**Universal Water Injection System for Internal-Combustion Engines**

**Abstract / Introduction**

Internal combustion engines are notorious for their thermal in-efficiency with an estimated average at only 20%. (See Equation 1.) Our goal was to improve this efficiency by designing and building a universal, cost-effective water injection system to utilize a portion of the engine’s waste heat to produce additional mechanical power per unit of input energy, therefore increasing the overall fuel-efficiency of the automobile system. The system design-metrics were largely based on the research of Wei et al.¹

\[
\eta_{\text{thermal}} = 1 - \frac{T_2}{T_1}
\]


**System Design**

- Heat Exchanger
- Micro-Controller
- Water Tank
- Electronic Injector
- Water Line
- Compressor

**Sub-System Testing**

The two main metrics of the Water Injection System are Fuel-Efficiency and Power Output. In order to test MPG increase and power output increase, multiple sub-systems had to be tested to ensure the system was functioning properly. The sub-systems include a water injector, a pressure system (pressure sensor, pressure tank, and compressor), a heat exchanger, and a micro-controller to control the overall system.

**Sub-System Testing Continued**

- The Micro-Controller was programmed to maintain a specified pressure range found by combining the Injector Spray Pattern and Pressure Sensor data
- The accuracy of the Micro-Controller’s engine speed reading was validated by direct comparison to the automobile’s (PCM) engine speed reading

**Results**

- **Maximum Power Output**

<table>
<thead>
<tr>
<th>% Water (kg water / kg fuel)</th>
<th>kW</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>131.5</td>
</tr>
<tr>
<td>5</td>
<td>132.5</td>
</tr>
<tr>
<td>10</td>
<td>133.5</td>
</tr>
<tr>
<td>15</td>
<td>134.5</td>
</tr>
<tr>
<td>20</td>
<td>135</td>
</tr>
</tbody>
</table>

**Mileage Testing**

- **Without Water Injection**
- **With 15% Water Injection**

<table>
<thead>
<tr>
<th>Year</th>
<th>Without Water Injection</th>
<th>With 15% Water Injection</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001 Dodge</td>
<td>16.2</td>
<td>37.0</td>
</tr>
<tr>
<td>2001 Dodge</td>
<td>15.9</td>
<td>37.1</td>
</tr>
<tr>
<td>2002 Acura</td>
<td>19.6</td>
<td>41.0</td>
</tr>
<tr>
<td>2002 Acura</td>
<td>19.5</td>
<td>44.6</td>
</tr>
</tbody>
</table>

- The mileage test on the 2001 Dodge Dakota (8-cyl 5.9L) showed an average increase of 7.8% with the use of 15% water injection
- The mileage test on the 2002 Acura RSX showed an average increase of 2.5% with the use of 15% water injection

**Conclusion**

- Based on the test results, the current system is not viable. The measured increase/decrease in fuel-efficiency was inconclusive
- A power increase of 1.6% was found when injecting 15% water
- Other benefits of the system that are difficult to measure monetarily include: Reducing environmental emissions (NOₓ), and Increased engine life due to lower operating temperatures

**Future Work**

- Test system using a dynamometer with a constant load to remove environmental unknowns
- Re-Design the injection method to achieve better distribution between cylinders