Recuperative Reforming (RR) for H₂ Enhanced Combustion

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Recuperative Reforming for H₂ Enhanced Combustion

- > Thermo-chemically converts sensible waste heat energy to chemical energy
 - Endothermic reforming reactions convert C_xH_y fuel and H_20 into H_2 and CO
 - Lower heating value of fuel energy flow to engine can increase up to ~20%
- > H₂-enhanced combustion increases flame speed and widens flammability limits
 - Extends the lean limit for lower NO_x

OSK60G RICE Energy Balance (Averaged)





Recuperative Steam/ Methane Reforming



Hydrogen Enhanced Combustion in Reciprocating Engines Using RR



Comparison of Natural Gas and Reformed Fuel

HYSYS predictions

Component	Natural Gas	Reformed Fuel
Methane	94.37	59.01
Ethane	2.82	0
Propane	0.42	0
i-Butane	0.05	0
n-Butane	0.06	0
i-Pentane	0.02	0
n-Pentane	0.02	0
n-Hexane	0.03	0
Hydrogen	0	28.11
H₂O	0	3.67
СО	0	0.13
CO ₂	0.94	8.25
Nitrogen	1.27	0.83
Sum	100	100

Recuperative Reforming System for Cummins QSK60G



Hydrogen Enhanced Combustion in Reciprocating Engines Using RR

WAVE Predictions with RR



Schematic of RR Experimental Test Layout (Simulated Exhaust)





Reformer Test Conditions (Scaled to simulate about 1 kW engine)

Natural gas	5.7 SLPM
Reformed natural gas (Approximately 18% increase in fuel flow)	6.72 SLPM
Pressure drop across the reformer (fuel side)	8"H ₂ O
Pressure drop across the reformer (exhaust side)	<0.2"H ₂ O
Temperature drop across the reformer (fuel side)	53° C
Temperature drop across the reformer (exhaust side)	138° C
Temperature difference at the reformer inlet	152° C

Fuel Composition



Natural gas conversion – 7.3%



Conclusions

- > Confirmed technical feasibility of the Recuperative Reforming concept at labscale.
- > Identified need to reduce heat losses and improving heat transfer on lab unit.
 - Our goal is 25% H_2 by volume
 - We achieved 18% H_2

Future Development Plans

> Natural Gas

- Test improved designs for lab-scale RR
- Develop engineering design basis for scale-up of RR system to GTI 50 kW test engine
- Install RR system on this engine to test hydrogen enhanced combustion
- Evaluate feasibility of retrofit RR system

> Diesel

 Initiate systems study of RR concepts for hydrogen enhanced low temperature combustion

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