

ADIABATIC FLASH DESIGN 2.0 FOR ENHANCED ENERGY EFFICIENCY



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AGENDA

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01



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INTRODUCTION

ABSTRACT: WHY IT MATTERS

- In the past, in urea plant design, reactor yield and thus stripping efficiency have been optimized.
- In the Adiabatic Flash Design 2.0 concept optimization is made towards HP steam consumption and investment cost.
- In a urea synthesis, HP steam is consumed and LP steam is produced.
 - LP steam is used in the downstream sections

ABSTRACT: WHY IT MATTERS

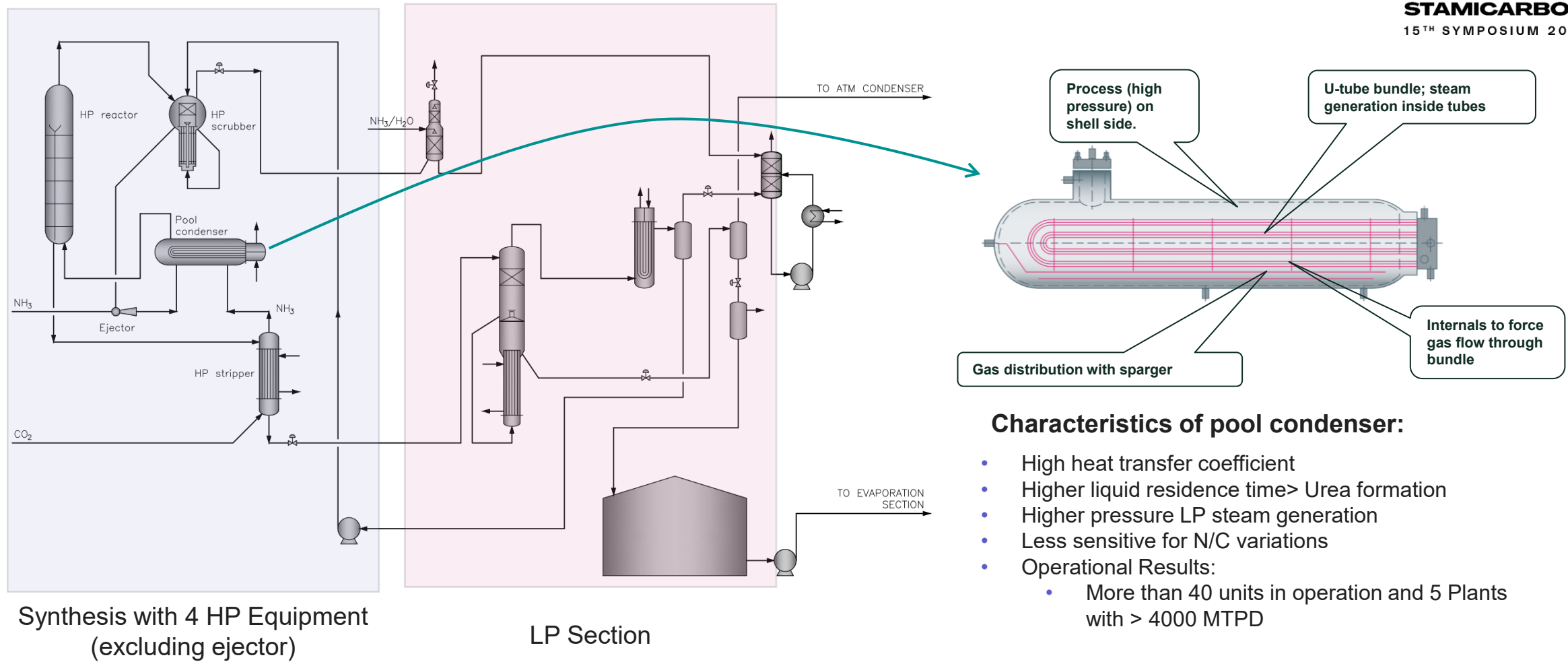
THE ADIABATIC FLASH DESIGN 2.0 CONCEPT:

- Minimizes excess LP steam production and export
- Lowers HP steam consumption
- Demonstrated HP steam consumption ~610 kg/ton of urea granules at 23 bara, 330 °C.
- Positions between Pool Condenser Design (~870) and Ultra Low Energy (ULE) (~540) in energy use.

POOL CONDENSER DESIGN (Base case): PROCESS DESCRIPTION (> 3000 MTD)



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POOL CONDENSER DESIGN: ENERGY FLOW DIAGRAM

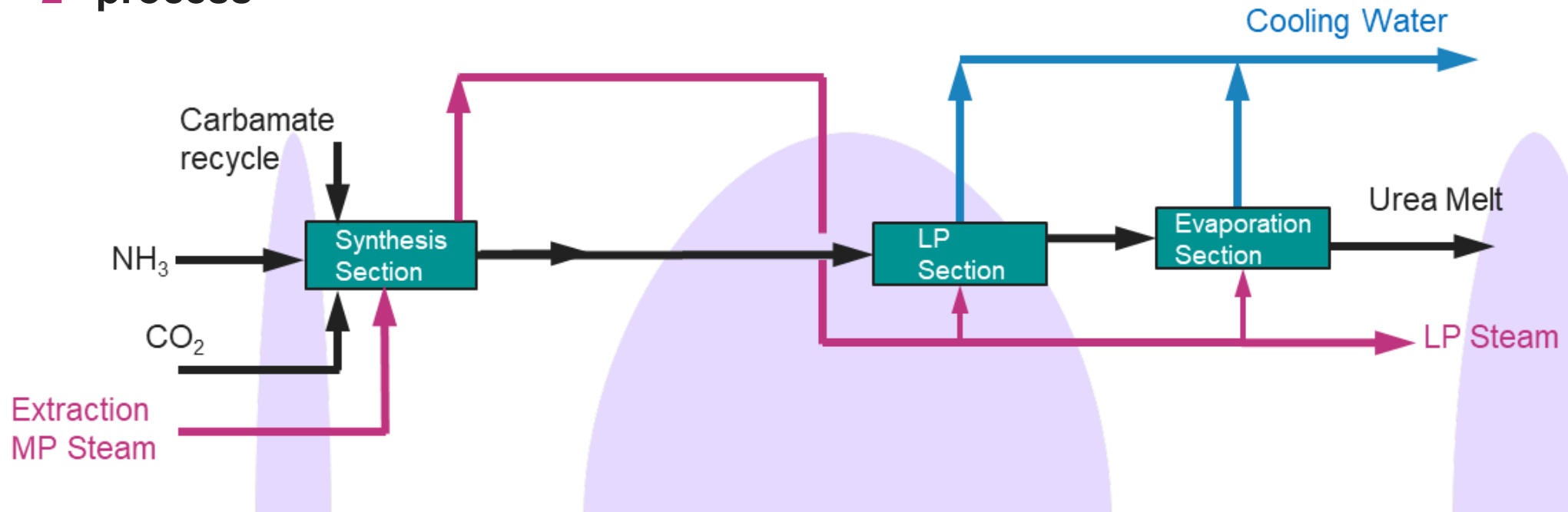


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- Steam requirement ~ 870 kg/ton urea granules at 23 bara, 330 °C
- About 96% of the 870 kg/ton steam is consumed by the stripper

Hence, the way to decrease the steam consumption is **optimizing the stripping efficiency**

The “N = 2” process

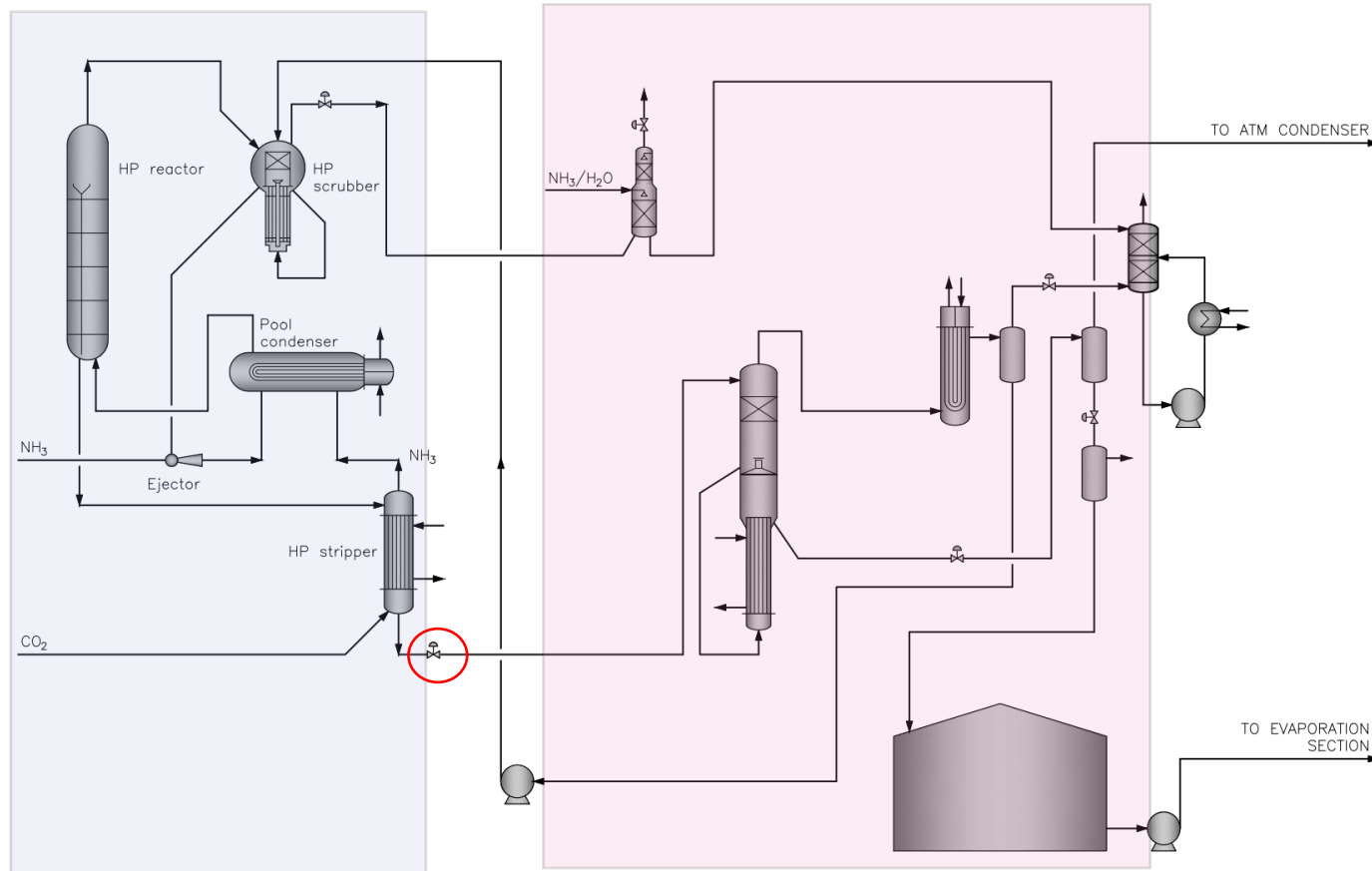


ADIABATIC FLASH DESIGN: PROCESS DESCRIPTION (> 3000 MTD)

In late 2000, a lower energy consuming urea plant design was developed and realized.



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Synthesis with 4 HP Equipment
(excluding ejector)

LP Section

POOL CONDENSER DESIGN:

Due to only presence of the HP and LP section:

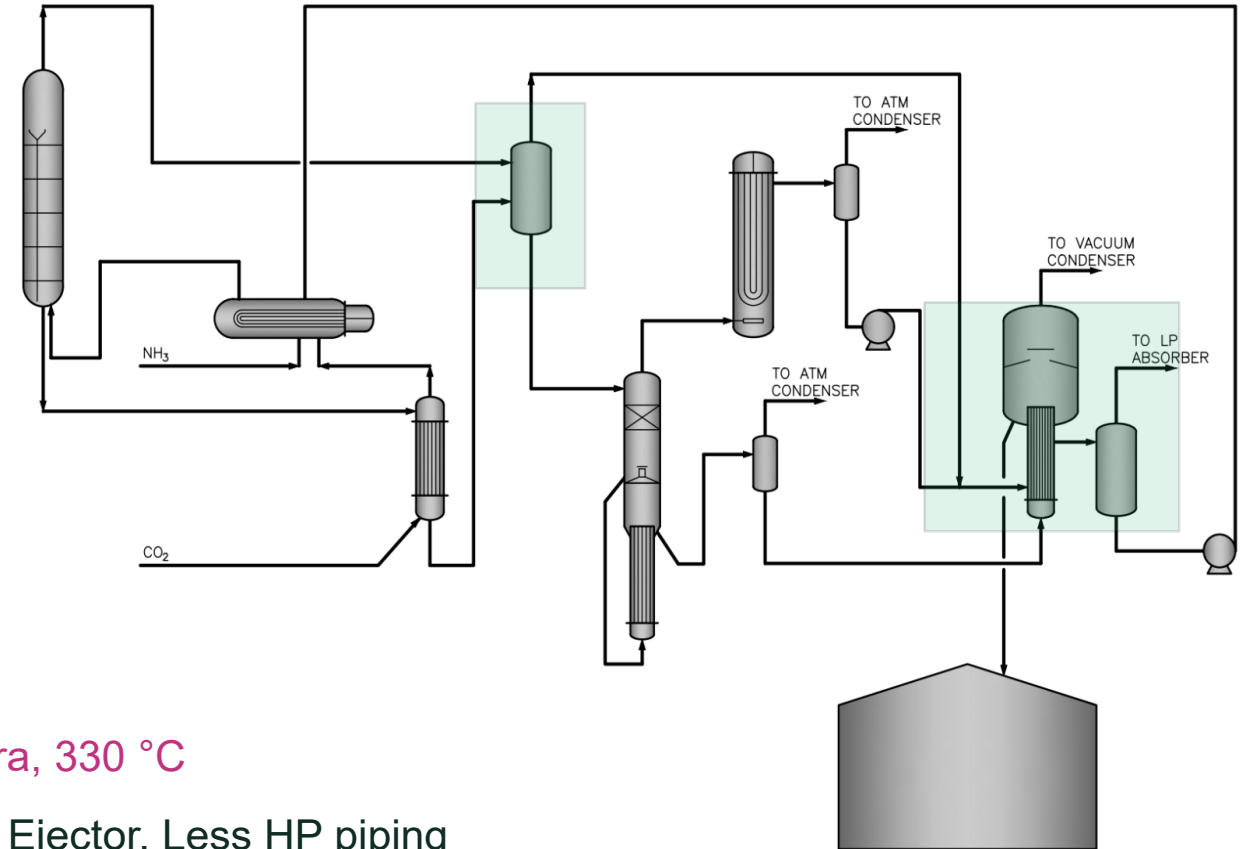
- The energy present in the flashed vapor generated from urea solution leaving stripper (HP section) to LP section was lost to CW at LP section

ADIABATIC FLASH DESIGN: PROCESS DESCRIPTION (> 3000 MTD)



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- In late 2000, a lower energy consuming urea plant design was developed and realized.
- Energy reduction by introducing “MP section” with process-process heat exchanger.
- The energy present in flashed vapor was not directly lost into CW and rather provided an opportunity to improve energy efficiency!



ADIABATIC FLASH TECHNOLOGY

Advantages:

HP Steam consumption ~ 760 kg/ton urea granules at 23 bara, 330 °C

Other advantages (CAPEX saving): No HP Scrubber, No HP Ejector, Less HP piping

02



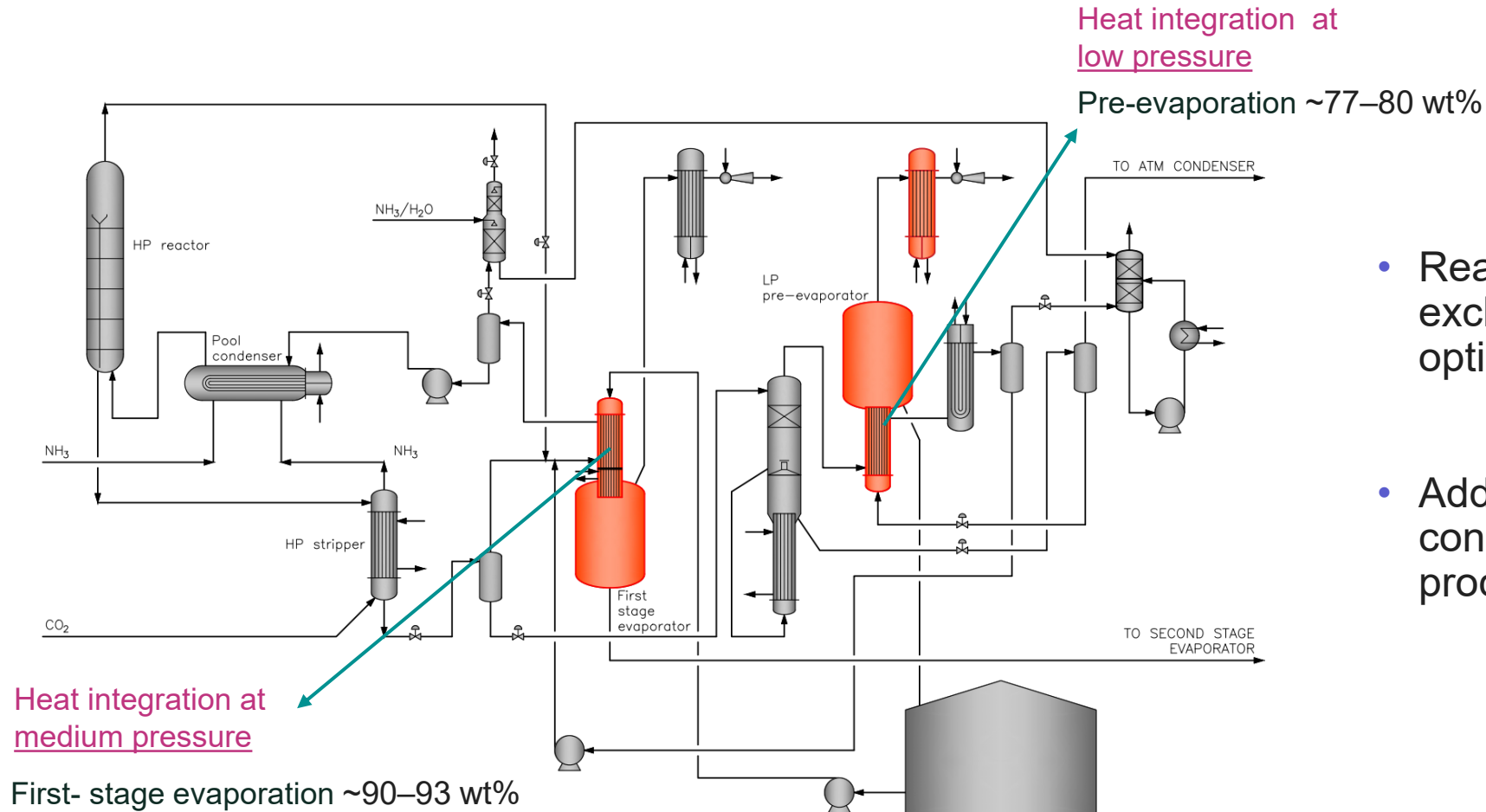
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ADIABATIC FLASH DESIGN 2.0

ADIABATIC FLASH DESIGN 2.0 (> 3000 MTD) — WHAT'S NEW



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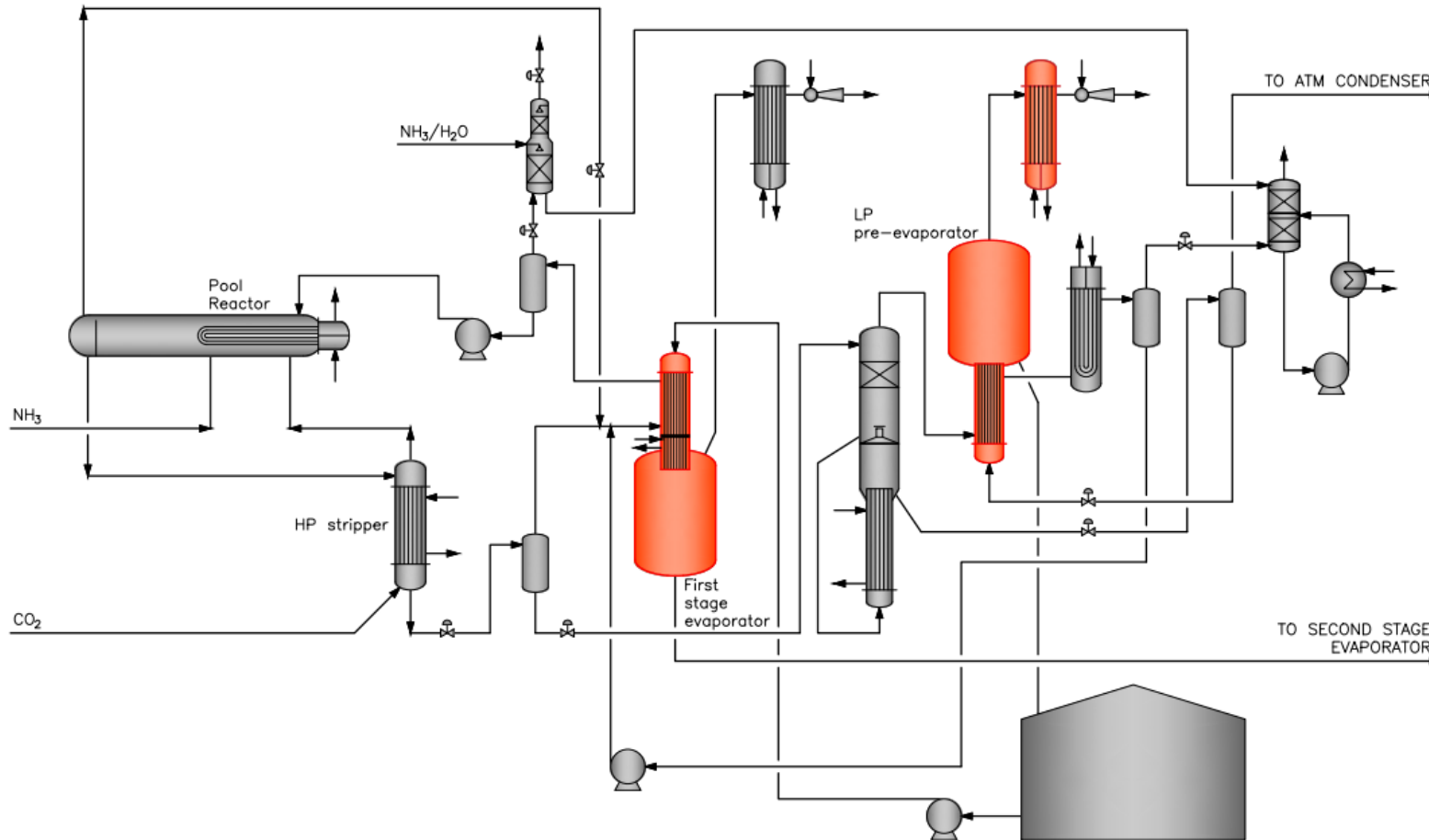


- Rearrangement of the Heat exchanger (MPCC / LPCC) to optimize energy consumption.
- Adds LP pre-evaporator: staged condensation (LP then MP) for process-to-process heat integration.

ADIABATIC FLASH DESIGN 2.0 (≤ 3000 MTD)



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- Pool reactor: horizontal design.
- Stripper located at ground floor.
- No HP scrubber needed which results to lower elevation of the structure.
 - Lower CAPEX and simpler construction

ADIABATIC FLASH 2.0 TECHNOLOGY WITH POOL REACTOR

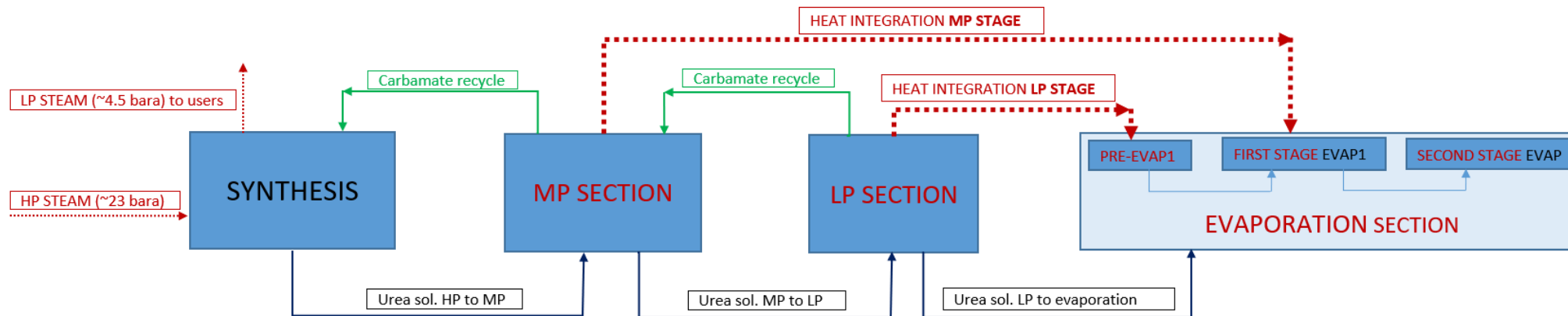
Pool reactor configuration, typically up to ~ 3000 MTD

ADIABATIC FLASH DESIGN 2.0 (> 3000 MTD) — WHAT'S NEW



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ENERGY FLOW DIAGRAM SCHEMATIC REPRESENTATIONS: WITH
HEAT INTEGRATION IN MEDIUM & LOW-PRESSURE SECTIONS



ADIABATIC FLASH 2.0 TECHNOLOGY

Advantages:

HP Steam consumption ~ 610 kg/ton urea granules at 23 bara, 330 °C

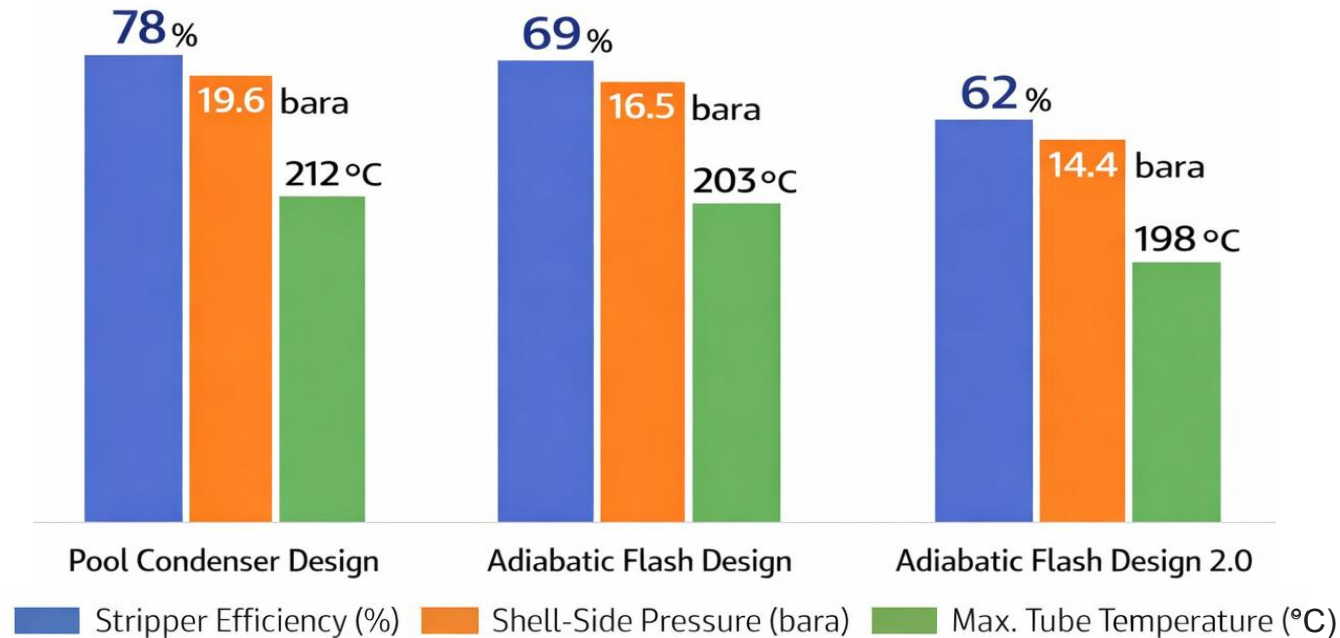
- Process/process heat exchange MP/LP

Other advantages (CAPEX saving): No HP Scrubber, No HP Ejector, Less HP piping

HP STRIPPER OPERATING POINT



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- Lower shell-side steam pressure → 10–15 °C lower shell temperature compared to the Pool Condenser design.
 - Typically, every 10 °C is half the corrosion rate
- **Benefits:** reduced passive corrosion; extended stripper lifetime; milder conditions → lower biuret.

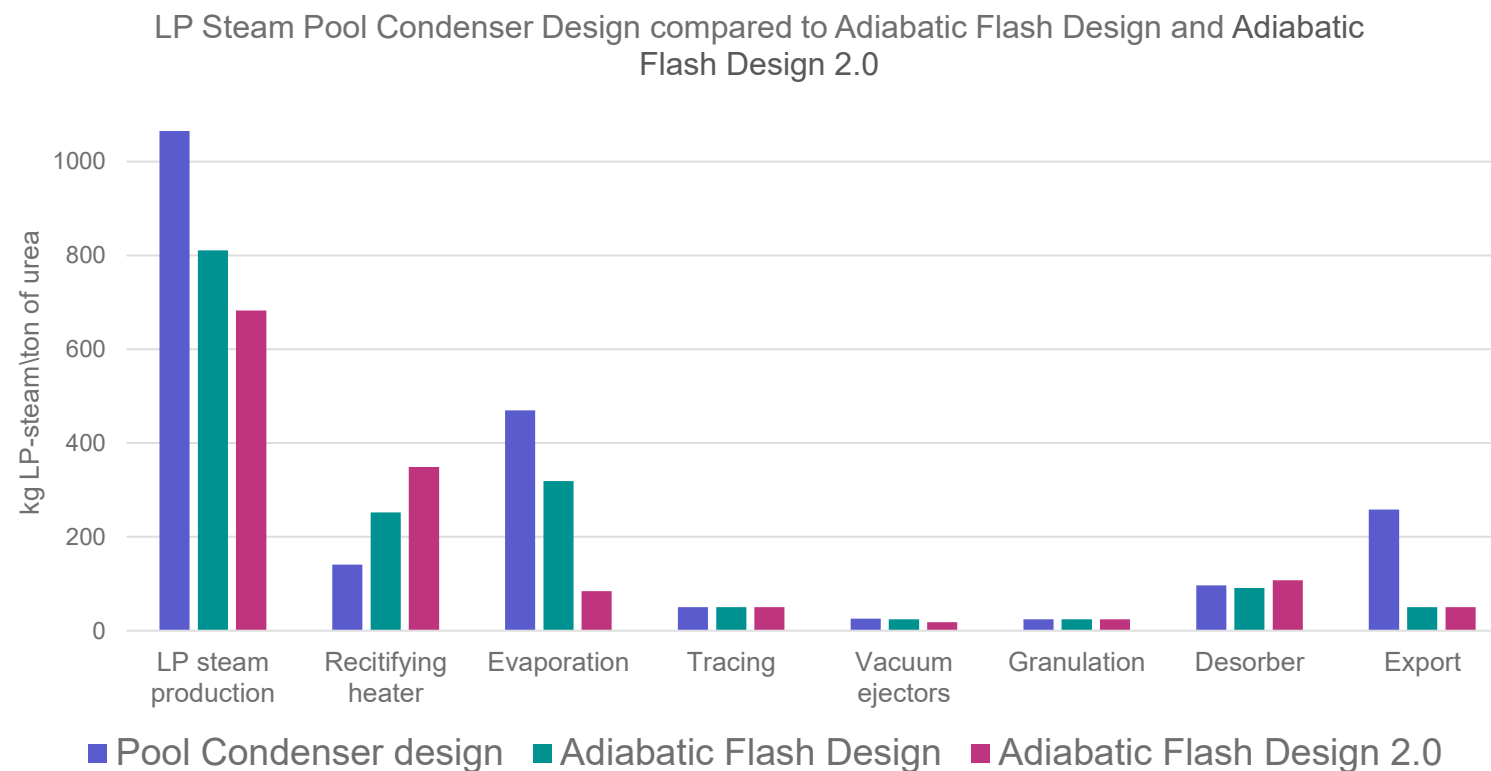
STEAM BALANCE OPTIMIZATION



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ADIABATIC FLASH DESIGN 2.0 COMPARED WITH ADIABATIC FLASH DESIGN AND POOL CONDENSER DESIGN:

- Energy saving only due to heat integration between LP and MP carbamate condensation in pre-evaporation and evaporation sections.
- Flash 2.0 reduces LP steam used for evaporation drastically via pre-evap + MP integration.
- Rectifying heater demand rises modestly due to lower stripping efficiency.
- Additional saving in HP steam due to minimizing LP steam export.





CAPEX/OPEX COMPARISON

OPEX/CAPEX COMPARISON (> 3000 MTD)



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THE FLASH DESIGN 2.0 AS COMPARED TO THE POOL CONDENSER DESIGN AND THE ULTRA LOW ENERGY DESIGN

- Comparable to first generation Adiabatic Flash Design; in terms of number of equipment: adds LP pre-evaporator (commodity heat exchanger, lower design pressure).
- Lower HP equipment count than Pool Condenser Design.
- The newly added equipment use standard material of construction (duplex) based on Stamicarbon specifications; for MP/LP additions which are not expected to dominate cost.

Design concept	HP Steam consumption* (at 23 bara, 330°C) [kg/ton of urea granules]	Number of HP equipment items
Pool Condenser Design	~ 870	4 (excluding the ejector)
Adiabatic Flash Design	~ 760	3
Adiabatic Flash Design 2.0	~ 610	3
ULE Design	~ 540	3
<i>*All concepts are evaluated based on Pool Condenser configuration for plant capacities higher than 3000 MTPD</i>		

REFERENCES FOR ADIABATIC FLASH DESIGN



Plant	Location	Technology	Name plate capacity [MTPD]	Status
Koch Eind	USA	Adiabatic Flash	3100	In operation since 2015; revamped in 2019
Linggu	China	Adiabatic Flash	2700	In operation since 2015
Agrium Borger	USA	Adiabatic Flash	1800	In operation since 2017
NCIC-2	Egypt	Adiabatic Flash	1050	In operation since 2023
Shaanxi Shanhua	China	Adiabatic Flash	2700	In operation since 2025
Xinjiang Xinji Chemical Co.ltd	China	Adiabatic Flash	3791	In operation since 2025
Talcher	India	Adiabatic Flash	3850	Under construction
Confidential client	Sub-Saharan Africa	Adiabatic Flash	2 x 4000	Under construction
Confidential client	Russia	Adiabatic Flash	5000	Design phase completed
Genesis Fertilizers	Canda	Adiabatic Flash	2500	In engineering phase
Confidential client	Sub-Saharan Africa	Adiabatic Flash	2 x 1700	In engineering phase
Confidential client	South America	Adiabatic Flash	140	In engineering phase

Biggest capacity under development: 6000 MTD



ADIABATIC FLASH DESIGN 2.0 AS REVAMP TOOL

REVAMP APPLICABILITY

ADIABATIC FLASH DESIGN 2.0 CAN BE APPLIED IN REVAMPS (EVOLVE),
IF ANY OF THE FOLLOWING IS RELEVANT:

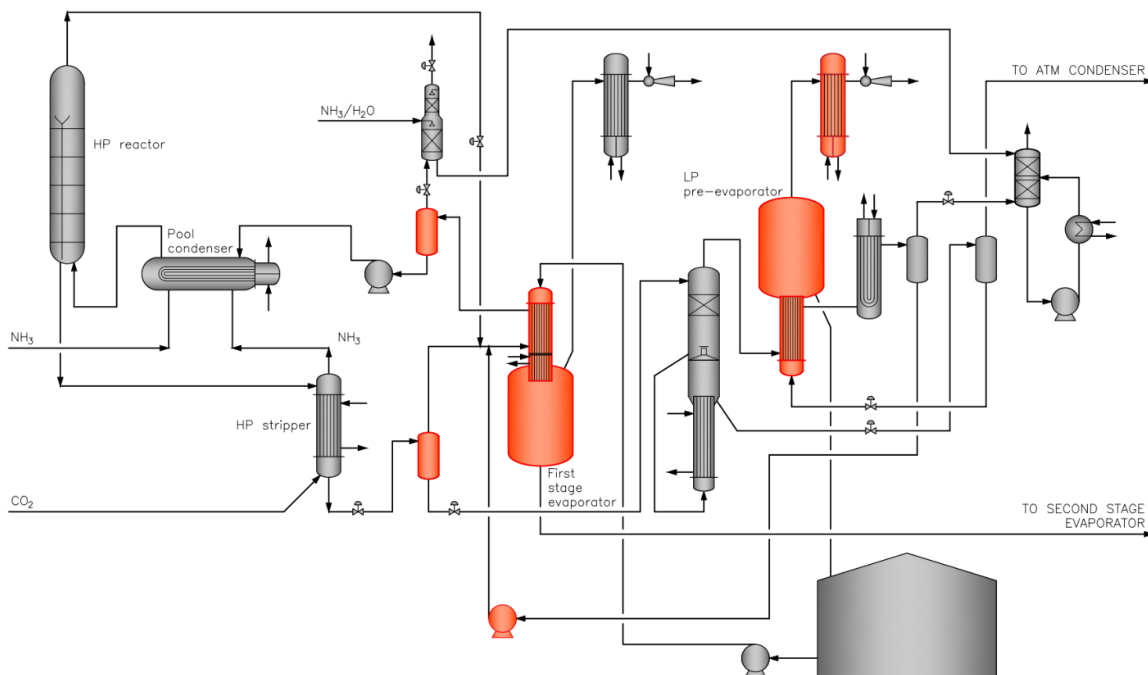
- Minimizing HP steam consumption – heat integration in pre-evaporator/evaporator at MP and/or LP sections.
- Optimizing production with limited HP steam or cooling water supply.
- HP scrubber is end of life (consider safety aspects).
- Slight increase in capacity combined with energy saving.

REVAMP APPLICABILITY EXAMPLES

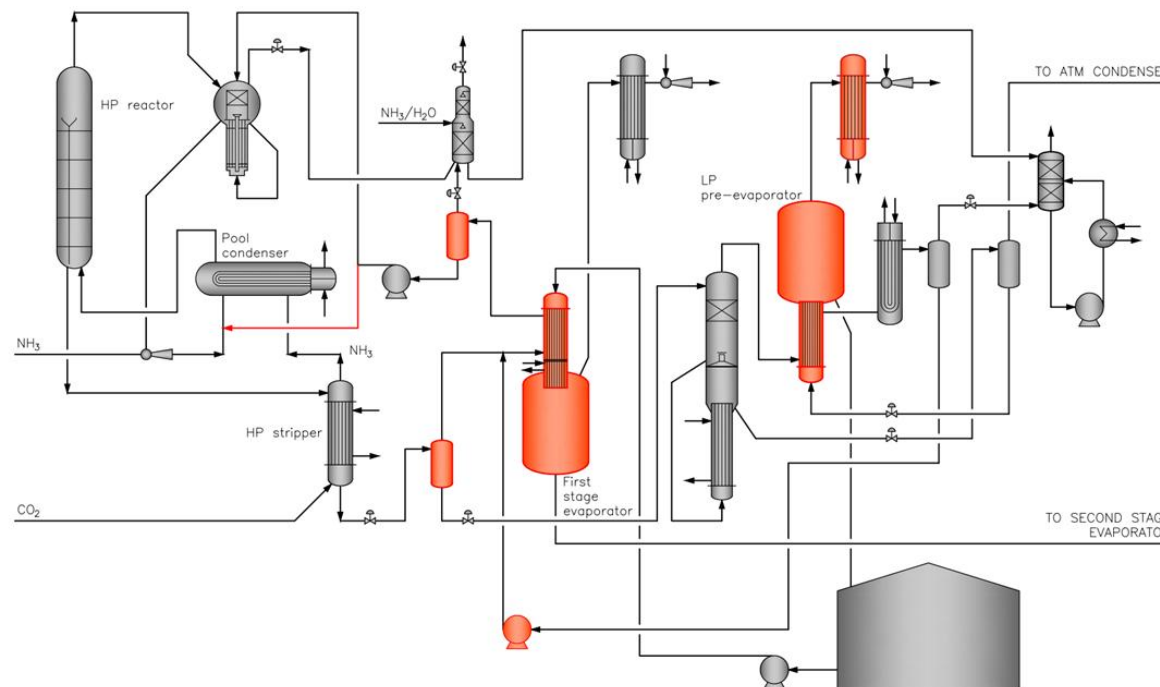


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Without HP scrubber



With HP scrubber



- Energy-saving revamps: minimize changes to synthesis; lower HP steam; balance LP steam.
- Options: **without HP scrubber**; **with HP scrubber**; bypass concepts to debottleneck and save energy.
- Typical energy benefit range: $\approx 150\text{--}250$ kg/ton reduction in specific steam depending on actual plant situation.

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OPERATIONAL EXPERIENCE

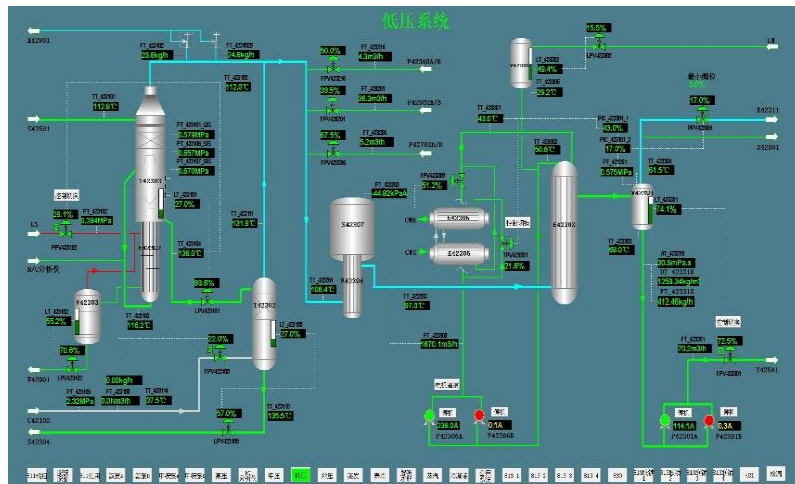
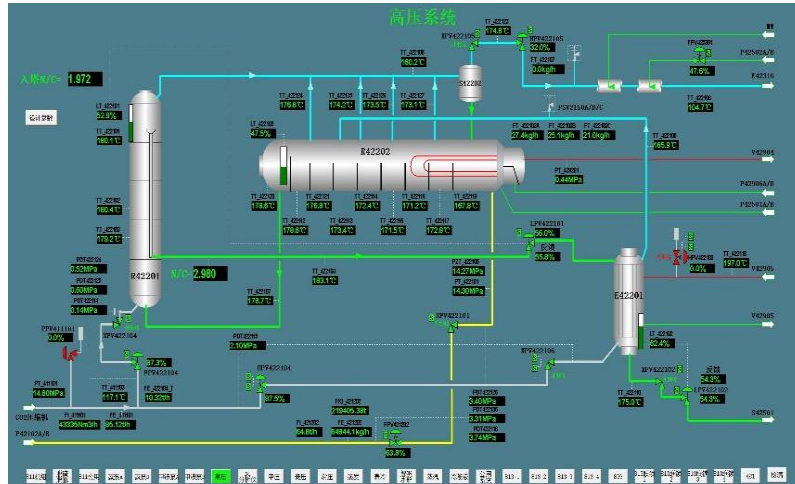
OPERATIONAL EXPERIENCE OF ADIABATIC FLASH DESIGN 2.0



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MAIN OBSERVATION FROM RUNNING PLANTS:

- Four plants operating (**two grassroots** since Apr 2025):
- Stable startups; targets achieved at 100% plant operation.
- Proven specific HP steam ≈ 610 kg/ton of granules at 23 bara, 330 °C.
- Biuret in final product <0.80 wt%; ~ 0.05 wt% lower than traditional designs.
- Lower shell side pressure of stripper (lower tube skin temperature):
Longer lifetime of stripper (see the DCS graphics).



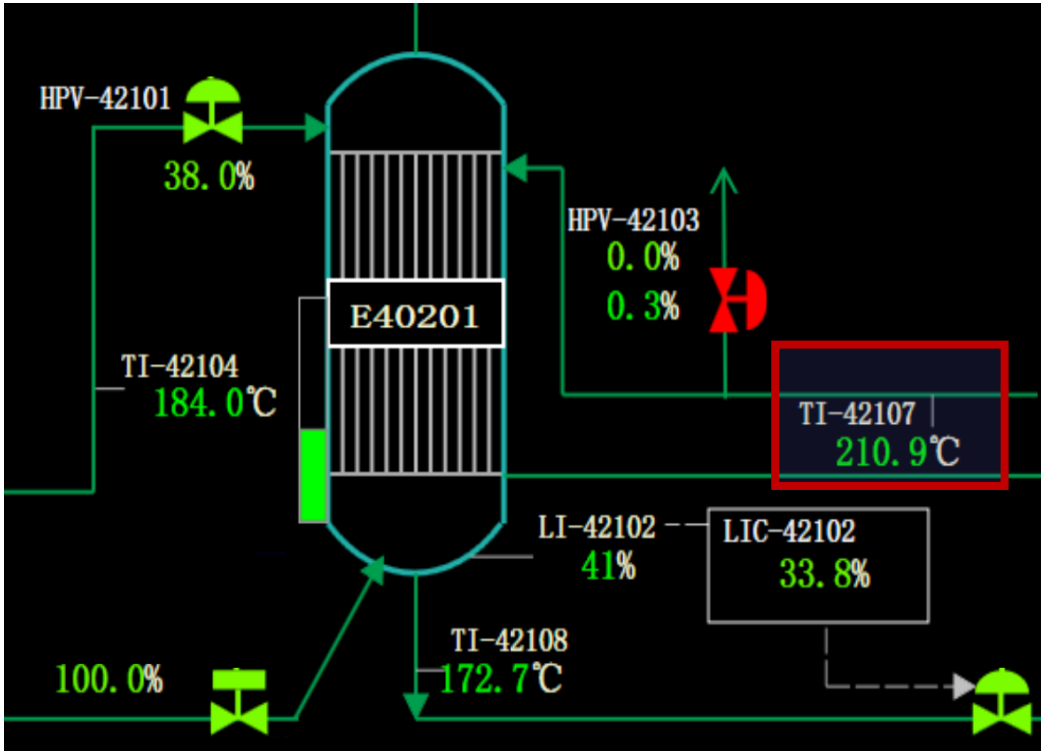
Plant: Shaanxi Shanhua

OPERATIONAL EXPERIENCE

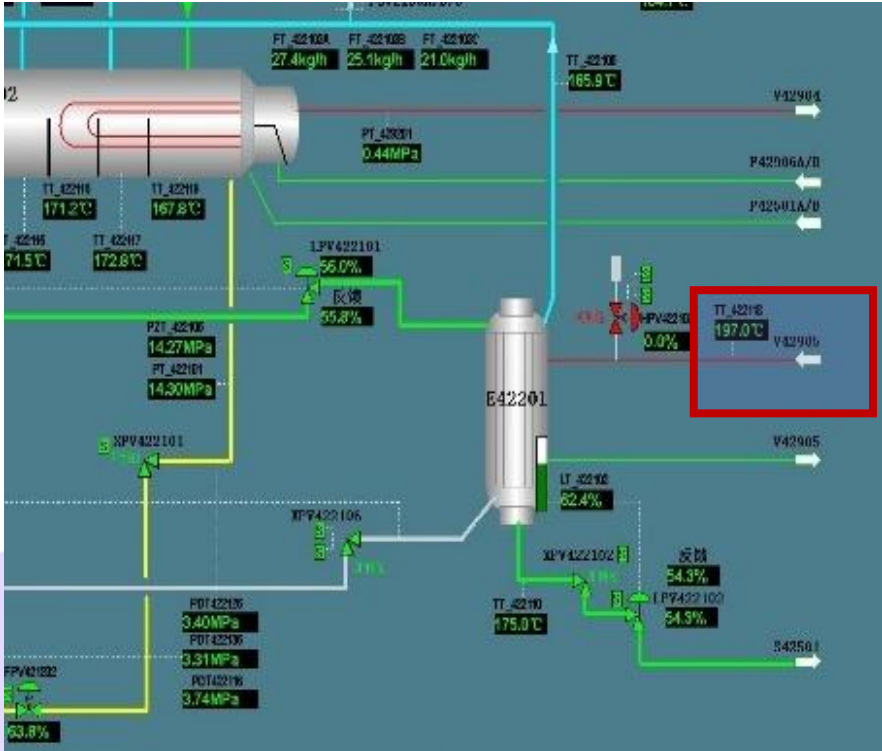
(STRIPPER OPERATING POINT)



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CO₂ Stripper in traditional synthesis (about 100 % capacity)
HP steam shell side: 211 °C



CO₂ Stripper in Adiabatic Flash Design 2.0 (100% capacity) synthesis (Shaanxi Shanhua -2700 MTPD)
HP steam shell side: 197 °C



CONCLUSION

CONCLUSIONS

- ≈25 to 30% HP steam reduction vs traditional Pool Condenser Design (23 bara, 330 °C).
- Balanced LP steam: minimize export, avoid HP steam import.
- All features with pool condensation are also observed with Adiabatic Flash Design 2.0 process, such as easy startup, stable plant operation.
- Better product quality achieved in terms of the biuret content in the final product.
- Longer lifetime of the stripper expected.
- OPEX/CAPEX optimized compared to Pool Condenser Design.
- Attractive for revamps; without modifying the HP equipment while delivering major OPEX gains.

THANK YOU



QUESTIONS?