Computational fluid dynamics-based study of novel technologies in the steam cracking process

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INTRODUCTION

STEAM CRACKING

Hydrocarbon feedstock is cracked at high temperatures to produce light olefins

IMPROOF objective: improving the energy efficiency of the steam cracking process

Emissive properties of both coated and uncoated materials typically used in steam cracking furnaces have been determined

Novel technologies reactor side

• 3D reactor design

furnace side

• high emissivity coatings
• oxy-fuel combustion

HIGH EMISSIVITY COATINGS

Enhanced heat transfer by modifying the reactor shape:

\[ Q_{\text{net}} = U A (T_{\text{reactor wall}} - T_{\text{fluid}}) \]

• increase tube surface area A ↑
• increase heat transfer coefficient U ↑

Increased pressure drop implies

• loss in product selectivity
• conventional bare reactor
• industrial patented designs

HIGH EMISSIVITY COATINGS

Enhanced radiative heat transfer by tuning emissive properties
Electrical circuit analogy:

\[ \frac{1}{\varepsilon_1} - \frac{1}{\varepsilon_2} = \frac{1}{\varepsilon_{12}} \]

High emissivity coatings reduce the resistance and hence result in lower temperatures in the furnace → less firing

\[ Q_{\text{firing}} = \frac{1}{\varepsilon_1} - \frac{1}{\varepsilon_2} \]

OXY-FUEL COMBUSTION

Oxygen is separated from air prior to combustion
Combustion of fuel in the presence of oxygen diluted with recycled flue gas
Reduce thermal NOx emissions

Produced concentrated CO2 flue gas stream easier captured and stored

CONCLUSIONS AND FUTURE RESEARCH

3D reactor technologies outperform bare reactors

→ research ongoing to develop new geometries
→ experimental validation: pilot plant & cold flow experiments (VKI)

Emissive properties of both coated and uncoated materials typically used in steam cracking furnaces have been determined

→ applicable in CFD models
→ experimental validation: pilot plant & emissivity measurements

Compare reactive CFD simulations to experiments performed by industrial partner

Define kinetic network based on laboratory scale experiments

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