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2ND ANNUAL ENERGY & INNOVATION CONFERENCE

Partnering for Innovation: Reducing Engine Air Emissions

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Technology and Capability Overview

- The use of a laser to ignite an air/fuel mixture in an internal combustion engine is a relatively adolescent technology that has the potential to provide significant benefits to the industry.
  - It has the potential to improve fuel efficiency, reduce green house gas emissions and provide for a more complete combustion process in the engine's combustion chamber
  - A laser is directed into the combustion chamber via a laser plug and is focused down to a spot size with a high enough intensity to induce optical breakdown

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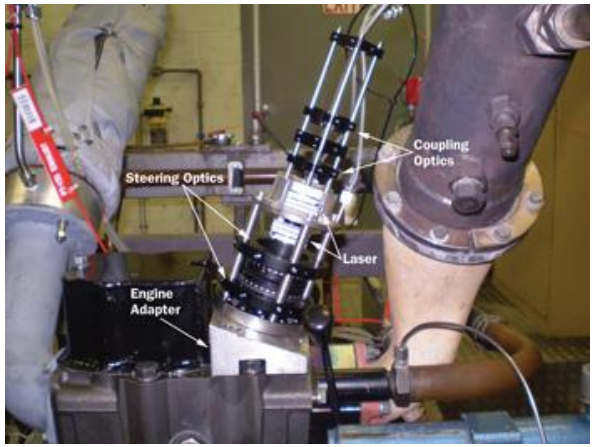
Technology and Capability Overview

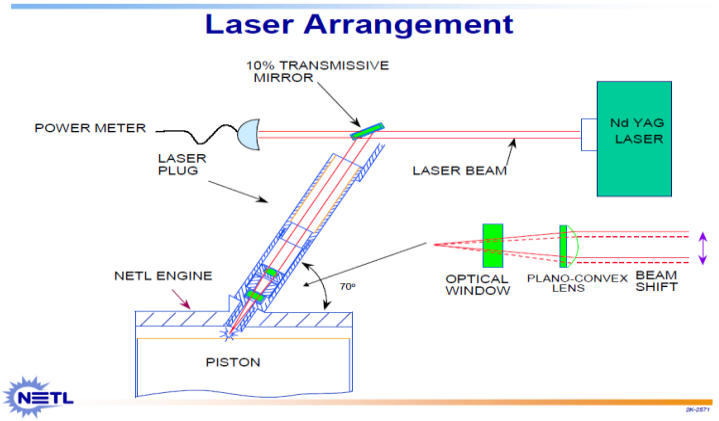
- Previous laser ignition research for IC engines
  - Open beam
    - Not applicable for industrial applications
  - Fiber optic cable
    - Hollow core vs solid core



- Current approach
  - Laser plug
    - Remotely located pump feeds a direct-mounted laser plug
- Development status
  - Prototype has been constructed and successfully operated on a single cylinder engine
  - Durability and reliability testing is required for industry applicability and mass production

Industrial Significance

- Significance to industry
  - Technology benefits
    - Extension of lean limit
    - Combustion optimization based on engine geometry
    - Self-maintaining
    - Higher compression ratios improving thermal efficiency
  - Cost savings
    - Self maintaining
      - $16,000/yr in spark plug replacement (assuming replacement every 500 hrs) vs $8,760/yr for a diode array (assuming replacement every 10,000 hrs)
    - Improved engine efficiency
- Process improvements
  - Production
    - Mass production of 500,000 optical plugs is possible at $32/unit



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Applications

- Long term goal: produce a drop-in laser ignition system to replace conventional electrode-based ignition systems.
  - Originally targeted towards stationary NG engines
    - Temperature and vibrational effects on the LI system are necessary to promote the technology towards smaller packaging size and mobile applications
- Key characteristics for various applications
  - Remote location
    - The ability/necessity to remotely locate a portion of the LI system makes it highly applicable for stationary engines.
  - Size and energy efficiency
    - The space and energy requirements necessary to achieve optical breakdown inside a combustion chamber have been optimized and are now considered to be applicable and mass produced for a wide array of engines

Partnership Opportunities

- Currently, WVU is partnered with NETL to promote research and development of laser ignition systems.
- WVU and NETL have a track record of jointly developing advanced laser-ignition technologies to enable efficient and environmentally sound use of gaseous fuels in transportation and stationary engines.
- Researchers at NETL have developed and validated a laser ignition system that has been fully coupled to a single cylinder IC engine.
- We are looking for an industry partner who has interest in further optimizing the combustion process of their IC engines via an alternative ignition source.
- Additional funding is necessary to promote the advancement of this research to fundamentally improve the combustion process.
- Being a worldwide leader in improving transportation and power system efficiency while working toward a cleaner environment, the CAFEE laboratories contains the tools necessary to perform and validate the testing of an alternative ignition system for internal combustion engines.

Benefits to Partner

- Benefits of partnering with NETL-RUA
  - The use of a laser to ignite air fuel mixtures in an IC engine possesses great potential to advance the industry and future NETL research.
    - Promotes the advancement of a technologically superior product that can improve combustion efficiency and reduce regulated emissions.
- Available resources
  - The Center for Alternative Fuels, Engines and Emissions (CAFEE) at WVU has over 20 years experience in the fields of engines and emissions technology.
    - Cooperation with WVU allows for students to gain valuable knowledge in engine emissions, advanced combustion technologies, data collection/processing and fuel property effects.
  - NETL has a significant amount of experience in the laser and combustion analysis industry.
    - Cooperation with NETL allows for the expertise and knowledge of qualified personnel to be utilized and implemented towards a common goal.

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