Fuel System for Achates 2.7L OP-GCI Engine

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Delphi
Technologies

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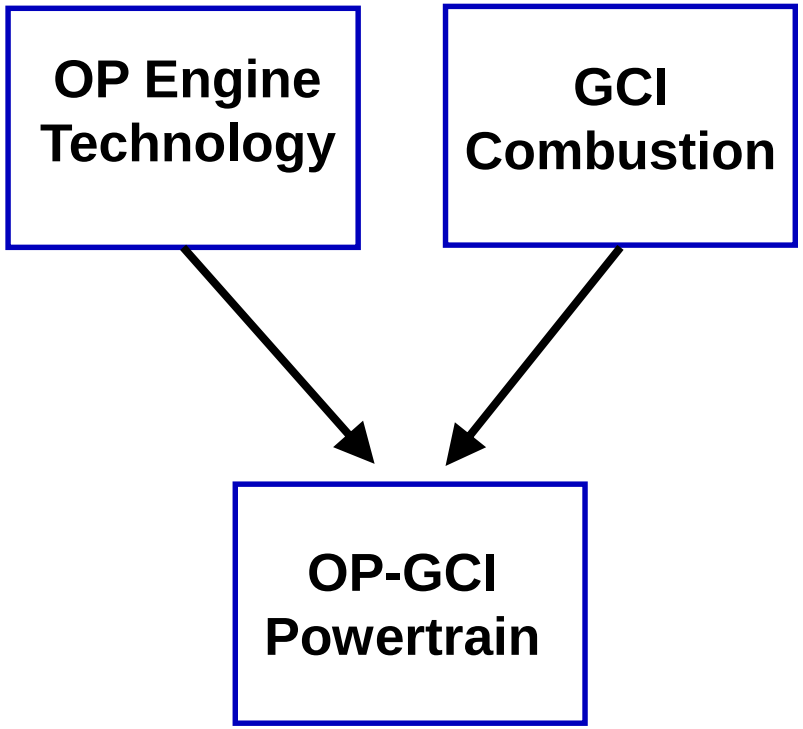
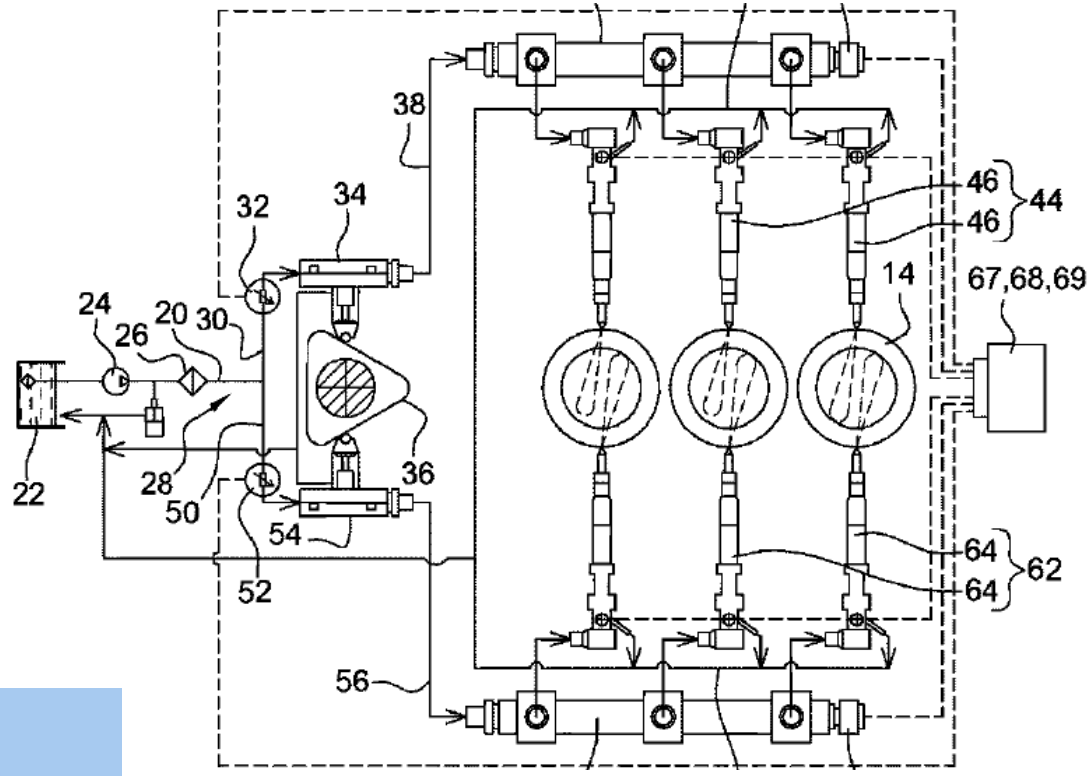
Introduction- OP & GCI

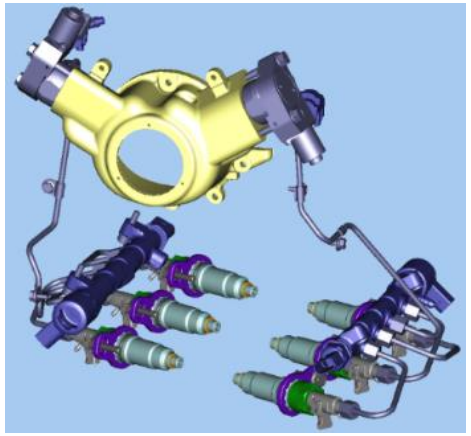
- Opposed-piston engine technology has fundamental efficiency benefits over conventional in-line or V-engine configurations
- Gasoline compression ignition (GCI) has also evolved as an efficient and clean combustion process representing the intersection diesel and spark-ignited technology
- **Objective**: Combine OP & GCI technologies in an innovative, ultra-efficient powertrain



FIE Architecture – 2.7L, 3-cylinder, OP-GCI Engine

- Two diametrically-opposed injectors per cyl
- Two independent fuel systems (left and right)
- Two unit pumps driven by intake crankshaft
- Two fuel rails with RPS and HPV
- **Benefit**: flexibility in the injection process for fuel quantity, timing, and splits





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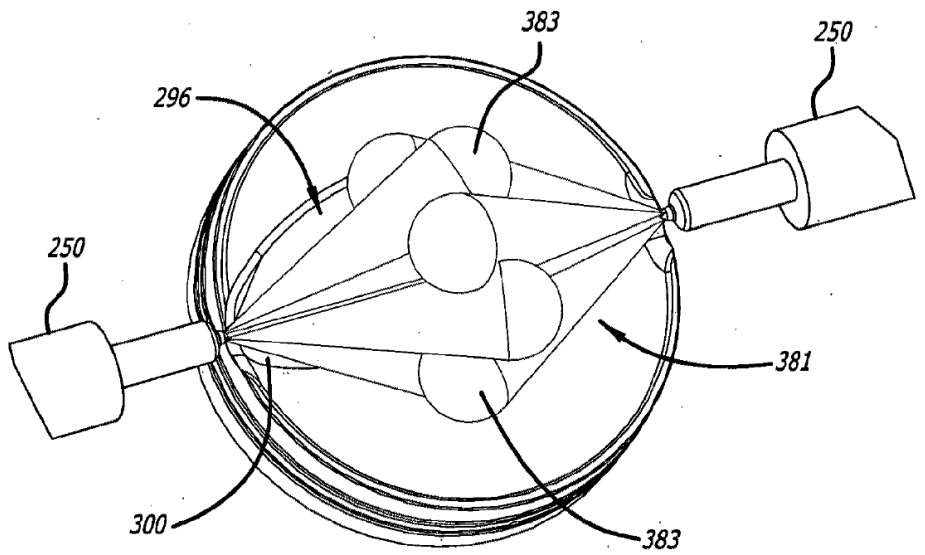
Injection and Sprays

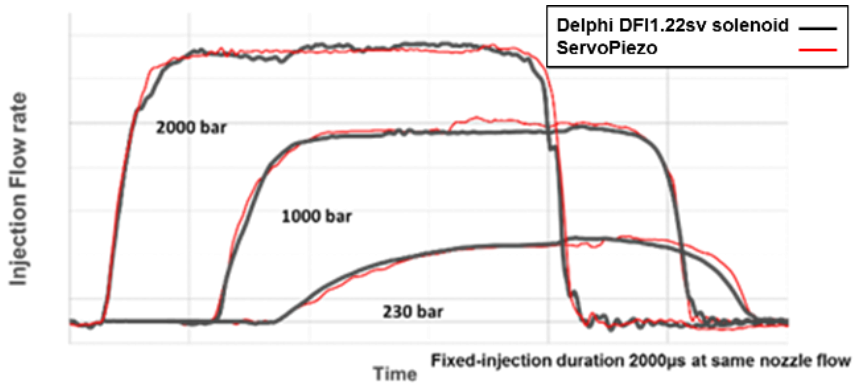
- One preferred arrangement
  - Two diametrically-opposed sprays
  - 4 holes with narrow spray angles
  - Interdigitated plumes for good mixing and air utilization
- Generally, injectors for OP engines feature fewer holes and narrower spray angles than typical diesel injectors

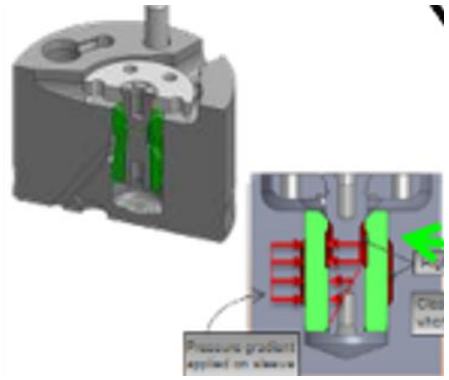


US Patent US 2012073541 2012
Achates Power, Inc.

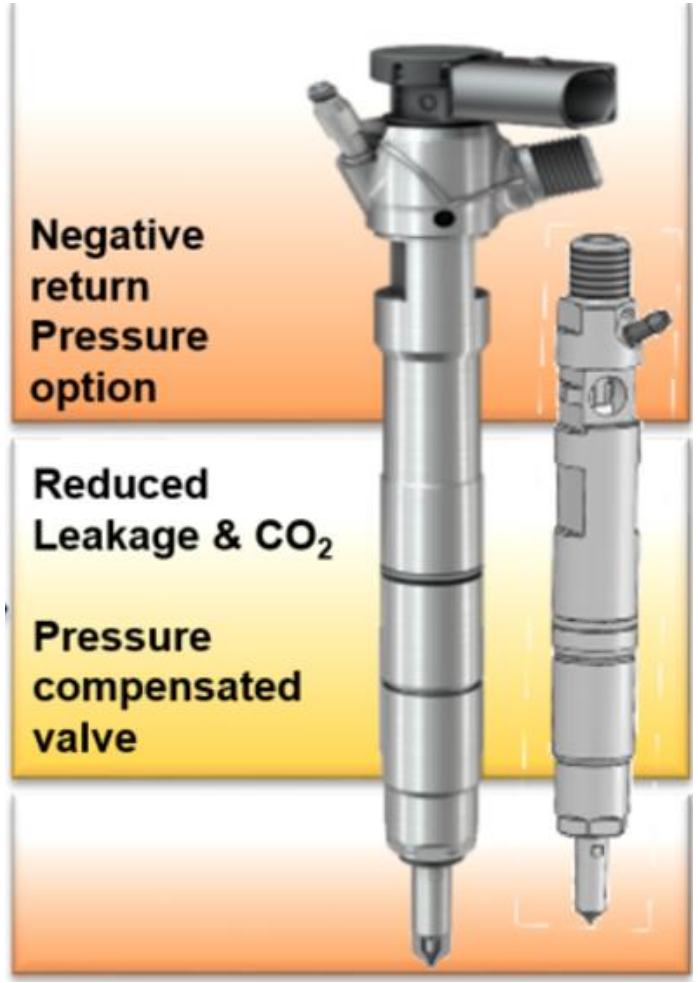
Injector

- Delphi Technologies DFI 1.22sv Injector
  - Fast response solenoid injector
  - 1800bar rated pressure on gasoline
  - Near-zero static back leak- important for low-viscosity fuels
  - Short overall length for good packaging on engine





Beduneau, J-L., et al., “Delphi New Diesel Common Rail System Family,” SIA Pwrtrn Conf 2014.



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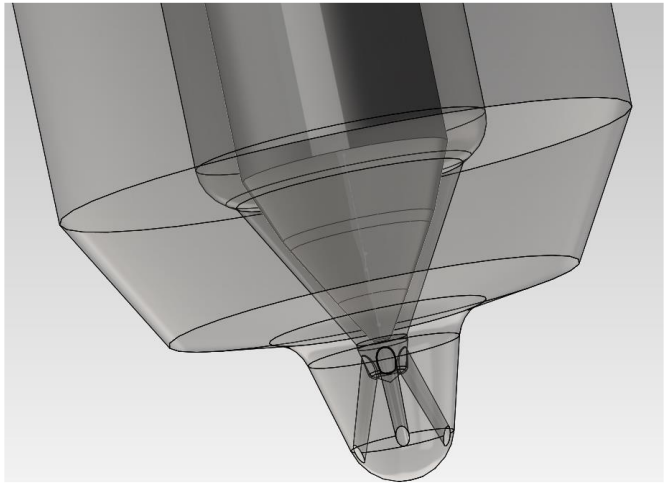
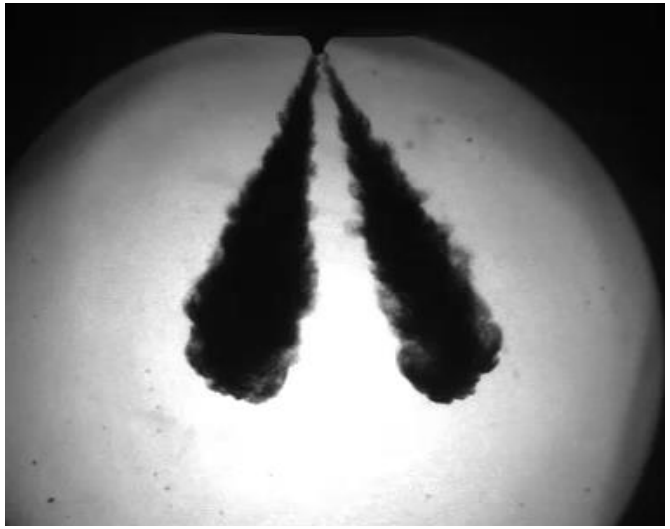
Nozzle and Sprays

- Example of Nozzle Design
  - Developed for OP applications using CFD tools
  - 3-hole design with 43 degree spray angle (incld)
- Spray Image
  - Back lit image at 600 bar injection pressure, chamber pressure 55 bar, chamber temperature 23C.
  - Coherent sprays with good penetration characteristics (3rd plume is obscured by left plume)

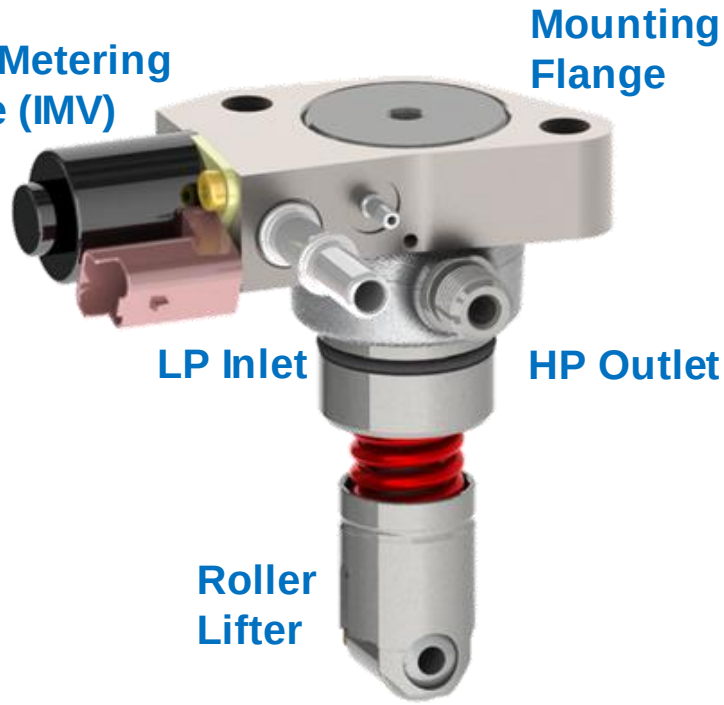


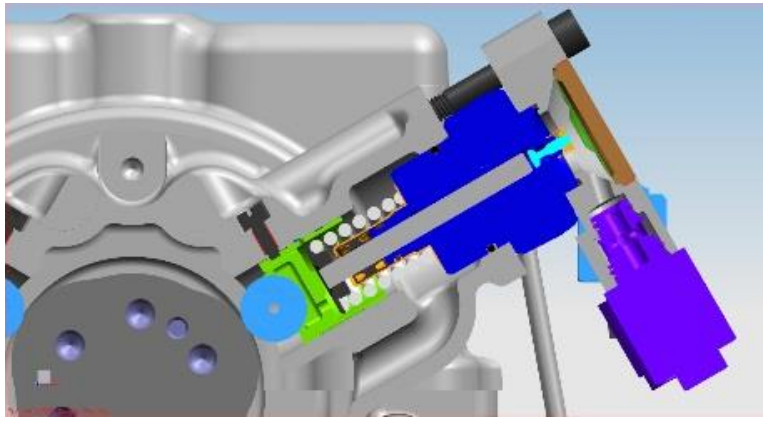


Injection Video

Unit Pump

- Delphi Technologies DUP pump (2nd generation)
  - Compact, low mass
  - High efficiency using inlet metering valve (IMV)
  - Engine oil lubricated
  - Reduced plunger-to-bore clearances for gasoline (reduced leakage)

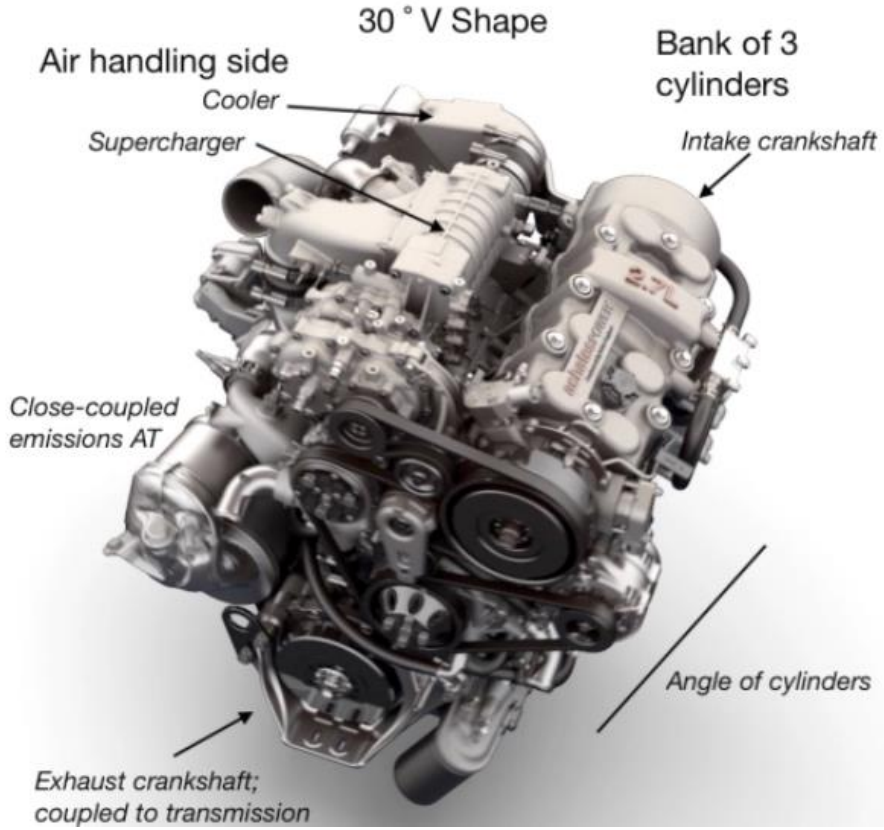




Meissonnier, G., et al., “Delphi Diesel 2000 Bar Unit Pump Common Rail System,” Aachen 2013.

Summary

- A high-performance fuel system for OP-GCI engines has been developed
- Enables partially-premixed compression ignition using E10 pump gasoline for high fuel efficiency and low emissions
- Collaboration between Achates Power and Delphi Technologies



Acknowledgements

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