Expansion Mediums

Gasoline contains chemical energy, which is of little value by itself when attempting to propel a vehicle. To accomplish useful work, the chemical energy must be converted to kinetic energy. Again the quandary lies in said fuel's inability to efficiently deliver such a direct conversion. Internal combustion engines, therefore, rely on a 2-stage conversion process:

Chemical-> thermal-> kinetic

The fuel is first burned to generate heat.

Chemical-> thermal

From a hot-rodder's viewpoint, this is where high compression and potent ignition systems get to show their stuff. Now there is a new problem. Heat can't power our vehicles any better than the liquid gasoline we started with. We need yet another conversion,

Thermal-> kinetic

As the fuel burns and generates heat, it heats up the nitrogen, water vapor (either water injected, ambient humidity, or a byproduct of combustion), and carbon dioxide (combustion byproduct). The nitrogen is present in the incoming air charge. Some of the water vapor and pretty much all of the carbon dioxide are results of burning the fuel. The water, nitrogen, carbon dioxide, and other elements that expand in the cylinder when heated are called the Expansion Medium.

An expansion medium is required to accomplish the Thermal-> Kinetic conversion. Without an expansion medium, you just heat up (or burn up) the engine. Furthermore, the different gasses have different thermal expansion coefficients. Stated in simpler terms, water expands at 12 times the rate of nitrogen, and carbon dioxide is more expansive than water. To get more power from the same fuel you could simply switch from nitrogen to a more potent expansion medium.

Let's consider how water injection can be expected to perform under this model. If the water is injected into the air stream in an aerosol (like from an injector or mister nozzle), it will first undergo a phase change from liquid to vapor. Some of the thermal energy in the combustion charge that could otherwise act on the expansion medium is consumed vaporizing the water resulting in no net gain or loss in mileage.
If the water is fed into the engine in a vapor form, then the available thermal energy acts upon the water vapor as an expansion medium, but without the parasitic losses associated with the vaporization process.

Exhaust gasses typically contain 13% CO_2, 18% H_2O, and 69% nitrogen. Aside from the effects on combustion rate, exhaust gasses make for a very potent expansion medium. Now factor in the effect on the burn and you net a slower and cooler burn with the presence of inert exhaust gasses.

Finally, add some Hydrogen and see how it purrs. At atmospheric pressures, gasoline burns at a rate of 41.5 cm/sec. In contrast, bottled hydrogen burns at 237 cm/sec. This is over 5.6 times as fast. HHO has been recorded to burn as fast as 240,000 cm/sec!! It depends on several factors as to the precise speed of HHO, but it is many factors faster than even bottled hydrogen. The Hydrogen produced by HCS is a powerful expansion medium which gives a net gain in power and efficiency.