

Internal Combustion Engines and Ammonia

Ted Hollinger

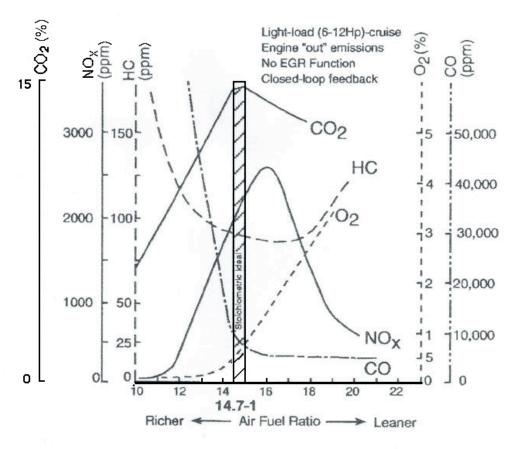
Hydrogen Engine Center, Inc.



The Need

- Reduce greenhouse gas emissions
 - California is a 'bell weather' state and leads the nation with it's CARB emissions standards
 - Tighter standards next year and very tight standards in 2007
 - Kyoto Accord will become law when Russia (123rd nation) signs.
 - Requires a 5.2% reduction in emissions by
 2012 compared to 1990 emissions

HEC Standard ICE Gas Emissions

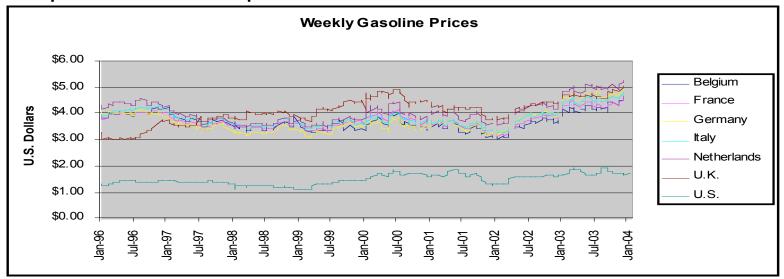


Stoichiometric Measured Air-Fuel Ratio



The Other Need

- Reduced dependence on foreign oil
 - The world oil production is about to peak and prices are expected to continue to rise.





A solution

- Hydrogen as a fuel
 - Cleanest of all fuels
 - · Only water (H₂O) as an 'emission'
- Internal combustion engines for power
 - Service network is already in place
 - Parts logistics system is already in place
 - Manufacturing is already in place
 - · ~17 million engines are produced annually



HEC Strategy

Combine

Hydrogen Internal Combustion Engine technology developed at

Ford Motor Company



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A Ford / DaimlerChrysler / Ballard Company



HEC



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Ford Motor Company HEC

 Ford Motor Company is introducing a line of hybrid electric vehicles that have an optional hydrogen engine.

 HEC will stay out of the 'on road' vehicle market, but similar technology in niche markets



HEC Strategy

With Power System Technology developed at

Ballard Power Systems

Theodore Hollinger

Vice President Power Conversion Group



Ballard Power Systems

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ELECTRIC DRIVES & POWER CONVERSION DIVISION

Hydrogen genset Introduction





Target Market #1

North American Ground Support Equipment (GSE) must use

Ford F300 engines and Ford C6 transmissions

North American Population ~90,000 Annual Rebuild ~25,000 Annual Replacement ~ 6,000

F300 engine production ended in 1996 Ford Power Products (FPP) put ~44,000 engines in a warehouse There are no engines left



Target Market #2

 Distributed Power Generation thru variable speed gen—sets, using 4.9 L
 Ford Engines modified to run on hydrogen combined with Permanent Magnet Generators (PMG) and inverters, developed at HEC.

HUGE market



The HICE Story

- HEC chooses an engine to convert to run on hydrogen fuel
 - Longest production run for any engine in Ford's history
 - 4.9L engine was in production for 33 years
 - Ford Motor Company produced about 63
 Million of these engines

The heritage, a humble beginning



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Pick of the Litter



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Boring the Block .030"

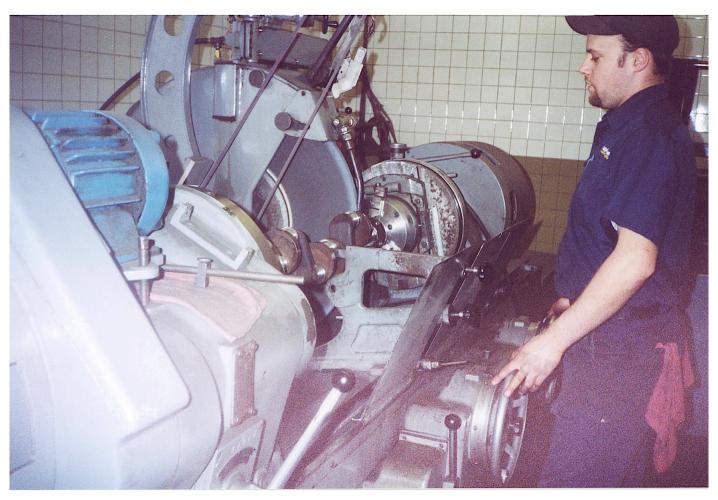


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Grinding the Crankshaft



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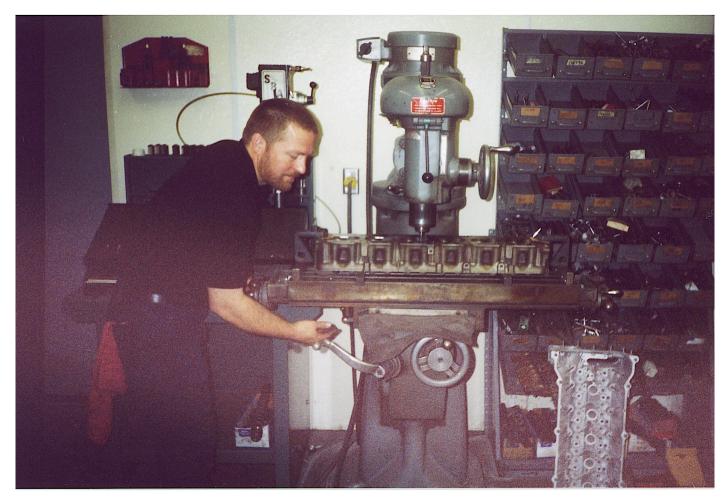
Machining the Rods



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Machining Head



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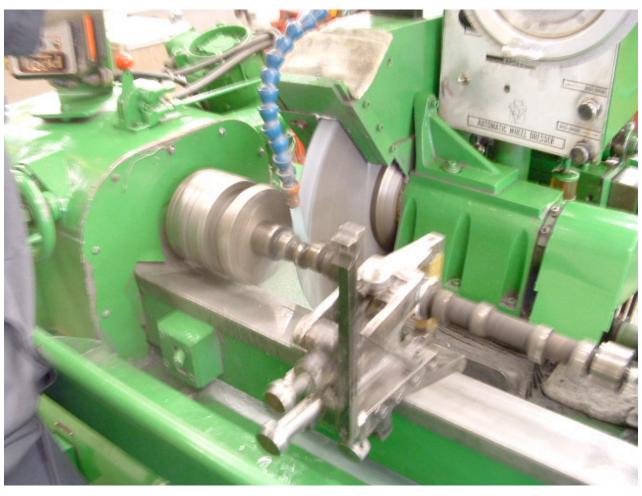
Machining Valve Seats



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HEC Camshaft being Ground



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New Pistons Installed



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Painting Complete



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HEC Crank Position Sensor Added



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Finished engine data sheet









Why Ammonia?

- Ammonia contains a high percentage of hydrogen and NO CARBON
- Ammonia allows easier transportation and storage of hydrogen.
 - Established delivery system
 - Low pressure high density storage
 - Eliminates expensive high pressure hydrogen storage tanks
 - Eliminates the need for inefficient high pressure compressors



Conclusion

We can provide

Cleaner Power . . . Sooner

With the help of Ammonia