Advanced Sensor Fusion for Injection System Shockwave Analysis of Alternative Aerospace Fuels

Amanda Weaver, Levi McKinney, Richard Collins Smith III, Austin Brant

Dr. Valentin Soloiu

Georgia Southern University

PRESENTED AT

Introduction

- For the function and performance of internal combustion engines, the lubricity of the fuel provides necessary protection from friction damage in mechanical components [7]
- Fuel properties such as viscosity and density change the rate at which a mechanical injector opens and the pressure in the fuel lines.
- The injection event causes fluidic shockwaves which are carried through the injector and the fuel lines the intensity of which changes the noise and vibration in the injection system

Hypothesis

- If a triaxial accelerometer, multifield microphone, fuel rail sensor, needle lift gap sensor, and an He-Ne Mie scattering laser are assembled in a system independent from an engine, the fuel injection can be analyzed at the millisecond level to determine the fuel line pressure, injector timing, spray profile, and NVH profile.

Literature Review and Preliminary Work

- Increasing the pressure of a fuel injection increases the performance of the engine [6]
- New alternative fuels and changes in the composition of existing fuels has lasting effects on the performance of the engine and the injection system [7]
- The design for the project is based on the use of a pneumatic pump to initiate injection and a cart to accommodate the sensors

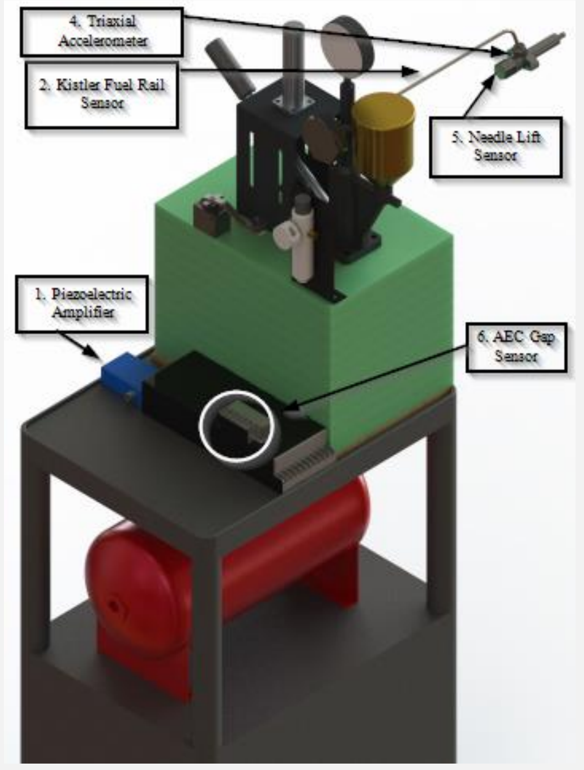


Figure 1: Design Configuration

Methodology or Approach

- The accelerometer, in figure 2, is a type 4527 DeltaTron accelerometer which measures a frequency range of 0.3kHz to 10kHz [2]
- The microphone, in figure 3, used is a Bruel and Kjaer ¼" type 4961 microphone and has a sensitivity of -24.5 dB and measures the noise produced by the injection [2]
- The Spraytec laser, in figure 5, measures droplet size and distribution of the atomized fuel sampling data at a rate of 10 kHz
- The pressure sensor, in figure 4, used on this system is a Kistler type 4067E and has a measuring range of between 0 and 3000 bar allowing accuracy of high-pressure flow analysis [3]
- A needle lift gap sensor, in figure 6, is mounted to the back of the injector and measured the displacement of the injector needle and specific injection timing [1]

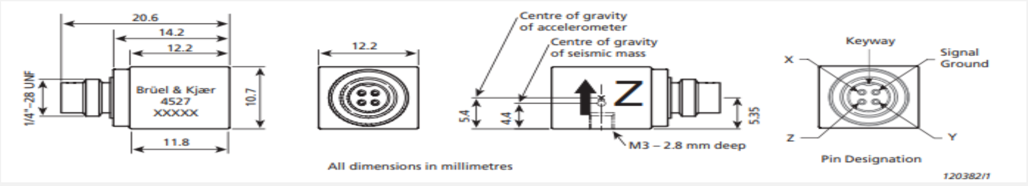


Figure 2: Triaxial Accelerometer

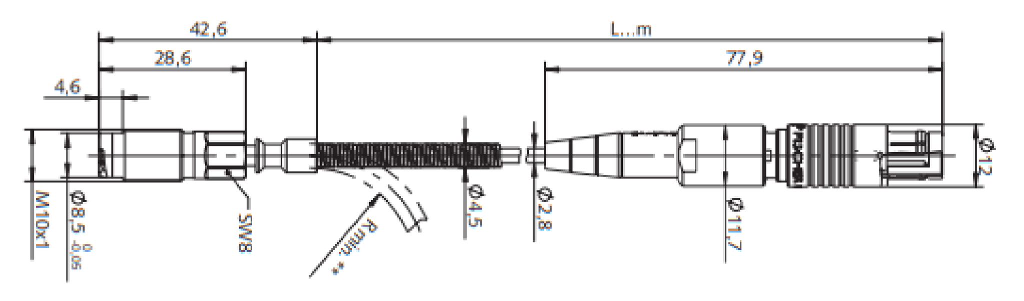


Figure 4: Fuel Rail Pressure Sensor

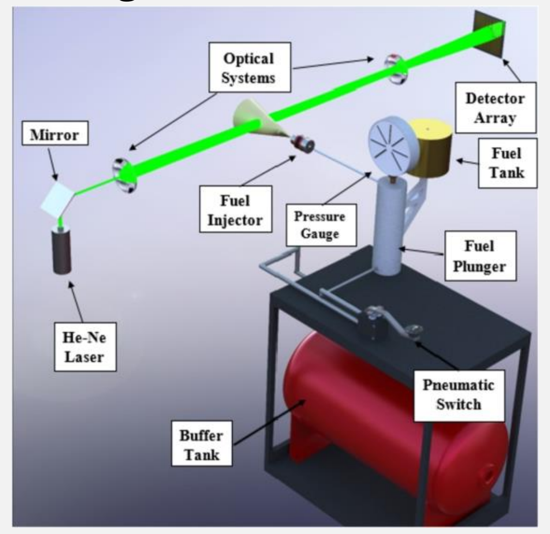
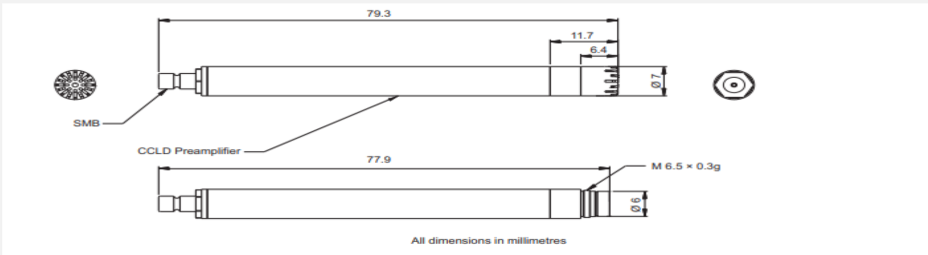


Figure 5: Spraytec Laser



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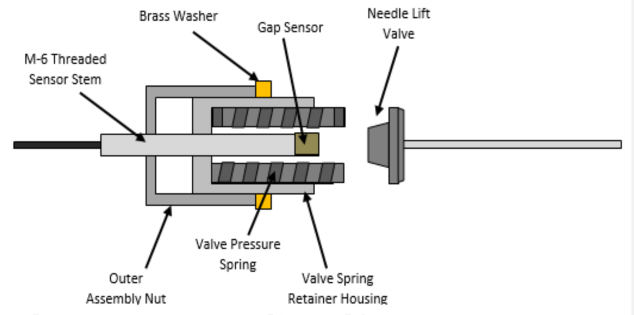

Figure 6: Needle Lift Sensor

Results and Findings

- Results from the needle lift increase indicate changes in the injection timing based on the different fuel.
- The fuel rail pressure sensor indicates the fluidic shockwaves and the injection line
- The microphone and accelerometer indicate increases in sound and vibration due to the injection event

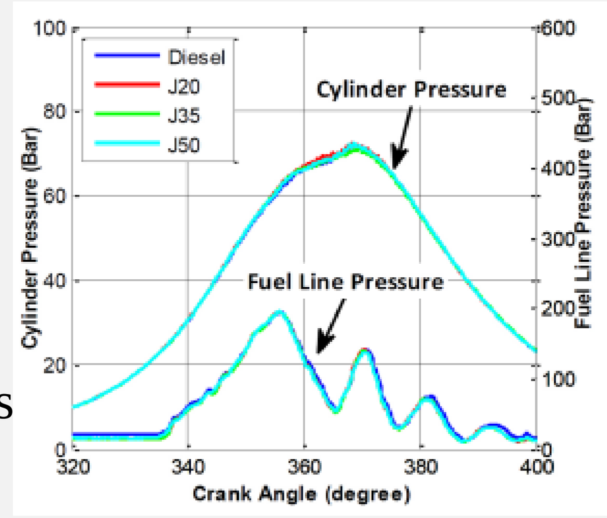

Figure 7: Fuel Line Pressure During Injection [4]

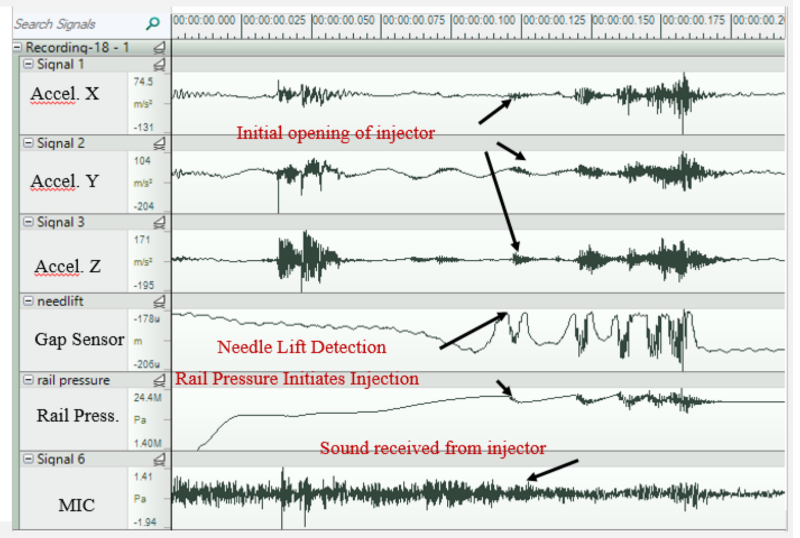

Figure 9: Combined Sensor Data for an Injection Event

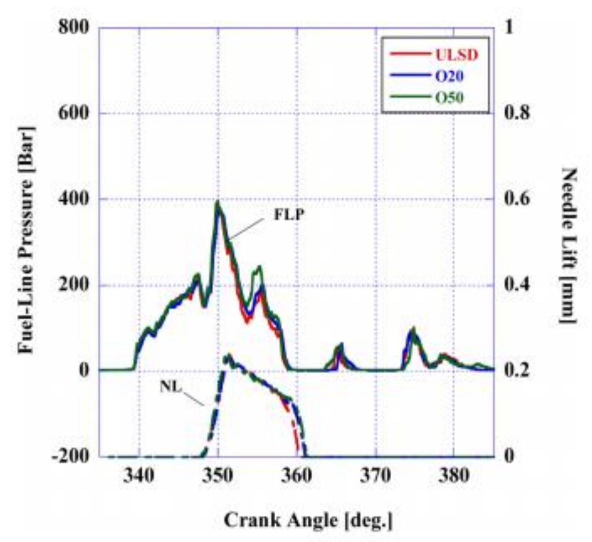

Figure 8: Needle Lift Position During Injection [5]

Discussion

- An increase in the viscosity of the fuel decreases the intensity of the fluidic shockwaves
- Additionally, fuels with a higher density and viscosity increase the time in which the needle is open
- This higher density and viscosity increases the sauter mean diameter of atomized droplets [5]
- Fuels with a higher viscosity and density are associated with a higher lubricity as well [7]

Key Findings

- There is a trade off between lubricity and spray atomization in fuels with a higher vs lower density and viscosity
- Increased lubricity reduces wear on the injection system but can decrease combustion performance
- Combined sensors provide more accurate results on the test fuel and determine its characteristics without interference

References

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