Division Engines

ePCC System Waukesha VHP

Engine Upgrade Packages

March 2018

HOERBIGER

Lean Burn Combustion

The Challenge

- A leaner mixture is more difficult to ignite and has typically a slower flame propagation

The Obvious Idea

- Improved ignition (key issue)

The solution

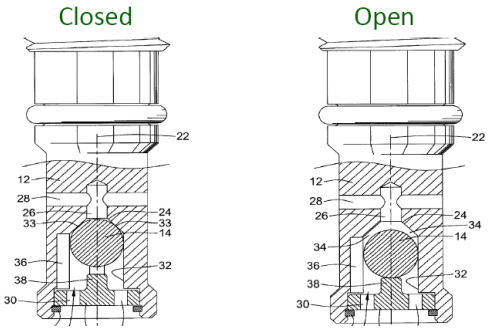
- Pre Combustion Chamber
  - Order of magnitude higher ignition energy
  - **BUT**, it requires precise air/fuel ratio control to ensure stable main chamber combustion

HOERBIGER

PCC Ignition

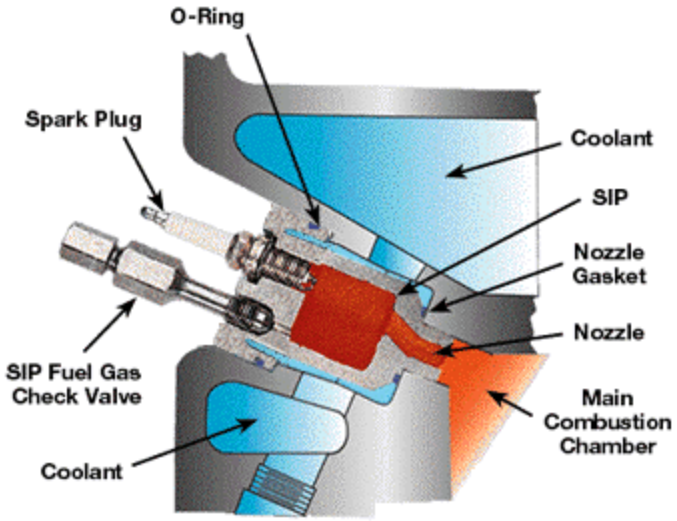
PCC – Pre Combustion Chamber

- Small cavity providing an easy to ignite environment (stoichiometric)
- Order of magnitude higher ignition energy compared to open chamber ignition



State of the Art

- Check valves
- Problems:
  - Inconsistent fueling
  - Frequently clogged / quit working
  - Varying Air/Fuel ratio
  - Too rich Air/Fuel ratio during startup
  - Fuel slip

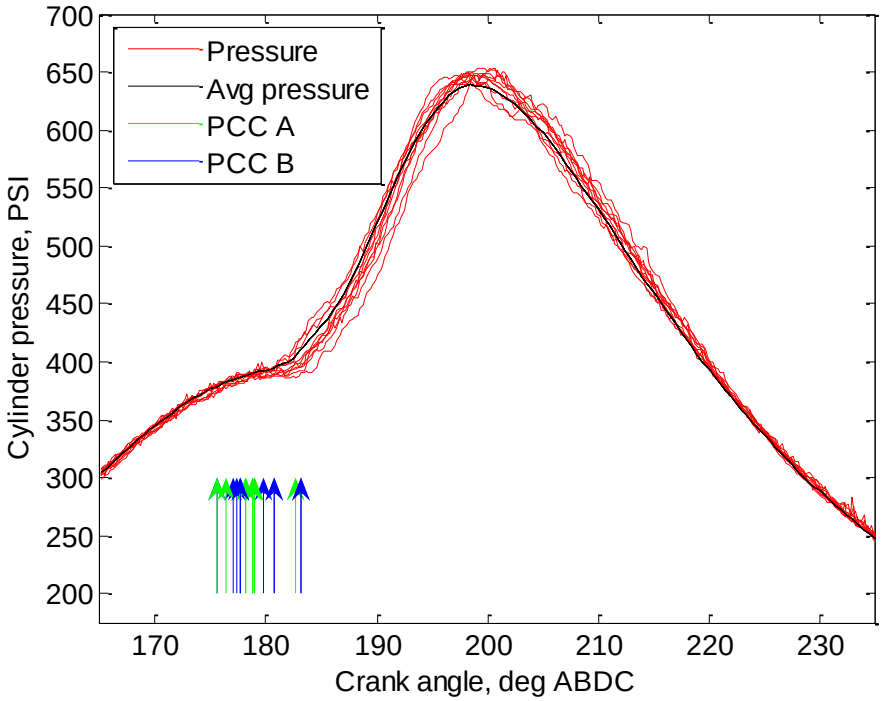


HOERBIGER

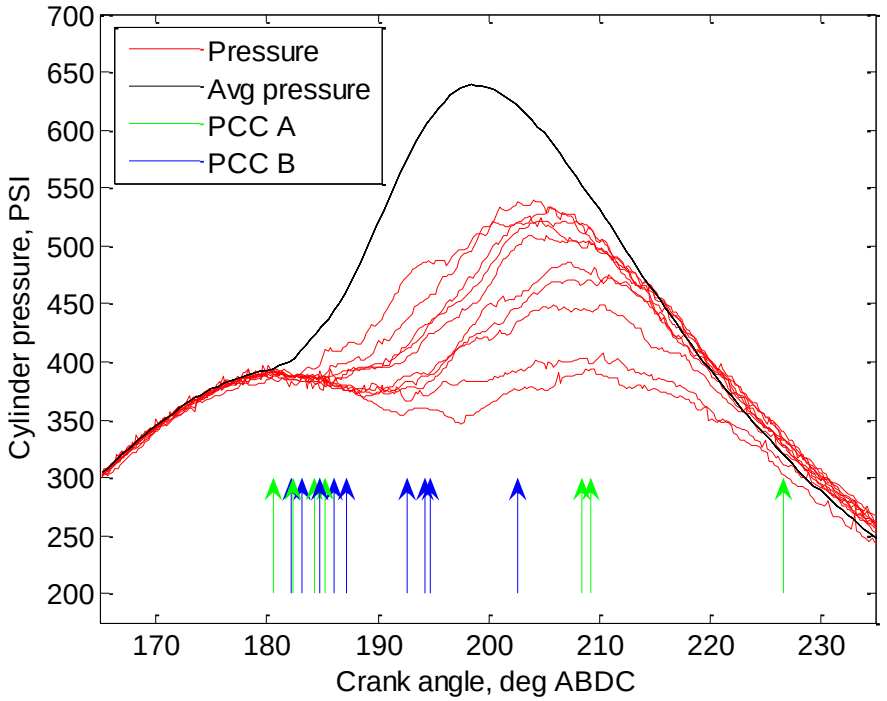
Combustion Stability at Lean Mixtures

Ignition (Pre Chamber)

- Evaluation of PCC performance – MCC pressure and PCC ion sense



Stable main chamber combustion due to perfect PCC firing

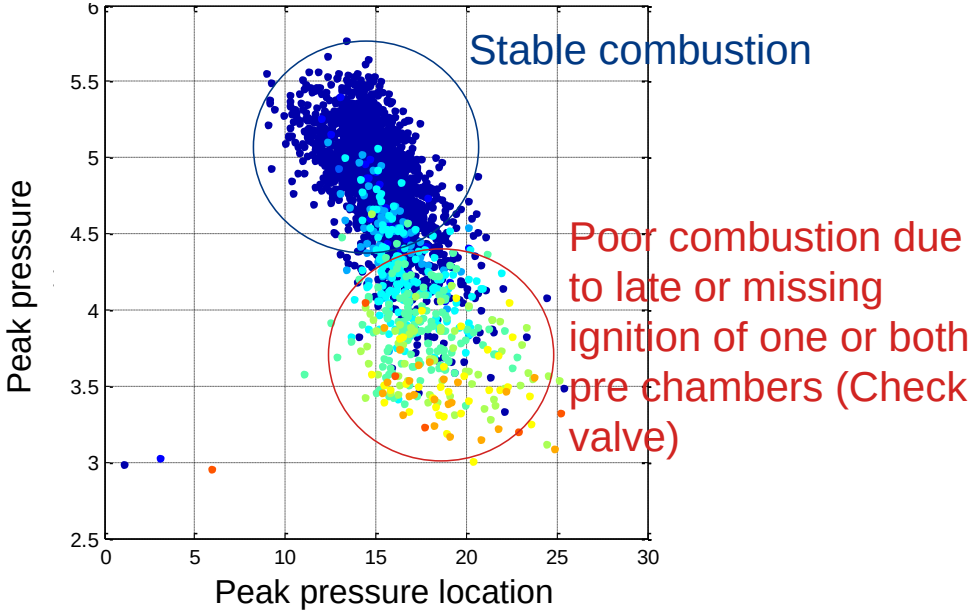


Slow and late main chamber combustion due to delayed PCC firing

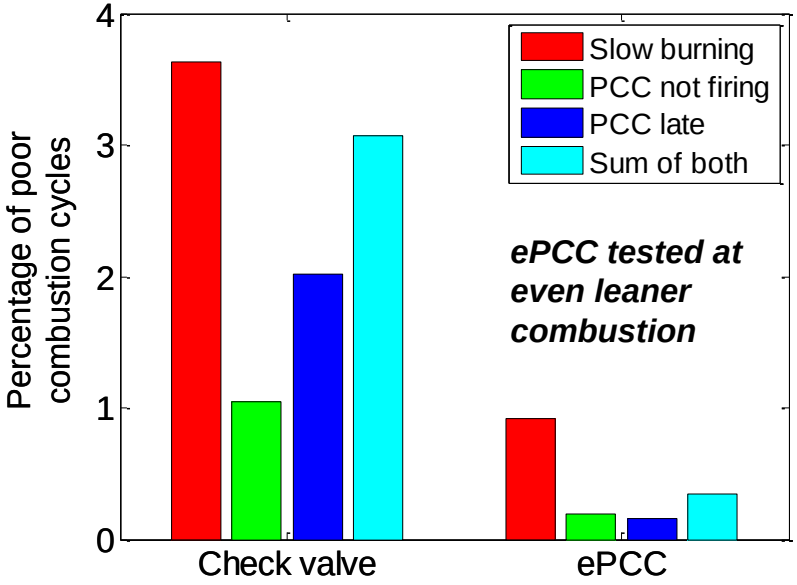
HOERBIGER

Combustion Stability with ePCC

Check Valve Performance



Check Valve vs. Electronic Valve



⇨The real solution is a pre combustion chamber with electronic fuel injection

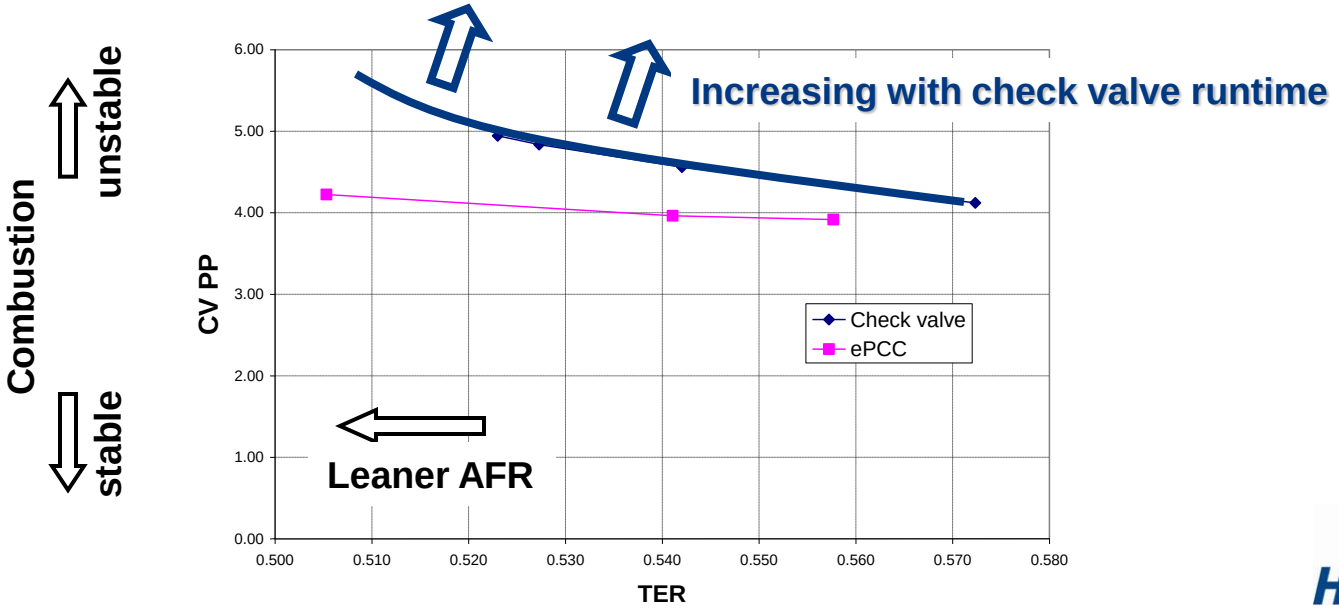
⇨ **ePCC**

HOERBIGER

Implementation on High-Speed Engines

Results Waukesha 7042GL

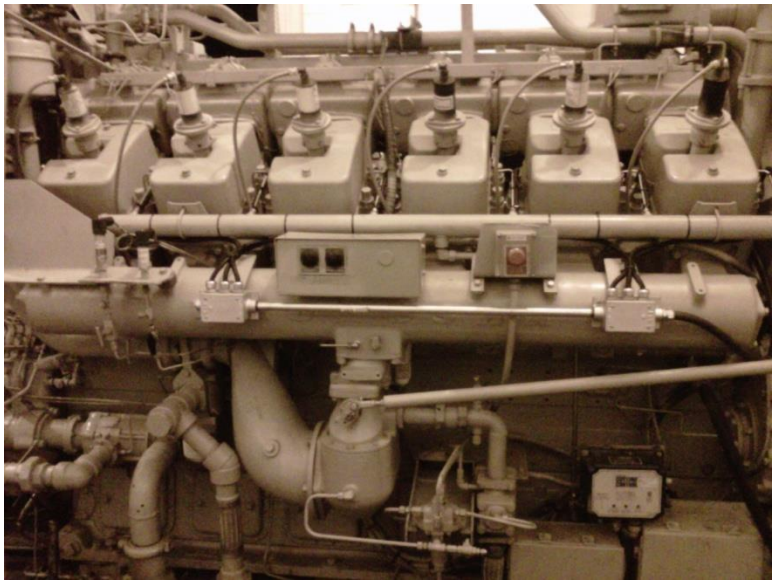
- Bulk engine PCC fueling optimization (same pulse width for all cylinders, individual adjustment possible)
- Improvements with ePCC could be demonstrated compared to new and optimal adjusted check valve fueling

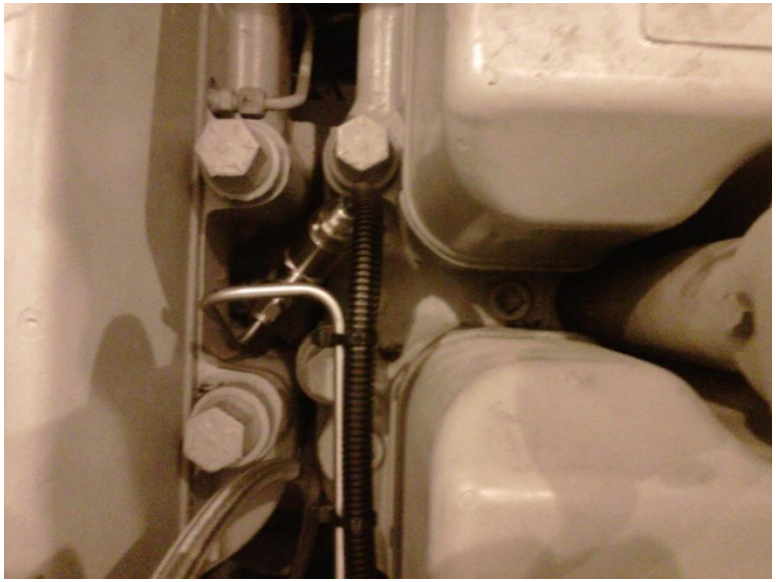


ePCC Waukesha 7042GL Package

Field and Lab Test Results

- Improved combustion stability at rated operating conditions as well as reduced hydrocarbons emission and slightly improved fuel consumption
- Achieved stable combustion down to 0.5g/bHp-hr NO_x





HOERBIGER

ePCC Waukesha 7042GL Package

Field Installation

ePCC Installation Experience

Slow Speed Engines

- 100+ engines are running successfully in the field
- Very positive customer feedback due to outstanding performance
- First installation in operation for more than 10 years

High Speed Gas Engines

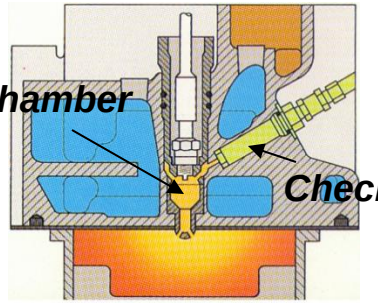
- 20+ installations on Superior 825 and Waukesha VHP engines
- Combustion performance improvements are identical to large bore engine results
- First installation in operation since Nov 2011

HOERBIGER

ePCC Highspeed Package – Summary

The Need

- Most lean burn engines require pre combustion chambers for igniting the lean mixture. The fueling is controlled via check valves, which perform poorly:
  - Frequently clogged / quit working
  - Inconsistent fueling; varying Air/Fuel ratio
  - Too rich Air/Fuel ratio during startup; fuel slip
  - **Root cause #1 for combustion issues**



The Solution

- Electronically controlled pre chamber fuel valve – ePCC
  - No maintenance issues
  - Precise and consistent fueling (each cycle)
  - Stable combustion even at very lean mixtures
  - Improved startup, smooth and efficient idling
  - Small Fuel Saving's

HOERBIGER

We are Engine.