for CO₂ abatement pathways in Ammonia, Methanol, H₂ & Petrochem plants. Also design and engg expertise in CO₂ capture, dehydration, Compression, Liquefaction including (g/b) H₂ integration, and O₂ Enrichment

Expertise & Services

- **Strategic Analysis & Studies**
 - ✓ CO₂ abatement Options
 - ✓ Green-Blue H₂/NH₃ options
 - ✓ gH₂/gO₂ integration studies
 - ✓ Ammonia Cracking
 - ✓ Plant Integration & Impact
 - ✓ New Technologies Evaluation
 - ✓ Project Risks & mitigation
 - ✓ Costs & Economics
- **CO₂ Capture Technologies**
 - ✓ Pre-Combustion (syngas)
 - ✓ Post-Combustion (Flue gas)
- **CO₂ Dehydration & Clean-up**
 - ✓ Glycol units
 - ✓ Adsorbents/Molecular Sieves
- **CO₂ Transportation**
 - ✓ CO₂ Liquefaction
 - ✓ CO₂ Compression
- Supercritical CO₂ Equip. specs
- H₂ & O₂ Compression Specs
- Owner's Engineers

"Two Patents pending- Reducing CO₂ footprint in Primary Reformers"

Methodology

- Integration with gH₂/bH₂
- Electrify & O₂ Enrichment
- Reconfigure to reduce Firing
- CO₂ Capture-Utilization or Seq
- gH₂ via Renewable energy

Tools

- Simulation modeling & sizing
- Extensive Cost database
- Rigorous Economic models

Studies/Projects References

- gH₂/NH₃ Engg Studies
- gH₂/NH₃ integration studies
- CCS study (2 x3000 tpd CO₂)
- CO₂ Capt/Comp/Dehy studies
- CO₂ Capture from Flue gas
- CCS study (3900 tpd CO₂)
- Electric Pre-reforming Studies
- O₂ Enrichment Studies

End Users Served

- CFI, Nutrien, Dyno Nobel, Yara, OCI
- Chemanol, CSBP, Statoil, USGC

Decarbonization via Blue & Green Solutions in Ammonia, Methanol & Petrochem Plants

Green-Blue Ammonia Feasibility
Green H₂ Integration Studies
Oxygen Enrichment Studies
CO₂ Capture Feasibility Studies
CO₂ Compression & Dehydration
H₂ Compression & O₂ removal
Oxygen Compression
New Technology Evaluation
Plant Impact & Engg Studies
Risk Assessment
Cost Estimates

SINCE 2005



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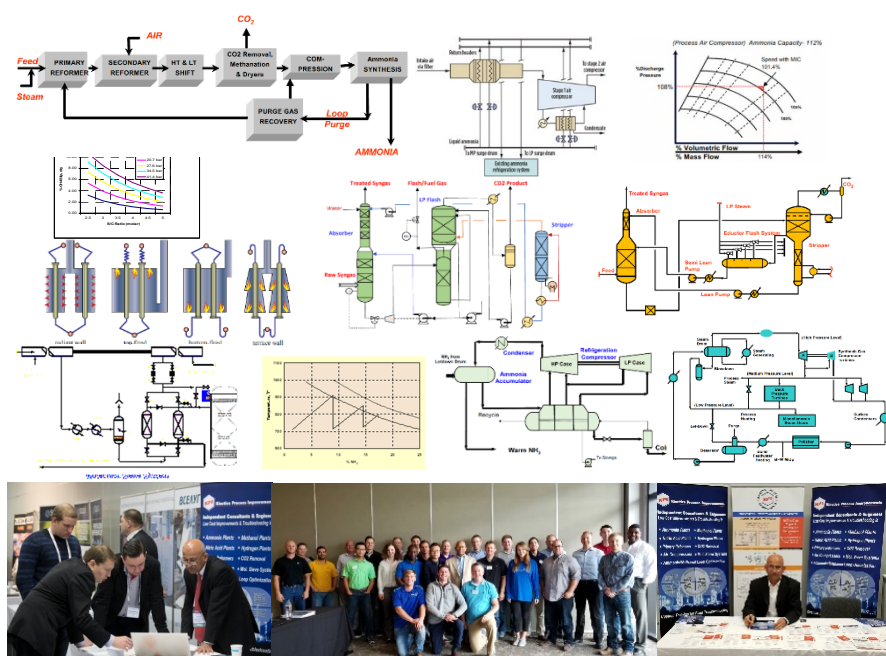
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Completed several Green & Blue Ammonia and gH₂/gO₂ integration studies as well as CO₂ Capture, Compression and Dehydration with total Cost Estimates

"Completed over a dozen Engineering studies and six successful upgrades of pre-combustion CO₂ capture units"



Ammonia Plants Audits, Revamps & Decarbonization Services

Practical & Cost-Effective Solutions to Improve Capacity, Efficiency, CO2 Emissions & Reliability

REVAMP EXPERIENCE IN AMMONIA PLANTS FROM 400 TPD TO 4000 TPD

SINCE 2005

Ammonia Plants: Audits|Revamps|Decarb

by Kinetics Process Improvements, Houston

KPI-Houston is an independent Process Design & Engineering Consulting group specializing in Ammonia & Methanol Plants Audits, Revamps, Decarbonization and Troubleshooting to improve Capacity, Efficiency, Reliability & CO2 footprint

Objectives & Key Benefits

- To improve Capacity, Efficiency, Reliability & CO2 Footprint
- Identify Best Revamp Options using Cost-Benefit Analysis
- Practical & Cost-effective Solutions

Resources & Expertise

- Integrated Suction Chiller™ to upgrade Process Air Compressor
- Electric Pre-Reforming
- Reformer Re-rating and Re-harping
- CO2 Removal System Revamps - a/MDEA & Benfield systems
- Rating & Optimizing Converters
- Modeling of Complete Ammonia Plants of different Configurations
- Rigorous modeling of Reformers
- Re-rating with Compressor models
- Basic Design & Engineering
- Equipment sizing/rating
- Project Cost Estimation
- Experienced Team

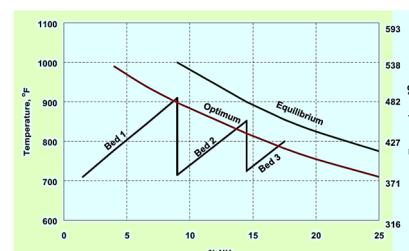
References

CFI, NUTRIEN, OCI, SABIC, DYNOL, NOBEL, CNC N2000, AUM, PLNL, CHEMANOL, METHANOL HOLDINGS, LSB, CSBP

*Integrated Chiller™ Patented granted
Pending Patent for Electric Pre-Reformer*

Ammonia Plant Services

- Plant Performance Audits
- Plant De-Bottlenecking
- Green H2 integration Studies
- O2 Enrichment Studies
- Revamp for higher Capacity
- Revamp for improved Efficiency
- Basic Engineering of Revamp
- Rating Primary Reformer
- Reformer Re-harping studies
- CO2 Removal System upgrades
- Mol-Sieve System upgrade
- Ammonia Loop upgrade
- Ammonia Refrigeration upgrade
- Compressors/Turbine upgrades
- Optimizing Steam System
- Cooling Water System upgrade
- Root-cause analysis
- CO2 Capture & Compression
- Value Engineering
- 3rd Party Design Reviews
- Critical Equipment Reviews
- Equipment design upgrade
- Cost Estimating
- Project Feasibility
- Technology/Project Evaluation
- Risk Assessment
- Derivatives Feasibilities



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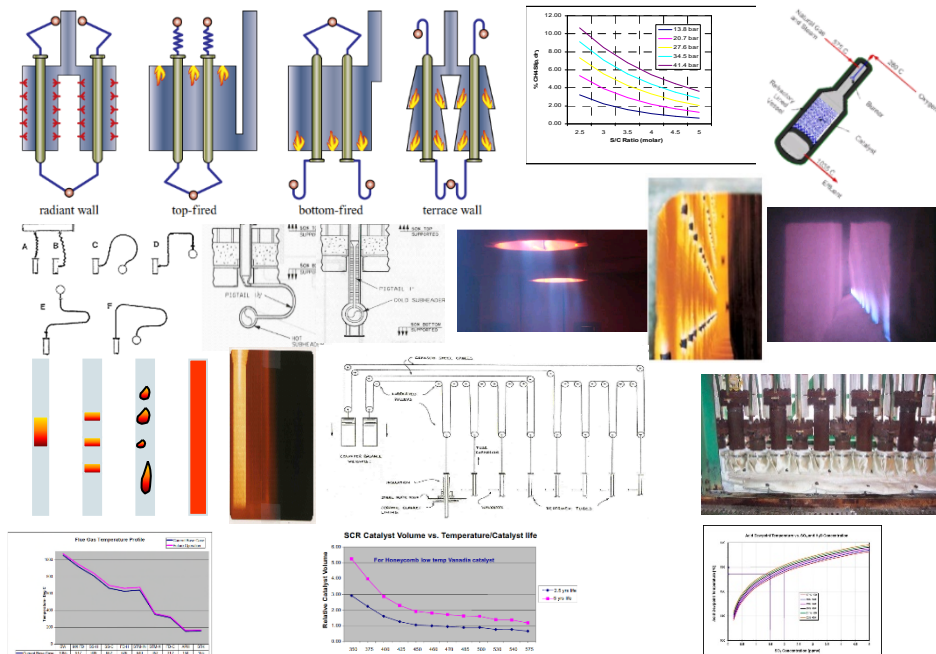
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HOLISTIC APPROACH TO INCREASE REFORMING CAPACITY. OVER 60 REVAMP STUDIES COMPLETED

Reformers Revamping & Troubleshooting Services

for
**Ammonia
Methanol
Hydrogen
Oxo-Syngas Plants**

SINCE 2006

Revamping & Re-Rating Reformers

by Kinetics Process Improvements, Houston

KPI-Houston is an Independent Process Technology, Design & Engg Consulting group specializing in Ammonia & Methanol Plants Revamps since 2006 to improve Capacity, Efficiency, Reliability & CO₂ footprint. Over 100 Revamp Studies completed

Objectives & Key Benefits

- To Improve Plant Capacity, Efficiency, Reliability & Emissions
- Identify Best Revamp Options using Cost-Benefit Analysis
- Practical & Cost-effective Solutions

Resources & Expertise

- Rigorous Reformer modeling
- Experience in all Reformer types
- Experience in Re-rating Radiant Section/Coils
- Experience in designing & optimizing Convection Section/Coils
- Experience in Burners & Combustion System upgrades
- Experience with APH, ID FD Fans
- Integrated Chilling* (patented)
- Basic Design Package
- Experienced Team of Process, Technology, Thermal Engineering

References

CFI, NUTRIEN, SABIC, CSBP, CHEMANOL, METHANEX, METHANOL HOLDINGS, SYNGAS Energy, OCI

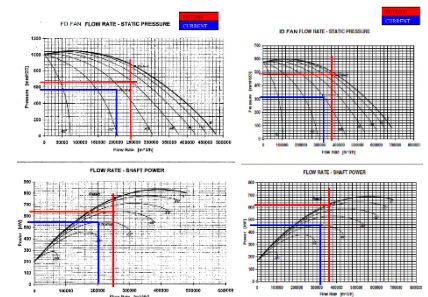
* Two Patents granted and one pending to reduce firing & CO₂ footprint in Ammonia & Methanol plant Reformers

Reformer Revamp Services

- Reforming System upgrades
- Radiant Section & Coil Re-rating
- Reformer Re-harping Studies
- Convection Replacement Studies
- Estimate Max. TMTs
- SCR sizing NO_x Emissions
- Reliability Review all systems
- Basic design & API datasheets
- Customized Training

Reformer Troubleshooting

- Reformer Performance Audits
- Review & Analysis of Design & Operational Limitations
 - Process & Controls issues
 - Heat transfer limitations
 - WHB/Steam System issues
 - Pressure drop/draft issues
 - Temperature excursion issues
 - Combustion & Firing issues
 - Air Preheater issues
 - FD and ID Fan limitations
 - SCR/NO_x issues



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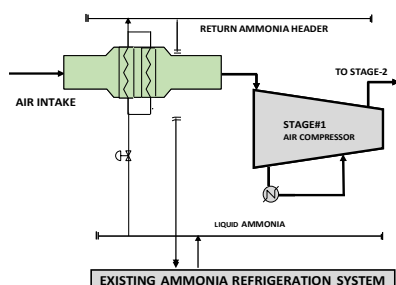
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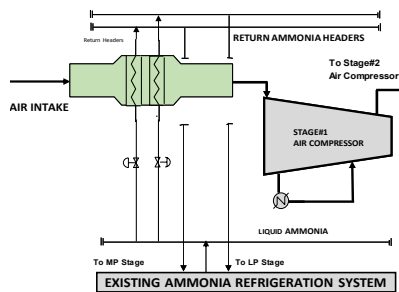
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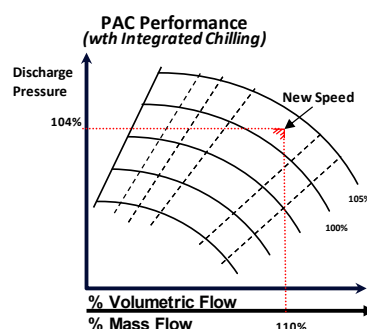
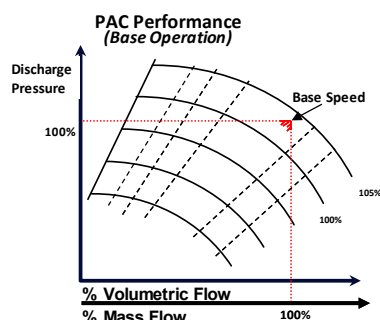




SIC™ - Single Stage Integrated Chilling



MIC™ - Multi Stage Integrated Chilling



'INTEGRATED CHILLING' PROVIDES MAXIMUM CAPACITY UPGRADE OF PAC WITH LEAST CAPEX & OPEX

“Integrated Chilling” to Upgrade Process Air Compressors
More Reforming
Reduced Inerts
More Ammonia
Less CO2 Emissions

SINCE 2006

Integrated Chilling to Upgrade PAC* Maximize Reforming with Least Capex & Opex

by Kinetics Process Improvements, Houston

KPI-Houston is an *Independent Process Technology, Design & Engg Consulting* group specializing in Ammonia & Methanol Plants Revamps since 2006 to improve Capacity, Efficiency, Reliability & CO₂ footprint. **Over 100 Revamp Studies completed**

Integrated Chilling

- Integrated Chilling uses existing Ammonia Refrigeration System with Process Air Compressor (PAC)
- Single or Multistage Scheme
- No Additional Compressor

Benefits of Integrated Chilling

- **110% PAC Capacity**-with Single Stg
- No Utilities for Integrated Chiller
- Least Cost & Space requirement
- Least incremental power for PAC
- Reduced firing in Reformer
- Reduced CO₂ footprint
- Efficient Synloop with lower inerts

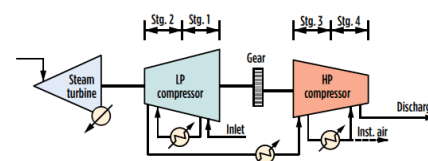
*PAC- Process Air Compressor

Services

- Integration Study with PAC
- **Basic Design Package**
- **Provide Performance Guarantees**
- **Engineering & Supply thro' approved Vendors**

References

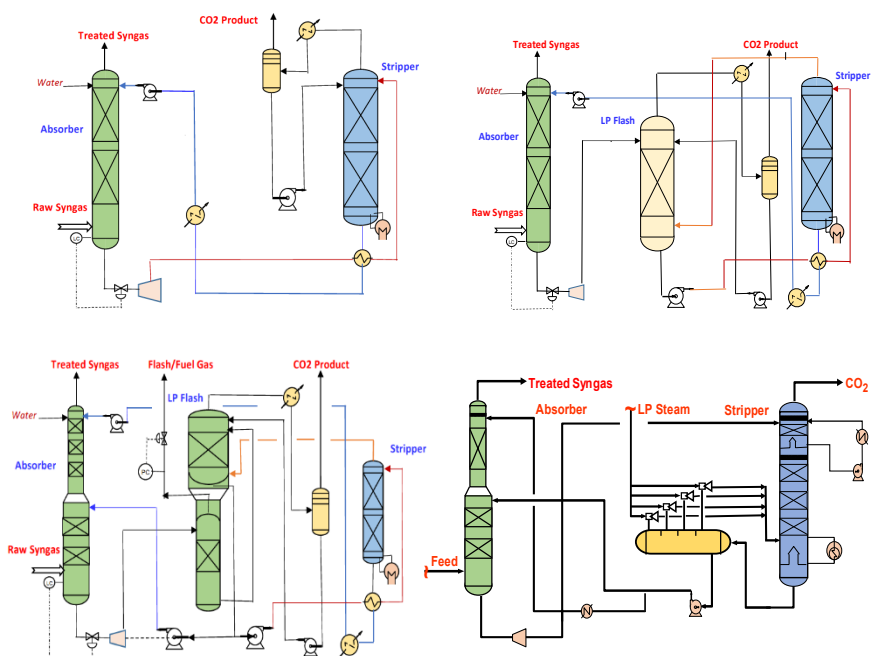
- *Approved for two large Ammonia Plants*
- *Two Patents granted (2017 & 2019)*
- *Refer “Increase Reforming Capacity”, N₂ & Syngas Conference, 2018*



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CO2 Removal Systems Revamping & Upgrading

aMDEA & Benfield Systems for Higher Capacity Reduced CO2 Slip

IMPLEMENTED MANY SUCCESSFUL REVAMPS OF AMDEA & BENFIELD CO2 REMOVAL SYSTEMS

Revamping CO2 Removal Systems

By Kinetics Process Improvements, Houston

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Revamp Experience

- **aMDEA Systems**
 - ✓ Single & Two Stages
 - ✓ Single-stage with LP flash
 - ✓ HP flash CO₂ recovery
 - ✓ Vac. Flash with LP Flash
 - ✓ Conversion of MEA to aMDEA
- **Benfield Systems**
 - ✓ With all Activators in use
 - ✓ All Process Configurations
 - ✓ Conversion to aMDEA study

Expertise & Services

- **Proven Simulation modeling**
 - ✓ aMDEA Systems
 - ✓ Benfield Systems
- Holistic approach
- Evaluation of Column internals
- Evaluation & sizing Flash Drum
- Evaluation & Sizing Ejectors
- Evaluation & Sizing Reboilers
- Equipment evaluation & sizing
- Revamp Cost Estimates
- Basic Process Design Package

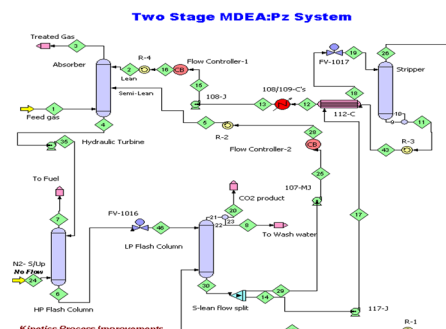
References

- **Revamp Engineering Studies:**
 - ✓ aMDEA- 1200 tpd Ammonia *
 - ✓ aMDEA- 3000 tpd Ammonia
 - ✓ aMDEA- 2520 tpd Ammonia *
 - ✓ aMDEA- 1950 tpd Ammonia *
 - ✓ Benfield-2200 tpd Ammonia *
 - ✓ Benfield-2200 tpd Ammonia *
 - ✓ Benfield-2250 tpd Ammonia *
 - *Successfully Implemented**
- **Revamp approach/scope:**
 - ✓ Simulation modeling
 - ✓ Engineering Study
 - ✓ Equipment Evaluation & sizing
 - ✓ Budgetary Cost Estimation
- **Revamp objectives included:**
 - ✓ Reducing CO₂ Slippage
 - ✓ Higher Capacity
 - ✓ Equipment adequacy & sizing

End Users

Nutrien, CNC, N2000, LSB
CFI & YARA (for various site locations)

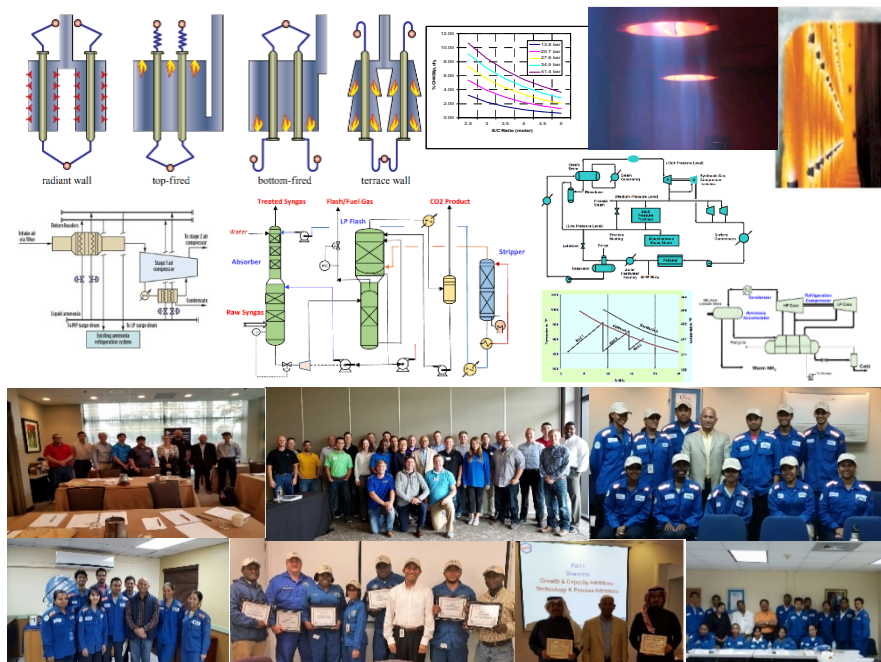
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Ammonia Production & Troubleshooting Training

Including
Best Practices
Lessons Learned
Equipment Monitoring
Improvements Tips
(Customized, as needed)

SIMPLE PRACTICAL IMPROVEMENTS & TROUBLESHOOTING TIPS

AMMONIA TRAINING SINCE 2006

Ammonia Plant Training Workshop

by Kinetics Process Improvements

OBJECTIVE: *The comprehensive workshop provides practical insights with a focus on process, reforming, troubleshooting, performance improvements in Ammonia Plants to improve monitoring, maintenance, reliability & safety*

OVERVIEW

- Process & Technology advances
- Process configurations & analysis
- Best Practices/Lessons Learned

PROCESS & TROUBLESHOOTING

- Improve Reforming performance
- Minimizing inerts in MUG
- Minimizing pressure drop
- Improve Compressor capacity
- Improve CO₂ removal performance
- Improve Mol. Sieve performance
- Cryogenic Purifier modeling & issues
- Optimize Synloop for max production
- Improve Ammonia Refrigeration
- Improve Steam system
- Process monitoring techniques
- Case studies/Lessons learnt
- Plant Modeling & Evaluation

CATALYST CONSIDERATIONS

- Feed Purification
- Reforming- Pre/Primary/Secondary
- Shift- LTS/HTS
- Methanation
- Ammonia Synthesis

PRIMARY REFORMER

- Thermodynamics and Chemistry
- Reformer Arrangements
- All about Radiant Tubes
- Critical design features
- Key Operating Variables
- Burners, Draft & Combustion
- Air Preheater & considerations
- Controls & Safety Systems
- NO_x mitigation- pre- & post treatment
- Startup & Shut down consideration
- Re-harping considerations
- Catalyst evaluation techniques
- Efficiency evaluation & monitoring

AMMONIA SYNLOOP

- Converter types & Loop configurations
- Ammonia Refrigeration
- Optimize loop for max production
- H₂ recovery improvements

PERFORMANCE MONITORING

- Primary Reformer Heat Balance, ATE
- Reformer Thermal Efficiency
- Compressor/Turbine Efficiency
- Heat Exchanger/Convection Fouling

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TRAINING FORMAT

- *Interactive Q&A for practical learning*
- *What-if scenarios for improvements*
- *Analysis of Practical Case Studies*
- *Models to demo Plant sensitivity*
- *Simple to follow Training material*

TARGET GROUP

- *Process/Operation Engr's*
- *Production Sup't/Supervisors*
- *Project/Mechanical Engineers*
- *Reliability & Safety Engineers*
- *Business Development/Analysts*

REFERENCES: CFI, NUTRIEN, SABIC, CNC, N2000, PLNL, AUM, ADVANSIX, MOSAIC (Trained over 600 candidates with many repeats)



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Independent Consultants & Engineers

Serving to Improve, Decarbonize & De-bottleneck

- **Ammonia Plants** (Integration with $\text{gH}_2\text{L}^{\text{***}}$
- **Methanol Plants** fCI m[Yb'9 bf]W a YbH₂
- **Primary Reformers** (Electrification)
- **CO₂ Removal Systems** (Tech-Evaluations)
- **Decarbonization Solutions** (Green-Blue Ammonia & Methanol Plant Studies)

- Technology Evaluation
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- Process & Technology
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- Pilot Scale Up
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