Next generation ultra-low NO$_x$ burner by Oilon

M.Sc. Lassi Karvonen—R&D Engineer
IX Flame Days
Espoo 23.10.2018
Content of the presentation

- Development goals
- Initial modelling study of premixed combustion
- Concept planning for commercial premix burner
- Performance optimization with CFD
- Prototype phase & results
- Next steps after R&D
- Summary
Development goals

- Ultra low NO\textsubscript{x} natural gas burner for 850 kW power scale
  - No external FGR
  - NO\textsubscript{x} < 15 ppm (O\textsubscript{2,ref} = 3\%) with 3\% residual oxygen
  - NO\textsubscript{x} < 9 ppm (O\textsubscript{2,ref} = 3\%) with higher residual oxygen
    → Premix burner?

- Typical premix burners have metal fiber combustion heads:
  - Frequent maintenance needs
  - Requires air filters
  - Sensitive to dirty combustion air
  - Required residual O\textsubscript{2} > 7.5\%

![Graph showing boiler efficiency with varying flue gas O\textsubscript{2} content for different flue gas temperatures: Flue gas T = 70 °C, Flue gas T = 120 °C, Flue gas T = 170 °C.](image)
Initial modelling study of premixed combustion

Objectives:
• Validate and optimize the CFD models for premixed combustion
• Better understanding of the premixed combustion concept
  • Problems and limitations
  • Benefits
  • NO$_x$ formation in premixed combustion
  • Stability
  • Power scaling

Test subject: 40 kW prototype
• Part of a catalytic combustion prototype
• NO$_x$ emission ≈ 1 ppm
• Residual O$_2 = 10\%$
Initial modelling study of premixed combustion

40 kW prototype:
• CFD models were optimized and validated against measurements
• The optimized models were later utilized in the design of the commercial premix burner
Concept planning for commercial premix burner

The benefits of the 40kW prototype:

- NO$_x$ < 9 ppm (O$_2$,ref = 3%) with 7% residual oxygen
- No air filter
- No frequent maintenance needs
- No expensive materials

Required improvements:

- Low NO$_x$ with low residual oxygen
- Cost-effective
- Compact size
- Must fit to wide range of furnaces
- Power scaling 40kW → 850kW
Performance optimization with CFD

Temperature [0°C – 1500°C]
Prototype phase & results

Good agreement between CFD and measurements.

- Two different test furnaces
- Different fuel loads
- Different residual oxygens

![Graph showing the relationship between NO concentration and residual oxygen content. The graph includes data points for both laboratory measurements and CFD simulations.](image-url)
Next steps after R&D

1. Field testing of pilot burners
2. Commercialization
3. Power scaling
4. Production optimization
Summary

- The development of new ultra low NO\textsubscript{x} natural gas burner was successful:
  - No external FGR
  - NO\textsubscript{x} < 15 ppm (O\textsubscript{2,ref} = 3%) with 3% residual oxygen
  - NO\textsubscript{x} < 9 ppm (O\textsubscript{2,ref} = 3%) with higher residual oxygen

- Good agreement between CFD and measurements

- Many benefits compared to typical premix burners:
  - Low required excess air / residual oxygen
    - Improved boiler efficiency
  - No air filter
  - No frequent maintenance needs
  - Not sensitive to combustion air quality