UTSR Fellowship Project: Further Development of Low Pressure Drop Duct Burners

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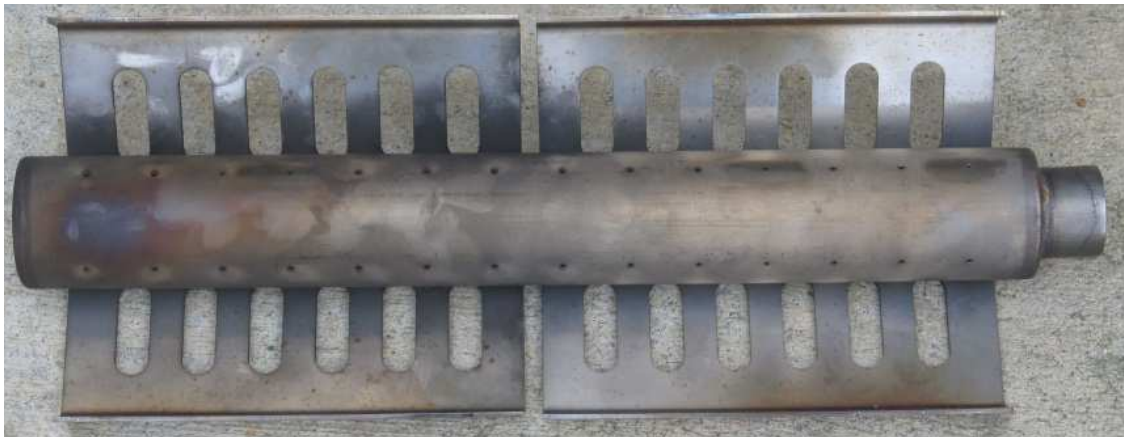
Purpose

- Improve startup and operation of FP250 system
- Develop duct burners for new fuels and lower emissions
- Performance testing of FlexEnergy Inc's next generation of microturbine (Proprietary, not presented)

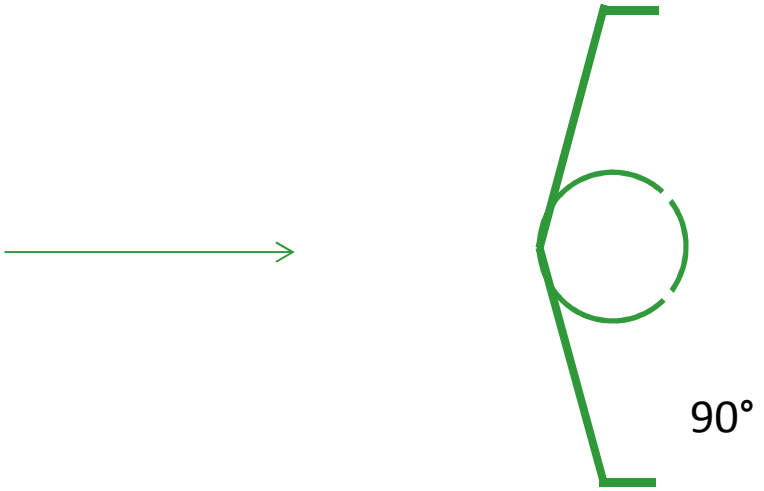
Current Duct Burners

- Provide hot gas to FP250 during startup
- Low pressure drop gutter-design
- Propane fueled
- Diffusion flame for stability, ignition, turndown



Natural Gas Duct Burners

- Investigate
  - Geometry changes
  - Fuel metering hole size
  - Fuel feed pressure
- Maintain current temperature rise, turndown



Natural Gas Duct Burners

- One-Dimensional Model
  - Compressible flow relations across orifice
  - Match energy input
  - Allow fuel pressure or hole size to float
- CFD (ANSYS FLUENT)
  - 3-D steady-state, two operating points
  - Realizable k-ε, standard wall function
  - Non-premixed flamelet model, 26 species
- Fuels
  - Propane (baseline)
  - Mixture of methane, propane, ethane typical of natural gas
  - Methane

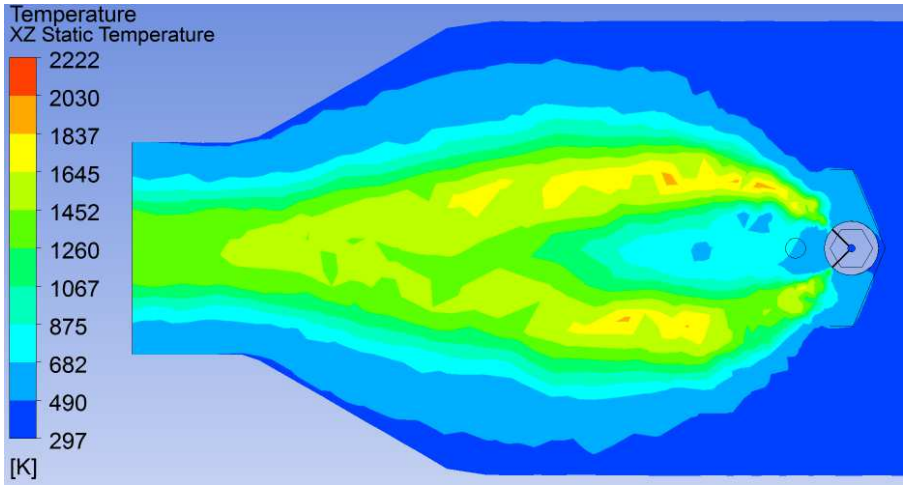
Example 1D - Results

Fuel	Fuel P	Meter Hole Diameter	# holes	Fuel Flow	Energy Rate	Choke Flow
C3H8	1.00	1.00	1.00	1.00	1.00	1.00
Natural Gas	1.00	1.06	1.00	0.70	1.00	0.74
Methane	1.00	1.04	1.00	0.66	1.00	0.71

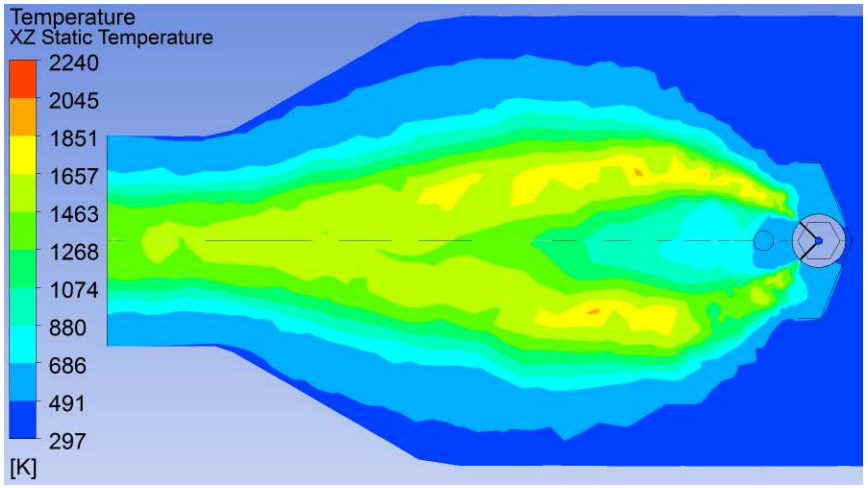
Fuel	Fuel P	Meter Hole Diameter	# holes	Fuel Flow	Energy Rate	Choke Flow
Propane	1.00	1.00	1.00	1.00	1.00	1.00
Natural Gas	1.08	1.00	1.00	0.70	1.00	0.68
Methane	1.06	1.00	1.00	0.66	1.00	0.67

- Natural Gas/Methane
  - Require higher feed pressure or larger hole size
  - Lower mass flow
  - Lower maximum flow rate

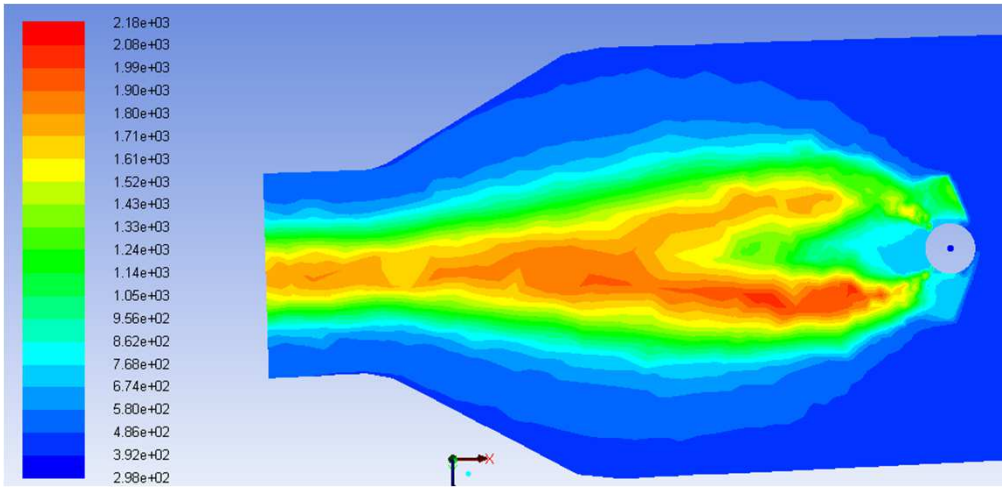
Example CFD Results-Current Hole Size



Methane



Natural Gas



Propane

CFD Results – New fuels relative to Propane

	Natural Gas	Methane
Fuel Pressure	1.49	1.51
Inlet Temp	1.00	1.00
Outlet Temp	1.00	1.00
ΔT	1.00	1.00
Duct ΔP	1.03	1.03

- Pressure trend confirmed
- Slight increase in duct pressure drop
- Propane shows hot core, little spread
- Natural Gas/Methane show cooler core, greater spread

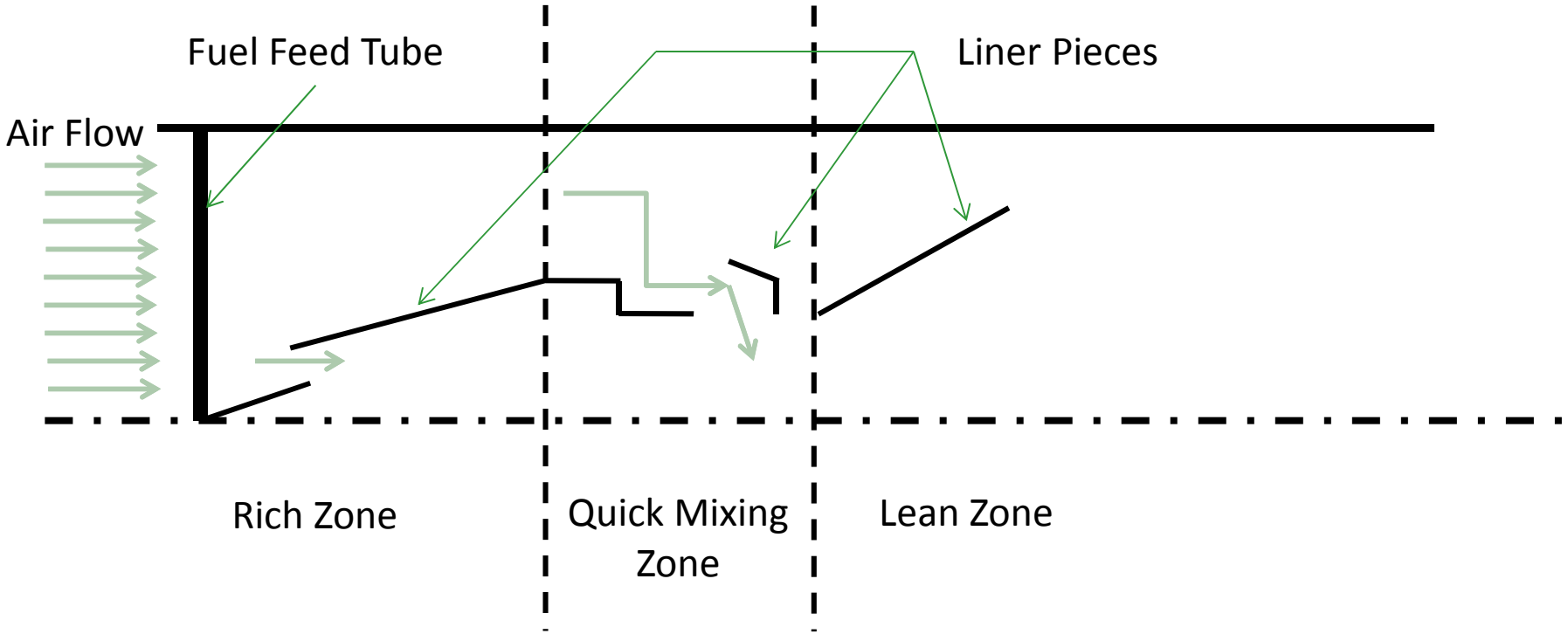
Natural Gas Duct Burners - Conclusions

- Maintain fuel feed pressure
  - Increase hole size: ~5%
  - Keep current feed pressure
- Change fuel feed pressure
  - Increase feed pressure
  - Keep current hole size

Low Emissions Duct Burners

- Improve startup emissions of FP250
  - Reduce NOx
  - Maintain turndown, pressure drop of current burners
- Two dry-low-NOx concepts
  - Rich, Quick-mix, Lean
  - Piloted, Lean-Premix

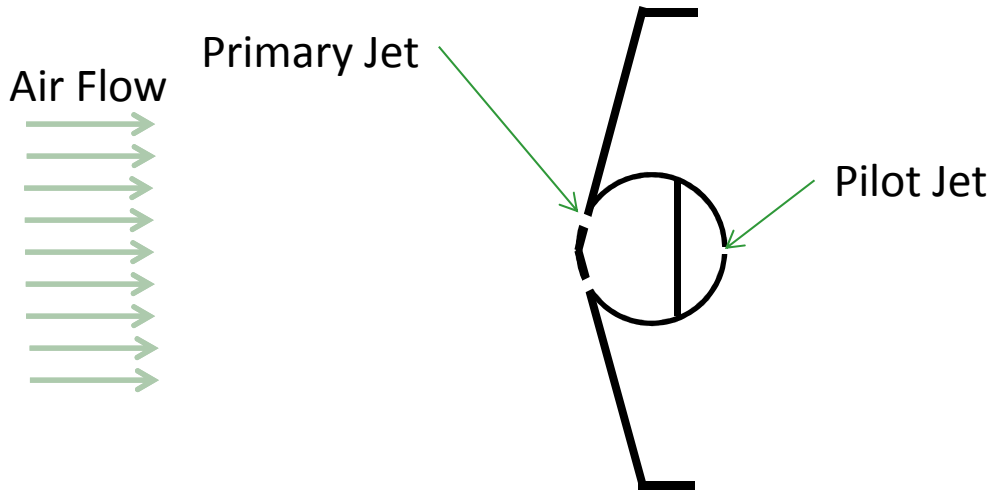
RQL Low Emissions Duct Burner



- Rich Zone for stability, min temp rise
- Quick mix zone to transition to fuel lean
- Lean Zone to burn out UHC and CO

- Complex geometry
- Requires support elements for liner segments

Lean-Premixed Low Emissions Duct Burner



- Diffusion pilot for min temp rise, ignition
- Primary jets inject upstream to promote mixing
- Lean premixed flame anchors in zone behind gutter
- Reuse proven geometry
- Hole position relative to slots used to control mixing/jet penetration

Conclusions

- Two studies were carried out
  - Determine fuel flexibility of current duct burners
  - Propose redesigns for lower emissions
- Duct burners for natural gas
  - Keep current geometry, increase feed pressure
  - Increase hole size, maintain feed pressure
- Low emissions duct burners
  - Use lean-premixed approach with current gutter
  - Use diffusion pilot for minimum temperature rise/stability

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