Intensification of the Steam Cracking Process

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Does Steam Cracking Need Steam

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Presentation outline

- Introduction
- Catalytic plate reactors
- Coke formation
- Objectives
- Benefits
- Methodology
- Experimental Work
- Results
- Conclusions

Introduction

Olefins demand in year 2005 :

Ethylene (107 million tons)

propylene (67.1 million tons)

Olefins demand growth during years(2005 –2010):

Ethylene about 4.3% per year

propylene about 5.4% per year

Olefins production capacity growth:

Ethylene about 5.4% per year

Propylene about 5.1% per year

Typical Steam Cracking Furnaces

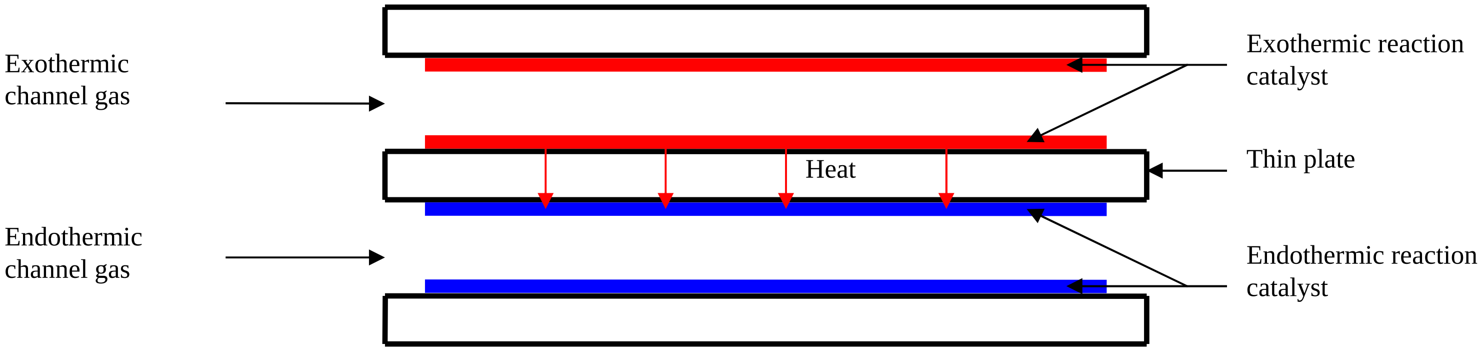
- Total Number of cracking tubes about 600
- Total Reaction Volume about 45 m^3
- Total firebox volume about 9,000 m^3
- Residence Time 0.25 to 0.75 s
- Firebox Efficiency about 65%

Steam function and process limitation

- Enhance heat transfer
- Reduce coke formation and deposition
- Improve selectivity towards ethylene
- Operation purposes
- Coke deposition is the main process limitations due to:

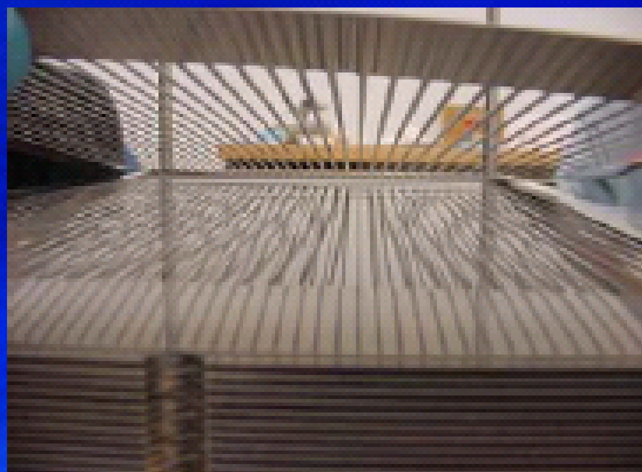
  - High tube skin temperature

  - High pressure drop



Catalytic Plate Reactor

Velocys Device Fabrication



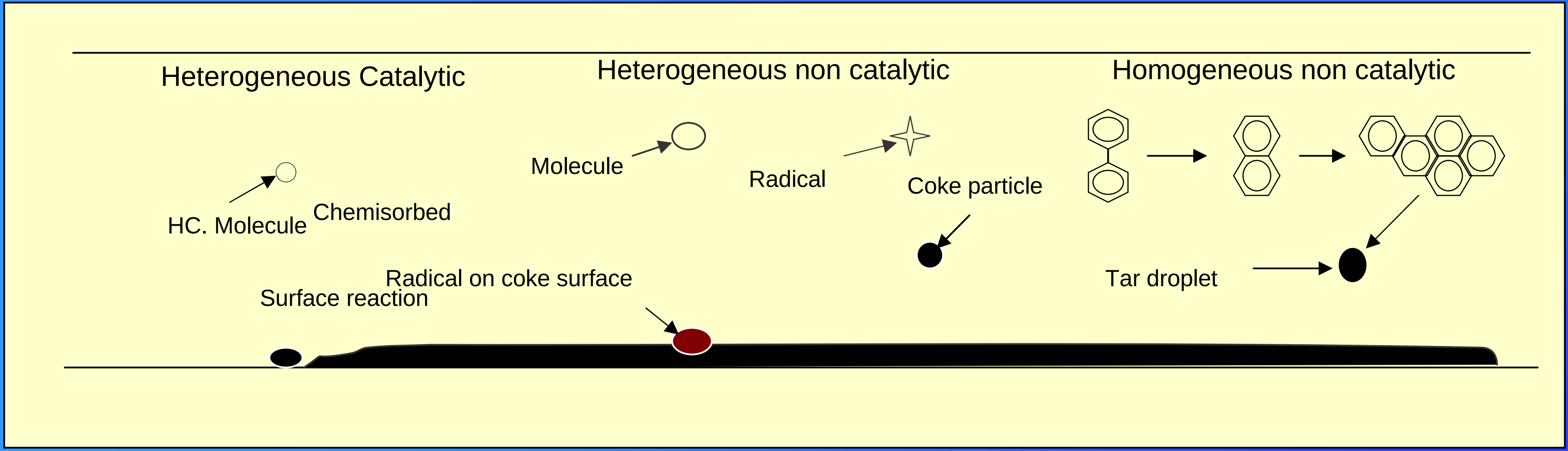
Source: Velocys,(2005),olefins by high intensity oxidation, http: // www.velocys.com/Img/pdf.2250.pdf

Advantages Of Catalytic Plate Reactor

- High Surface to volume Ratio
- Laminar flow Conditions
- High Heat transfer Coefficient
- Thin Catalyst Layer Minimize Diffusion Limitation
- Surface Temperature only few degrees above the process temperature
- Improved Safety and Environmental Impact
- Scale-up by Numbering –up
- Low Capital and operating Costs

Coke formation

- Metal-catalyzed coke
- Non-catalytic coke from tars
- Small chemical species (coke precursors) react with free radicals on the coke surface



Objectives

1-Study and investigate the possibility of intensifying the thermal cracking of propane to produce ethylene through the use of the catalytic plate reactors.

2- Reducing the coke formation and deposition.

3- Reducing the use of steam.

4- Modelling and simulation for propane cracking using Catalytic Plate Reactor.

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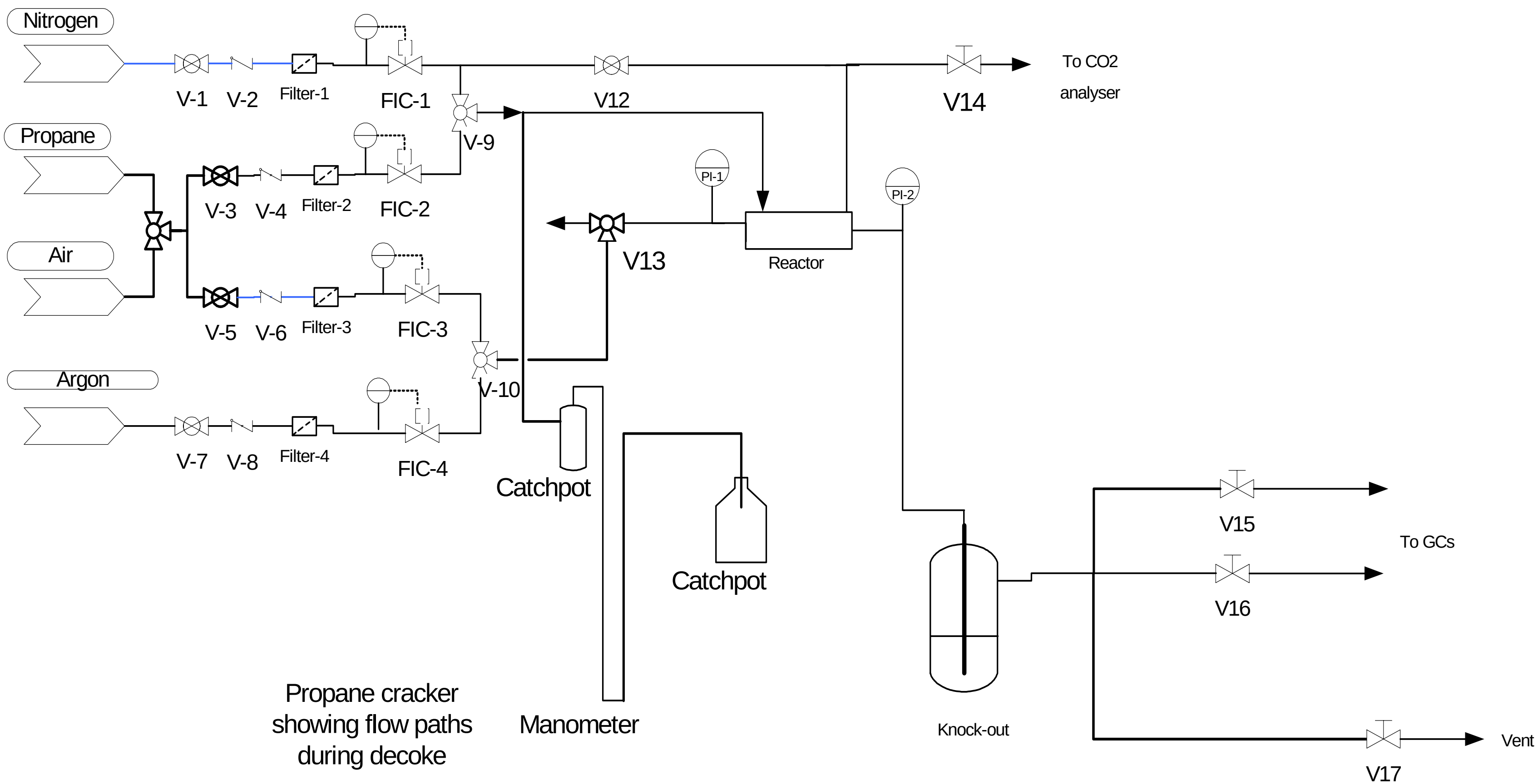
Benefits

- Lower environmental and safety impacts. (NO_x, contaminated water, CO_2, H_2S)
- Improved energy efficiency.
- Lower capital cost.
- Improved overall plant economics

Experimental setup design criteria

- Allows for accurate coke measurement
- Constant and uniform temperature along the reactor
- Very fast cooling of reaction products
- Easy to change reactor size and material



Propane cracker showing flow paths during decoke

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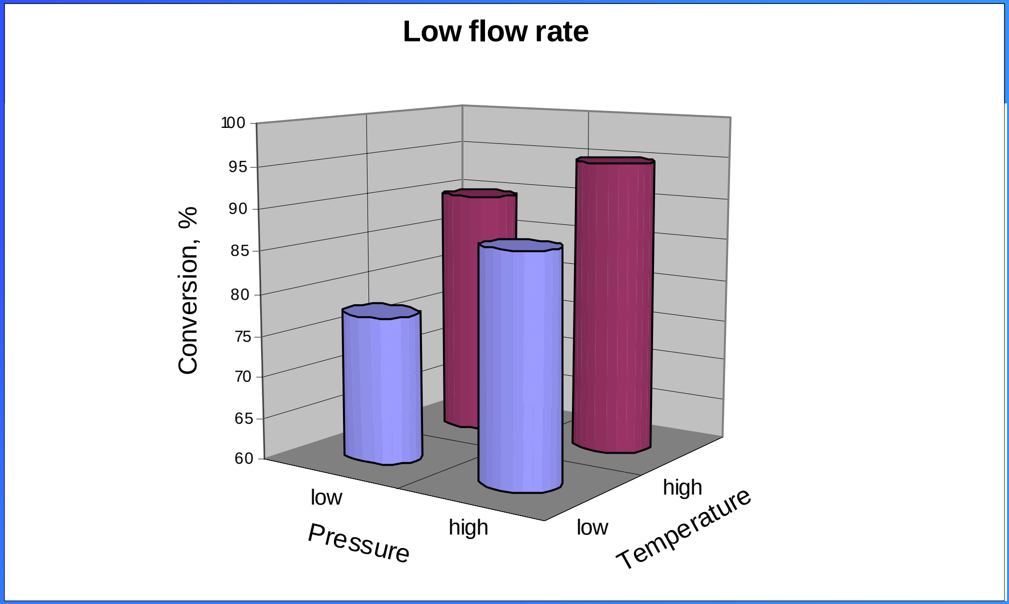
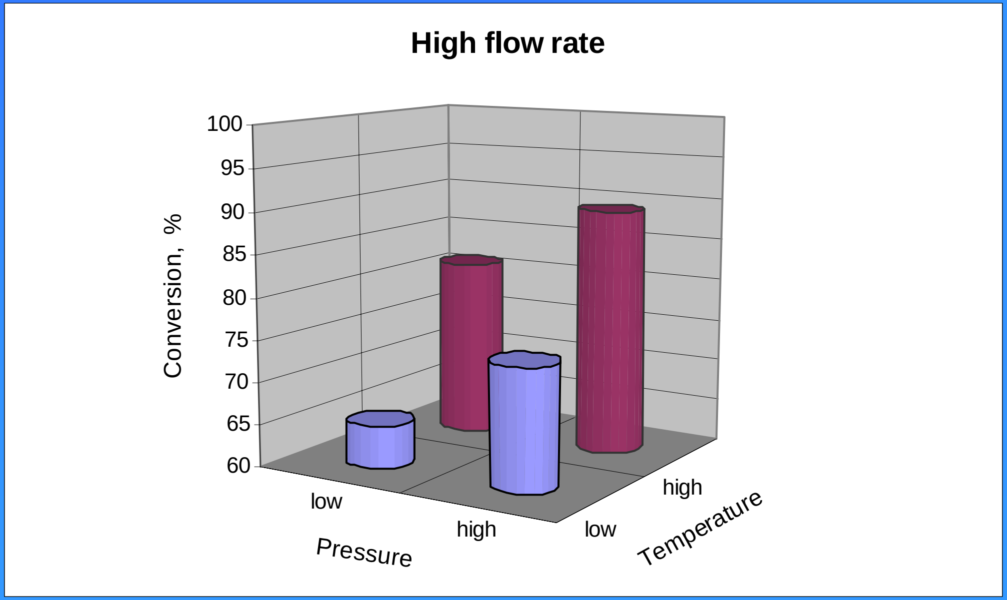
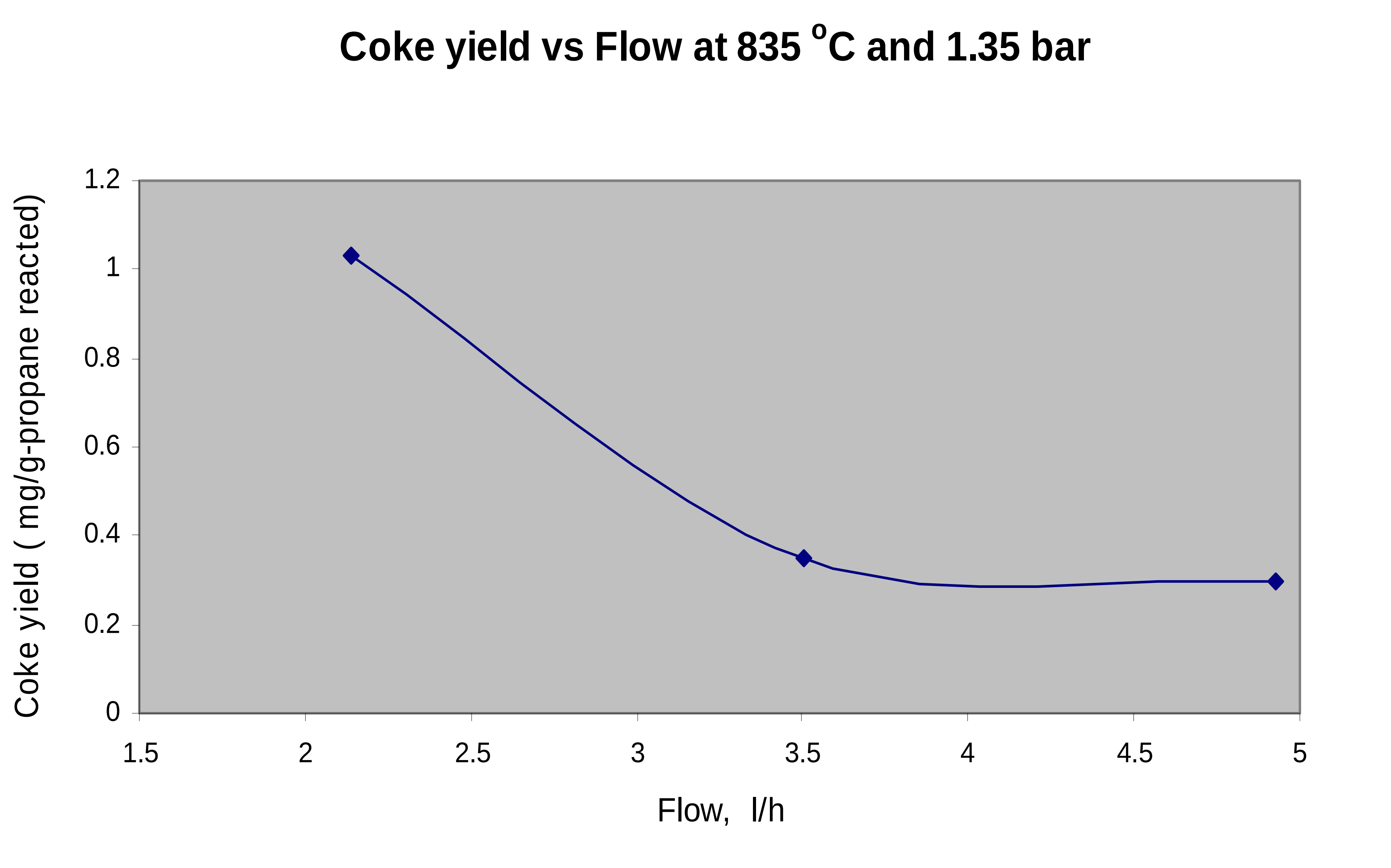
Experimental variables

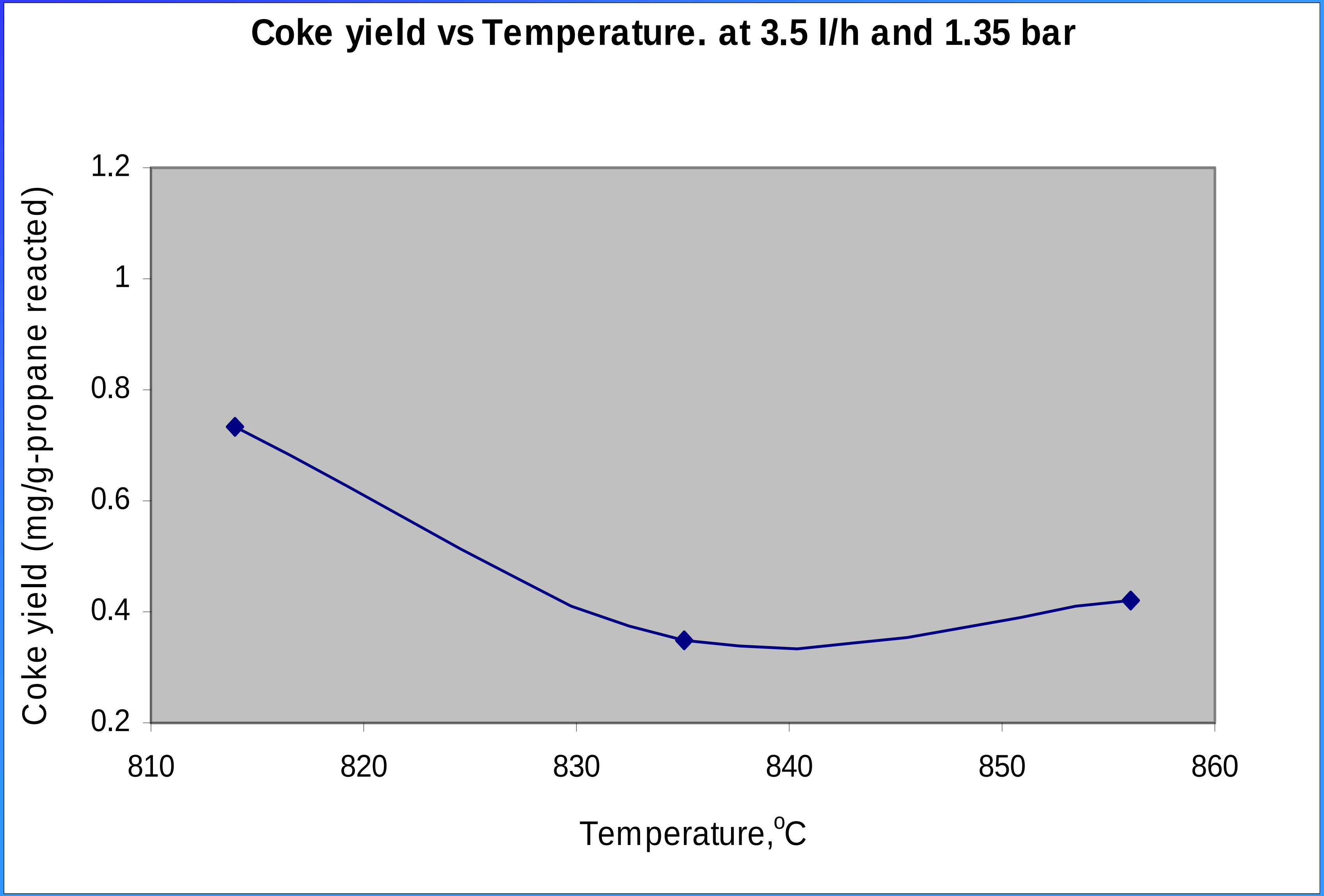
- Reactor materials and internal coatings
- Reactor channel size
- Process variables (temperature, pressure, and flow rate)
- Run time length

Conversion at low and high operating parameters



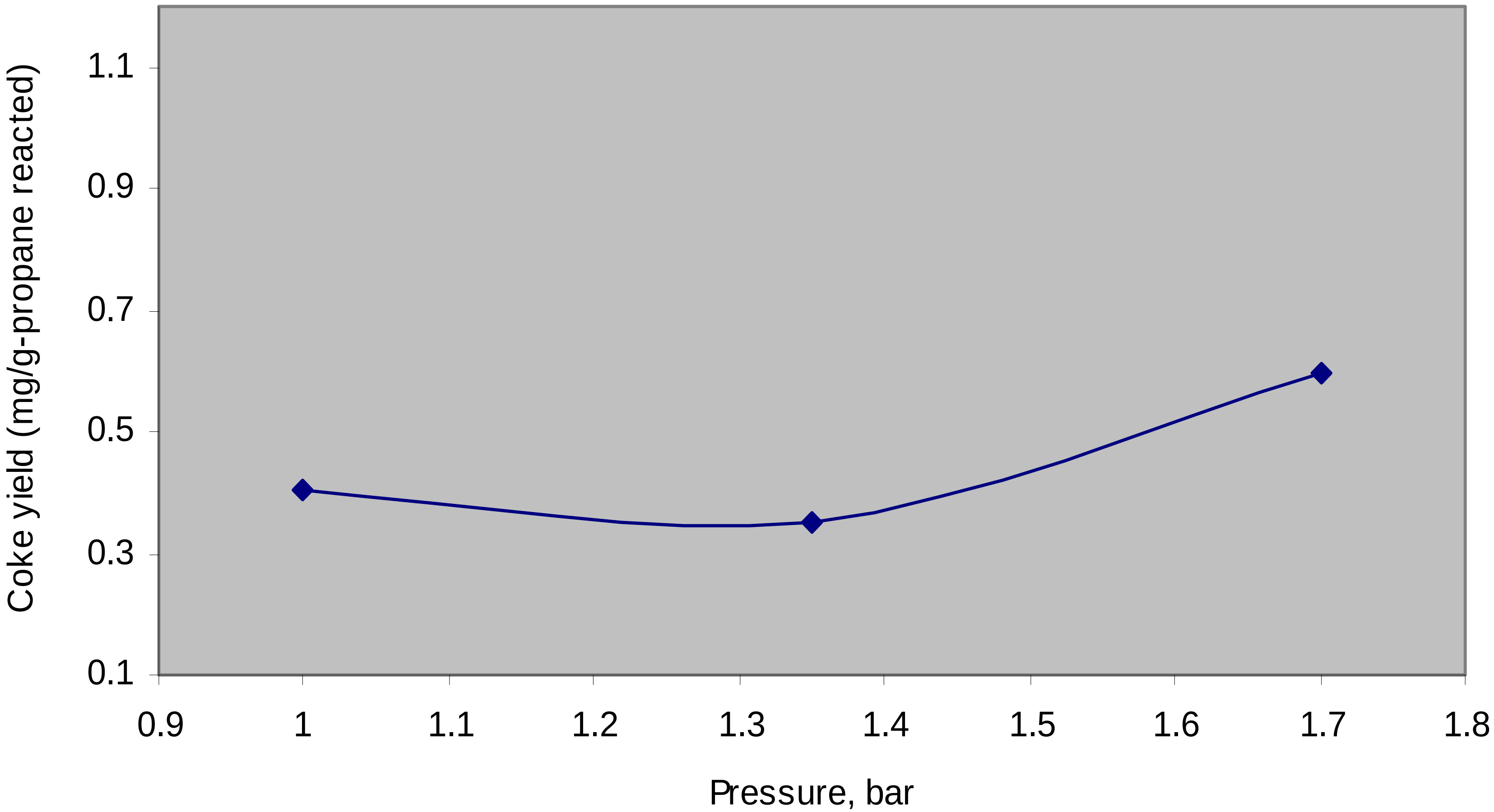



Coke yield vs Flow at 835 °C and 1.35 bar
Coke yield (mg/g-propane reacted)
1.2
1
0.8
0.6
0.4
0.2
0
1.5
2
2.5
3
3.5
4
4.5
5
Flow, l/h

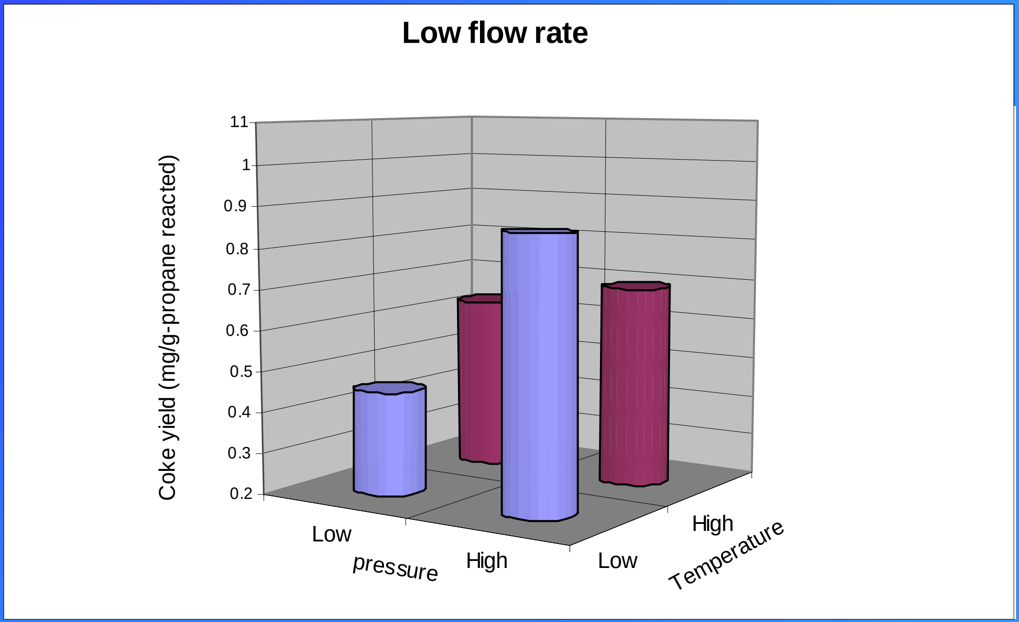


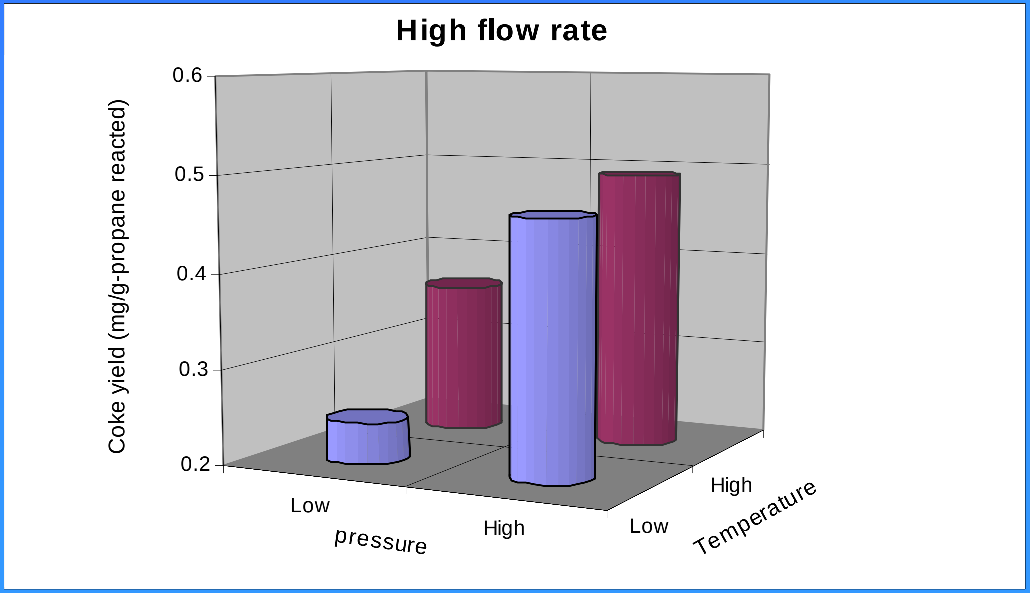
Coke yield vs Temperature. at 3.5 l/h and 1.35 bar
Coke yield (mg/g-propane reacted)
1.2
1
0.8
0.6
0.4
0.2
810
820
830
840
850
860
Temperature,oC

Coke yield vs Pressure at 3.5 l/h and 835 ^{o}C



Coke yield at low and high operating parameters





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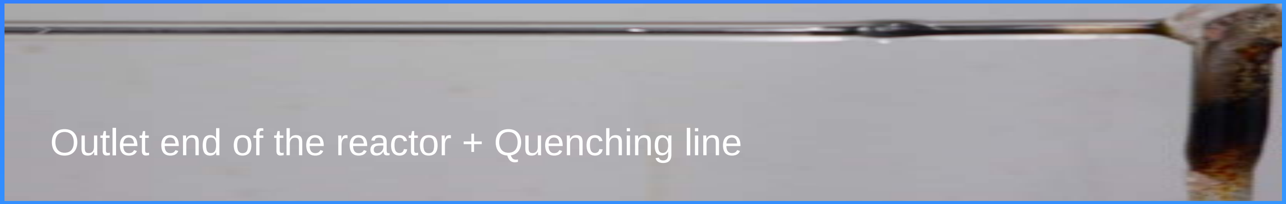
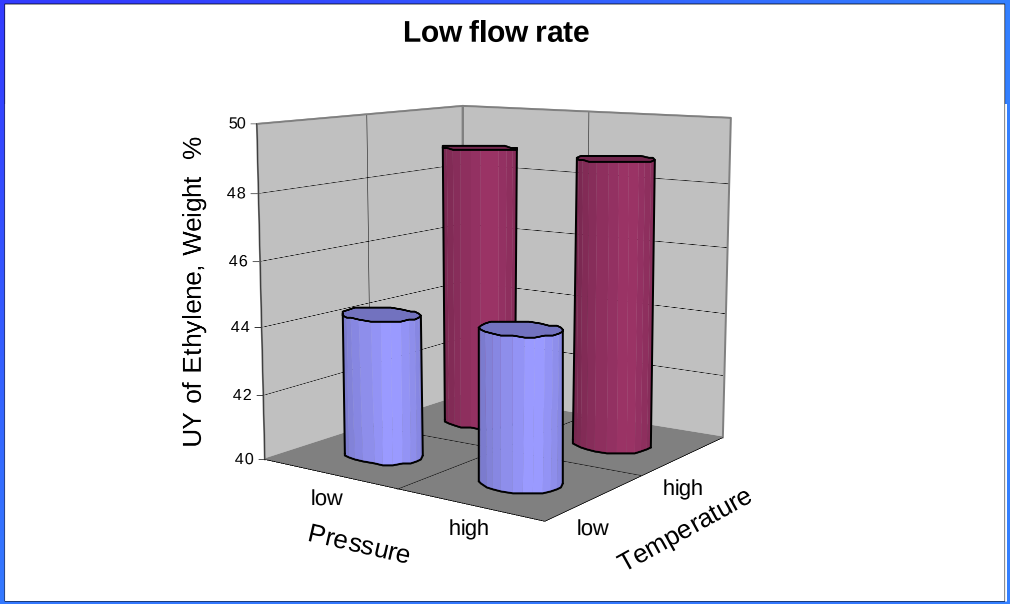
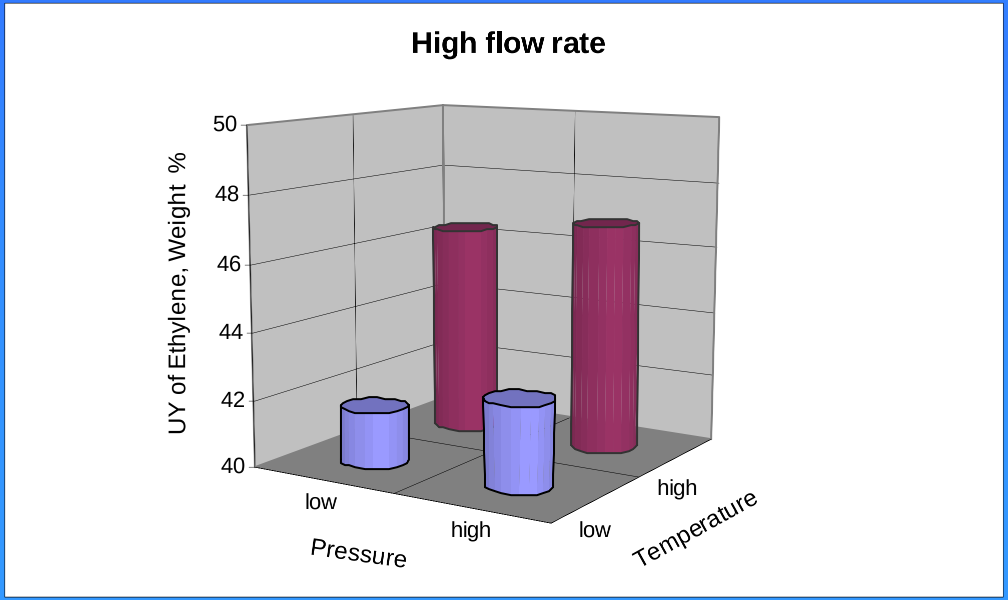
Inlet of the reactor


Middle of the reactor


Outlet end of the reactor + Quenching line

UY of Ethylene at low and high operating parameters





$$\text{Ultimate Yield} = \frac{\text{Mass Ethylene Produced}}{\text{Mass Propane In Feed}}$$

Assuming that the unreacted propane and the ethane produced by one pass through the reactor, are recycled to the feed

Conclusions

- Conversion of about 90 % can be achieved in 2 mm internal diameter fused silica reactor without any significant pressure drop.
- Steam use can be reduced or possibly eliminated.
- High olefins yield can be obtained without steam.
- Low acetylene and C_4^+ yield.
- Run length of about 14 – 20 days was estimated to be possible before any decoking is required. This run length was achieved with no steam.

THANK YOU