JOHN ZINK HAMWORTHY COMBUSTION

Using BioFuel gas under O2 enriched flue gases in steam crackers

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Outline

- Introduction about IMPROOF EU project
- JZHC deliverables
- Testing setup at JZHC test facility
- Testing Results
- Conclusion

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Introduction

Improof

- Improof project funded by EU:

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Introduction

Improof Project partners

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JZHC deliverables

Testing objectives

- John Zink Hamworthy Combustion deliverables
  - Demonstrate the combustion performance of Bio-Fuel gases and their influence on combustion behaviour using ULN burners under ambient air conditions and oxygen enriched flue gases.

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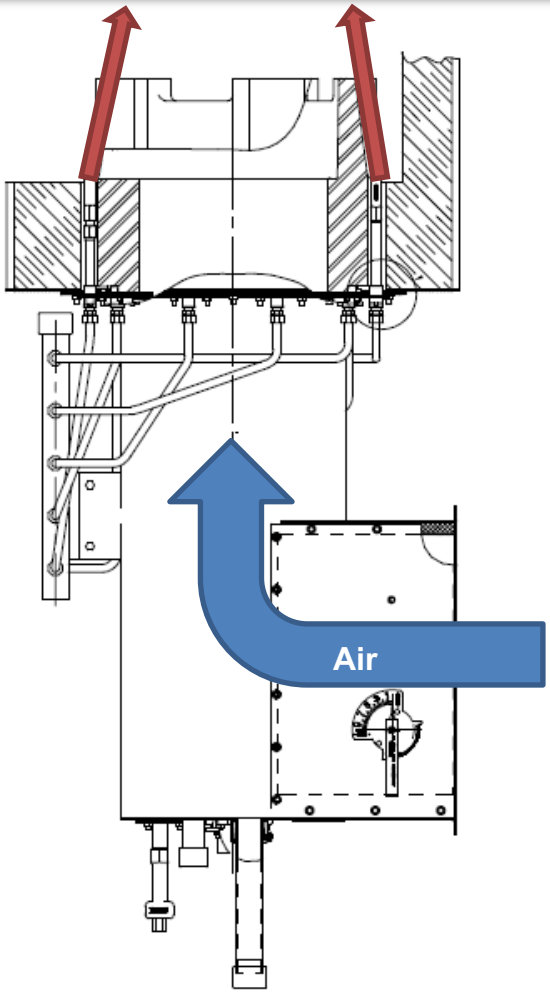
JZHC deliverables

COOLStar™ Ultra Low NOx Burner



COOLStar™-burner

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Testing setup at JZHC test facility

Furnace 14 at JZHC Tulsa test center

F14 test center

2 COOLstar TM burners installed

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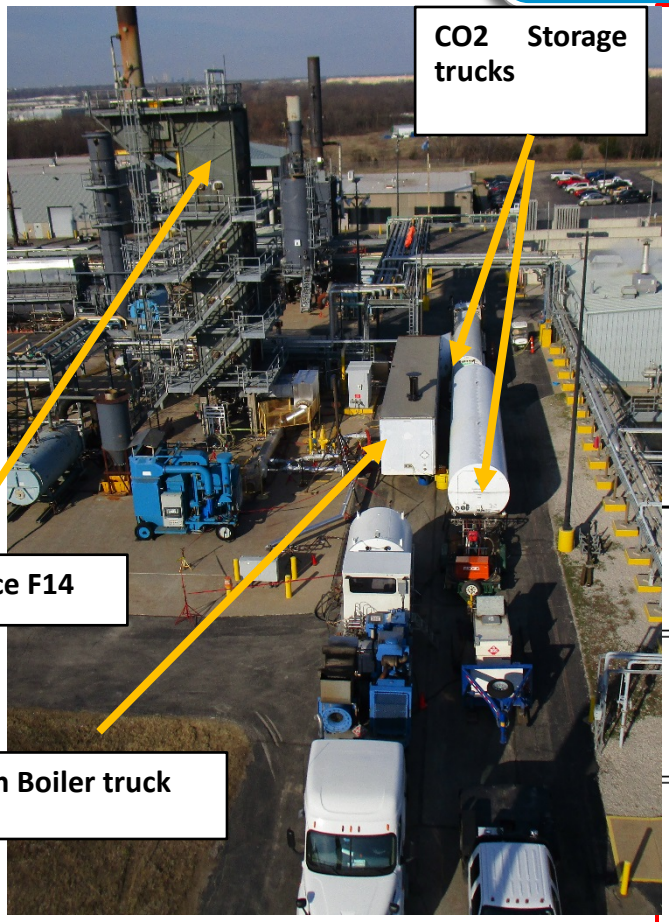
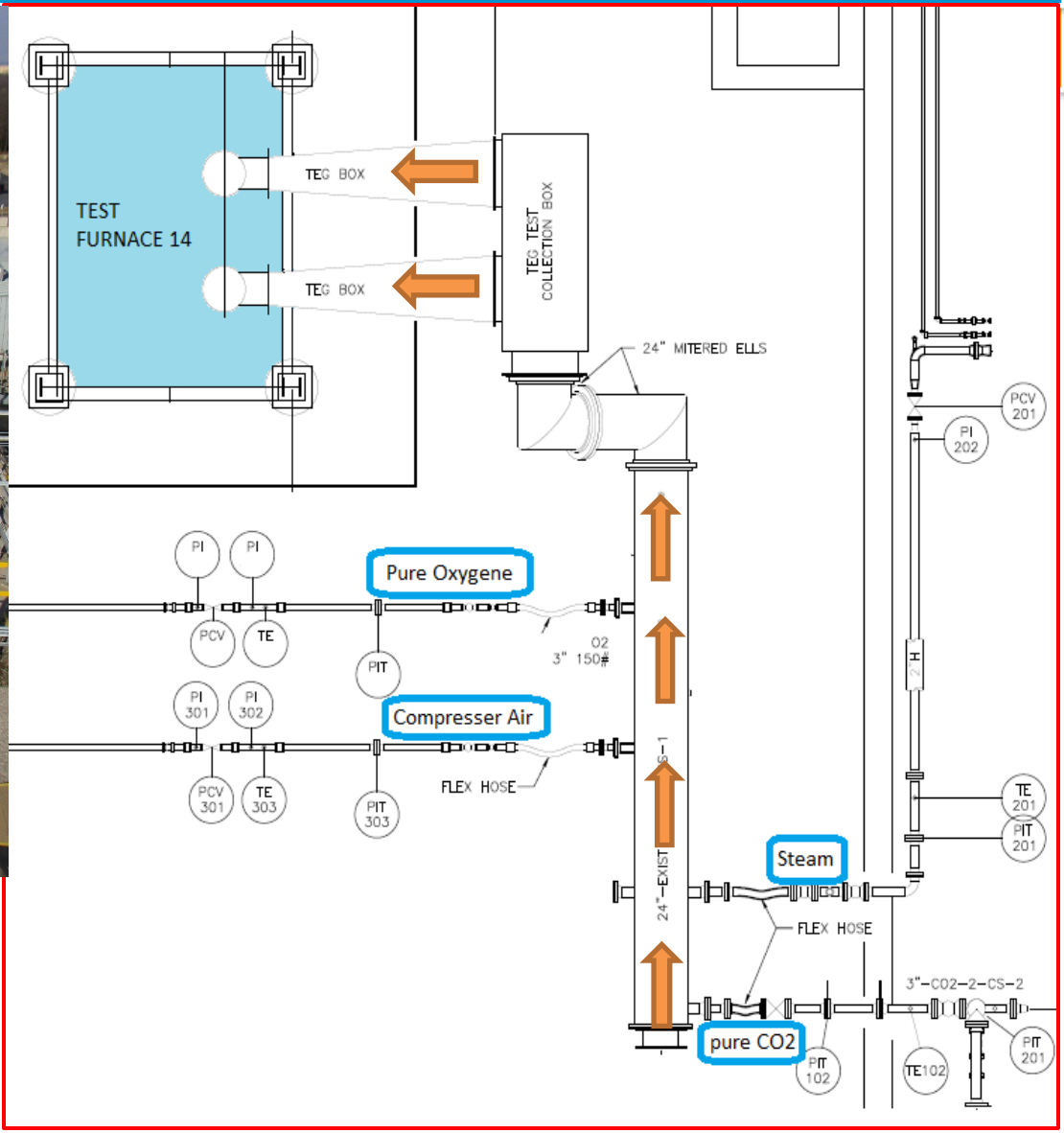
Testing setup at JZHC test facility





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Testing results

Air flow stream composition: Ambient

- Ambient air testing: 21% O2, 79% N2
  - Test fuel 1: 100% Tulsa Natural gas (TNG fuel)
  - Test fuel 2: 10 vol% CO2 in 90 vol% Natural gas
  - Test fuel 2: 20 vol% CO2 in 80 vol% Natural gas
  - Test fuel 2: 30 vol% CO2 in 70 vol% Natural gas
  - Test fuel 3: 40 vol% CO2 in 60 vol% Natural gas

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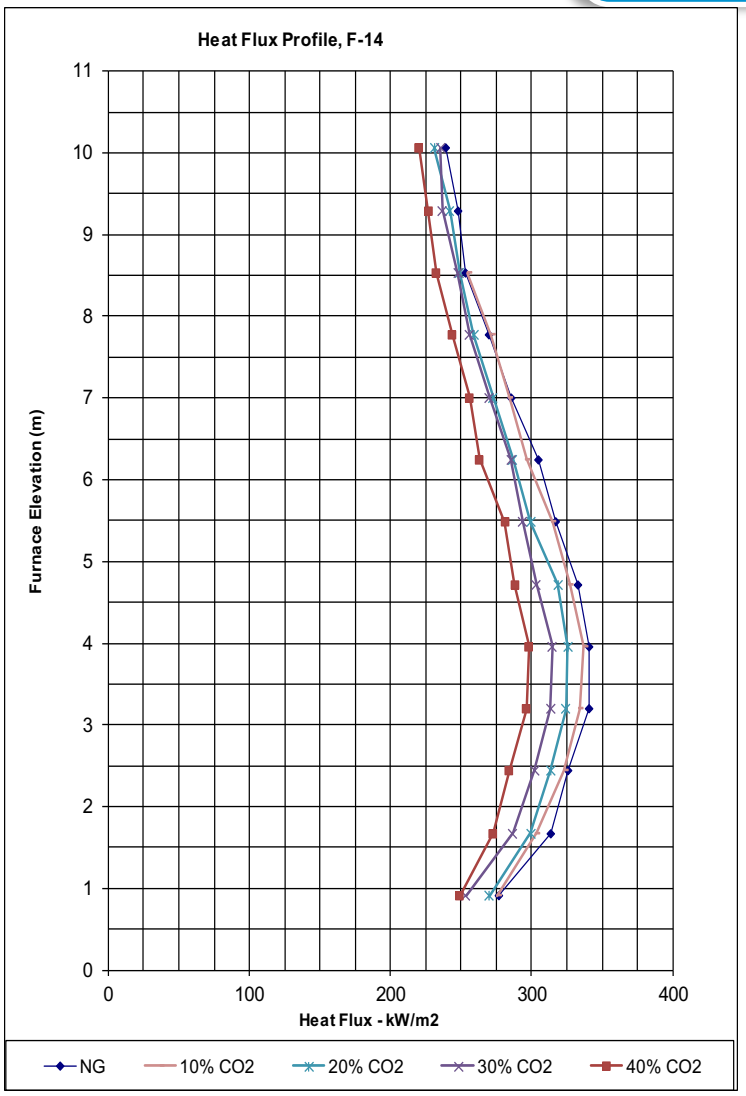
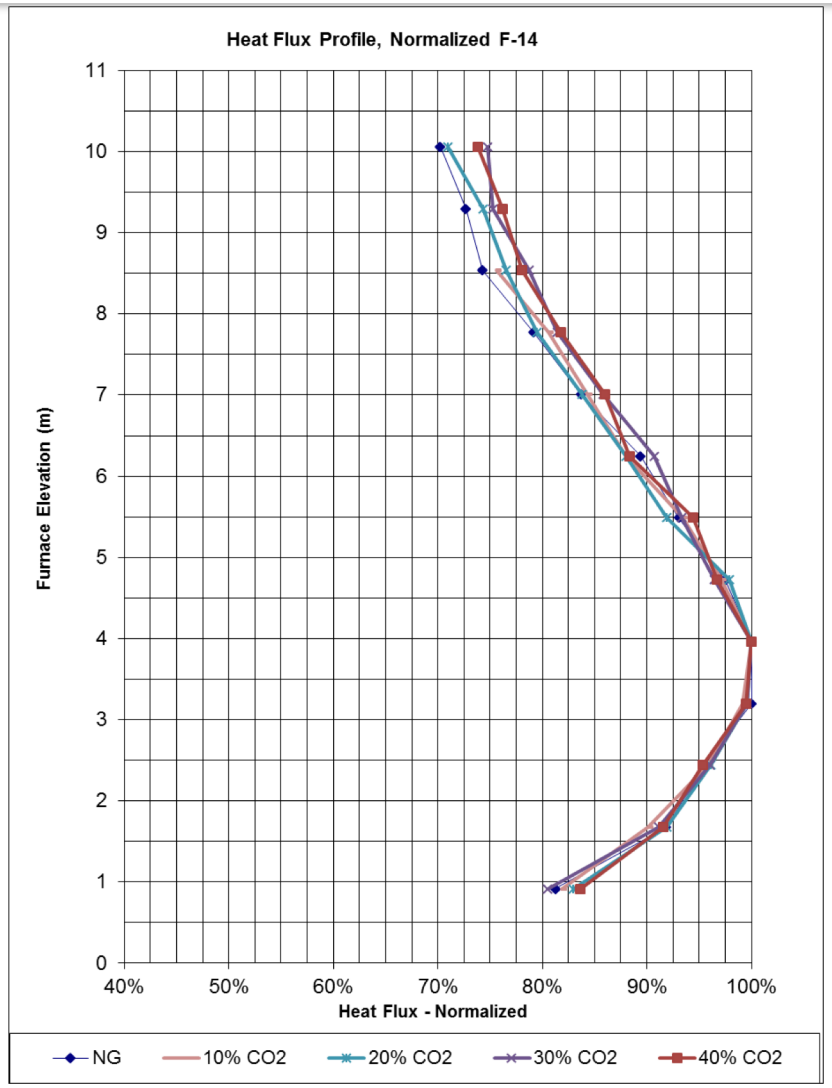
Testing results: Ambient air



Absolute Heat Flux, ambient air testing



Relative Heat Flux, ambient air testing

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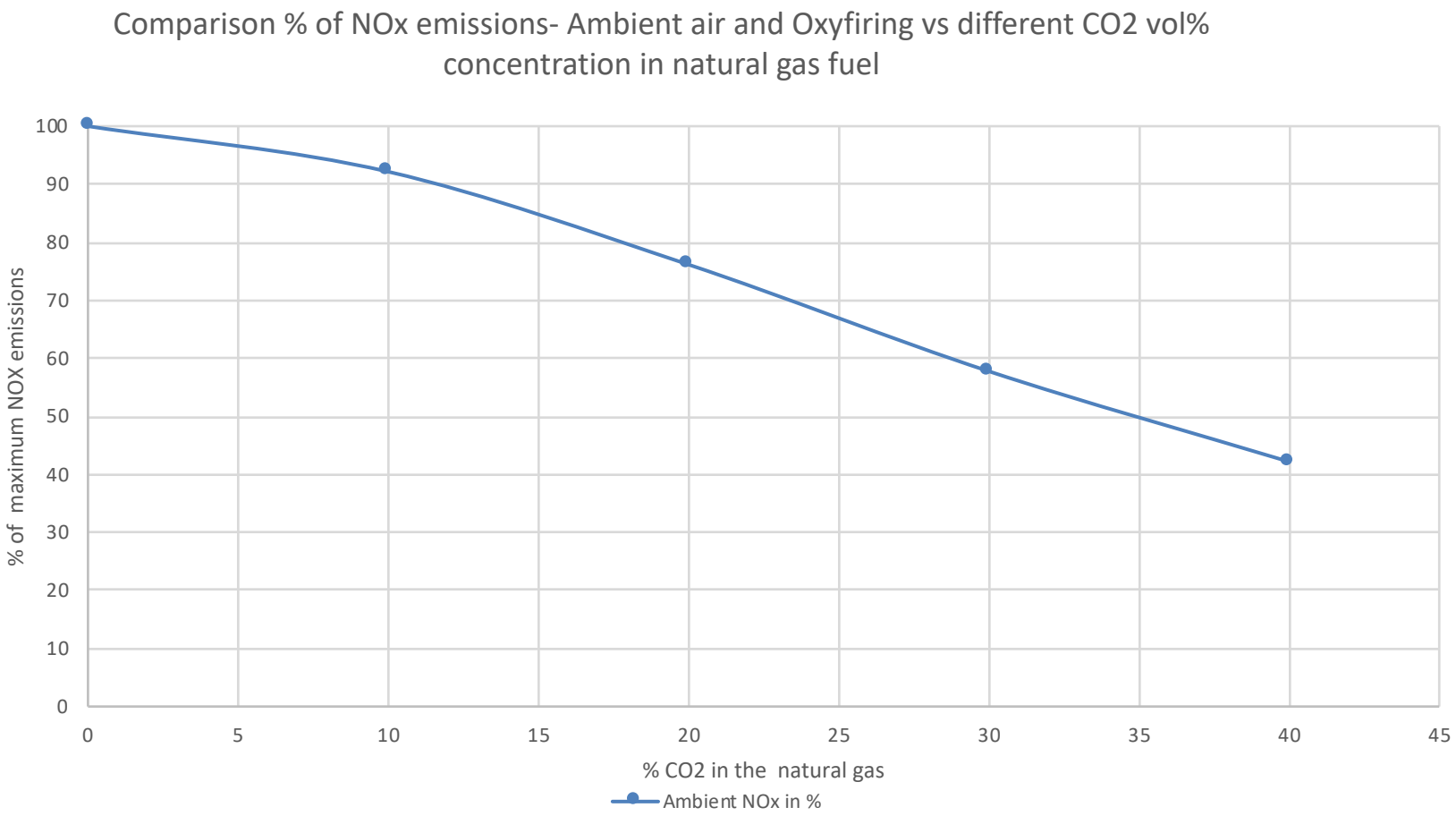
Testing results: NOx emissions



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Testing results

Air stream: Oxy-firing 21% O2

- Oxy-firing: 21 vol% Oxygen, 26 vol% CO2 and 53 vol% H2O(g)
  - Test fuel 1: 100% Tulsa Natural gas (TNG fuel)
  - Test fuel 2: 20 vol% CO2 in 80 vol% Natural gas
  - Test fuel 3: 40 vol% CO2 in 60 vol% Natural gas

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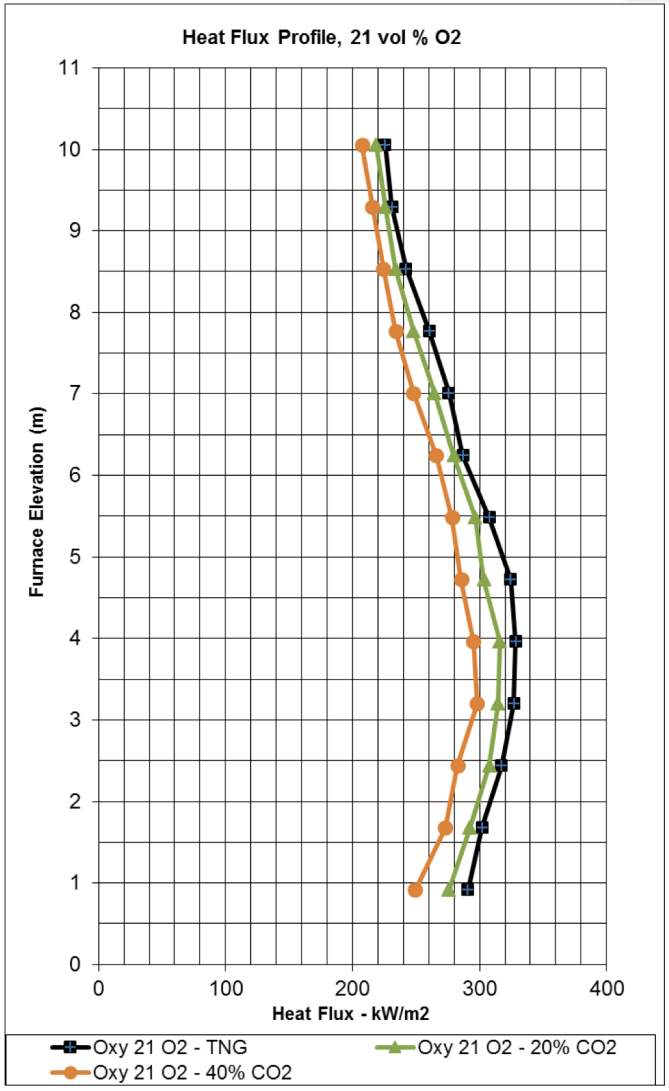
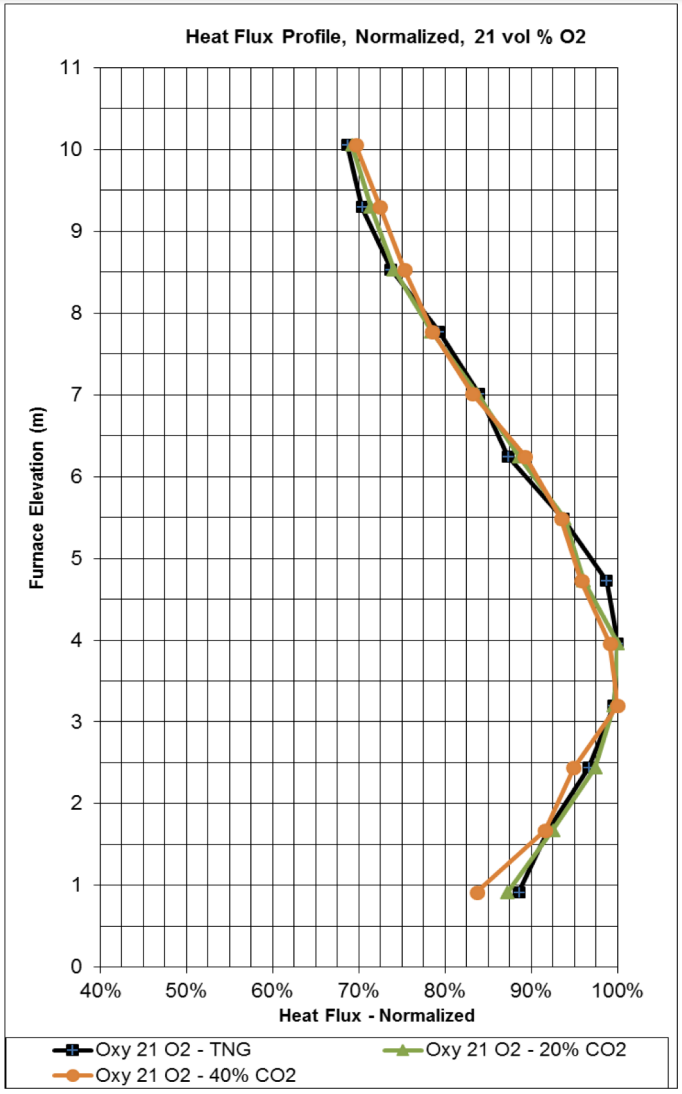
Testing results: Oxy-firing



Absolute Heat flux, simulated air, 21 vol% O2



Relative Heat flux, simulated air, 21 vol% O2

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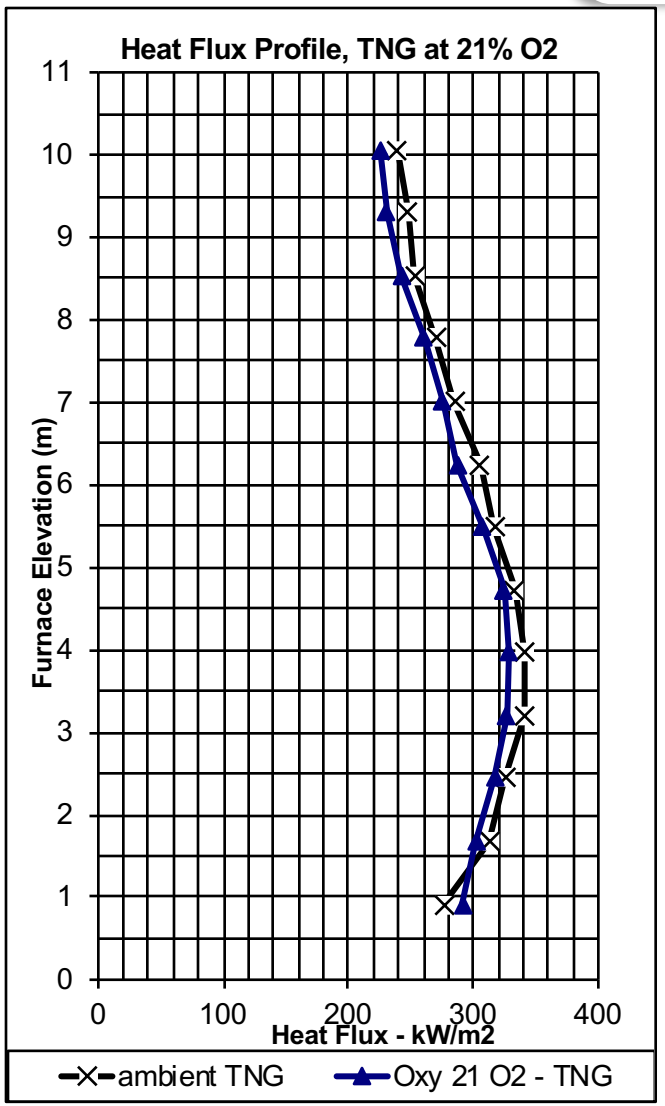
Testing results

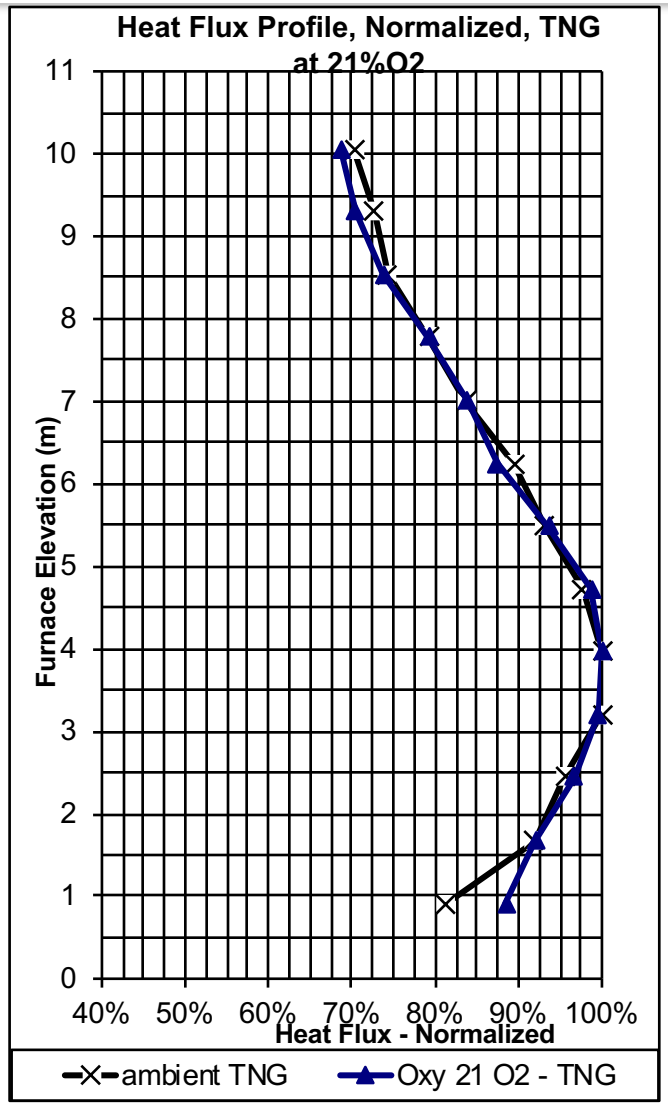
Air stream: Oxy-firing 18% , 21%, and 24% O2

- TNG fuel gas for all cases
  - Ambient air
  - O2 concentration: 21% vol

Testing results: Flux profile



Absolute Heat flux, TNG, 21% O2 concentration



Absolute Heat flux, TNG, at 21% O2 concentration

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Testing results: summary

- The test results show that there is no difference in the heat flux profile of the COOLStar™ burner if operated on a same fuel, irrespective if it is operated with ambient combustion air, or under oxyfiring conditions.
- A difference is observed between a typical natural gas and biofuel gas, where the CO2 is reducing the heat transferred by the flame, as it is causing a flame temperature reduction.
- For most of the cases, the achieved relative heat fluxes of all tested fuels on a same oxidant composition are very similar, which is beneficial for the practical operation of the cracker during fuel changes.

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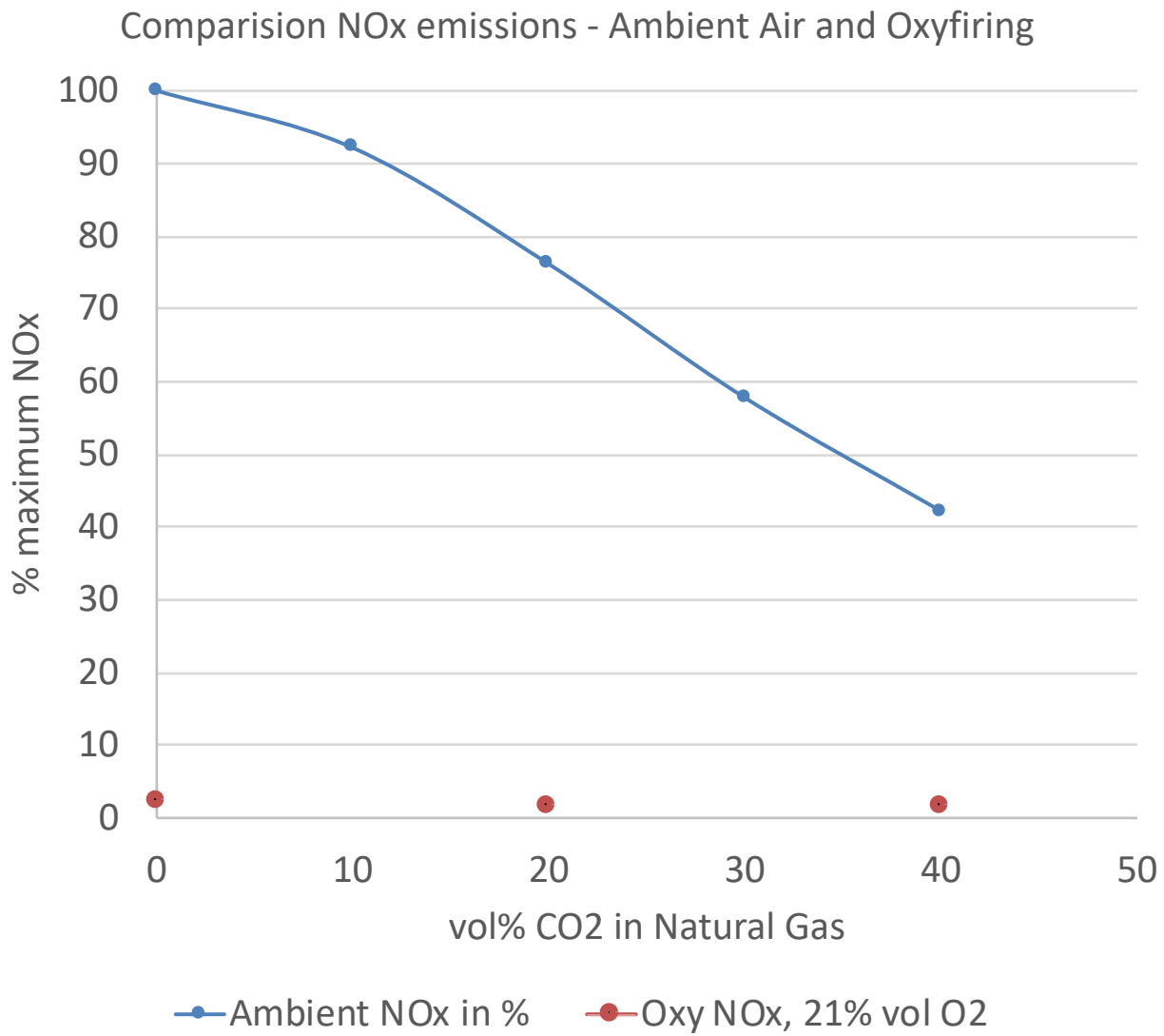
Testing results: NOx emissions



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Testing results: NOx emissions summary

- Considering a Biofuel gas with 40 vol% CO2, NOx measured during oxyfiring showed to be few percent of the emission recorded during ambient air operation.

- The NOx measured during testing is caused by Nitrogen contained in the Natural gas. Some ambient air will have leaked into the test furnace, to which amount cannot be quantified, but it is expected to be very low, especially at the burner level. The furnace tightness was tested prior the combustion test.

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Conclusion:

- Several tests have been performed to evaluate the performance of the burner if operated on an oxygen enriched flue gas. In addition, simulated biogas was simulated and evaluated.

- With respect to the combustion system only and focusing on the radiation zone, it has shown the furnace temperature and relative flux profiles are comparable. It can be therefore expected that an existing cracking furnace can be operated on both oxygen enriched flue gas and biofuel at the same time.
- The NOx emissions have been reduced by as much as 95%, as hardly no nitrogen is avaible in the combustion process.

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Questions?

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Thank You!