My Methanol Motorcycle

I commute to Cal Poly from Nipomo daily on this motorcycle. I modified it to run on methanol, ethanol, gasoline or any blend of these fuels.

Modified 1984 Kawasaki ZX750E1

This is my daily driver. Modified to run on methanol, ethanol or gasoline, while reliable enough to get me 32 miles each way to work every day. I use methanol almost exclusively. My objectives were low emissions and high efficiency, but without compromising these objectives, the power output was increased to approximately 180 BHP, so it's reasonably fast. Methanol fuel and advanced feedback fuel control are the key to the very clean exhaust emissions, and reduced CO2 (greenhouse gas) compared with gasoline. Methanol is a renewable fuel that can be made efficiently from biomass as well as almost any hydrocarbon source, unlike ethanol which is currently derived only from food crops such as corn.

I radically modified the original fuel injection system: a home-made ultra-wide-range variable fuel pressure regulator (18 psi for gas - 72 psi for MeOH), alcohol-compatible high-pressure fuel pump, different fuel injectors and other fuel-wetted components, and a home-made electronic fuel mixture control, similar to most modern automotive engine controls for catalyst-equipped vehicles. Exhaust oxygen is used to sense the air-fuel ratio, which is used to modify the fuel delivery via adaptive real-time adjustment of the injection pulse-duration. Exhaust oxygen content and volumetric fuel delivery are displayed on a custom instrument cluster. Engine displacement is actually 810cc, and the compression ratio was increased to approximately 9.5:1, taking advantage of the higher research octane number (115) of methanol to improve efficiency.

With the engine fueled by methanol, a turbo boost pressure of 18 psig can be used without risk of detonation due to the higher octane rating and an intrinsic intercooling effect due to its high latent heat of vaporization - about 4 times that of gasoline. As Indy racers know, the combination of alcohol fuel and high turbocharge boost yields an estimated power output nearly double that of naturally aspirated gasoline. Methanol is also a much more efficient fuel than gasoline. My average fuel economy during daily commuting is 27 mpg of methanol, equivalent to 54 mpg of gasoline. With conservative driving, I've achieved up to 35 mpg of methanol, equivalent to 70 mpg of gasoline. The 3.7 gallon tank capacity limits my range on methanol to approximately 120 miles. I can always refuel with gasoline on longer trips, but I try to avoid burning liquid that is so valuable for other uses.

With a blend of different fuels in the tank, the fuel pressure regulator is manually adjusted (while driving) while watching the O2 indicator, until the feedback fuel control acquires lock. It then automatically maintains a stoichiometric mixture except during rapid transients or deceleration fuel-cut-off.

Other novel features include an experimental switching-type voltage regulator, that is much more energy efficient than the original shunt-type voltage regulator (used on all motorcycles). This circuit enables the generation of more electrical power while reducing the heat dissipation in the stator and load on the engine, which can amount to as much as one horsepower at high engine speeds. With the number of additional electrical loads I have on this bike, I need greater-than-stock electric power, even at idle. High pressure fuel pump draws 7 amps compared with stock 3.5 amps. Self-designed stroboscopic brake light (safety equipment) also draws twice power of original.

Operational problems occur with methanol when the temperature drops below 40 degrees F. The engine becomes very difficult to start, and runs rough until fully warmed up. I overcome the starting problem with a home-made auxiliary butane fumigation system. A small butane tank (from a handheld torch) is mounted inside the frame. Opening the valve floods the intake manifold with butane, with an effect equivalent to starting fluid. Of course, when it's *really* cold, even the vapor pressure of butane is too low, so I'm out of luck. One other problem can occur in cold weather with methanol-gasoline blends that are nearly 50-50: phase separation of the two fuels in the tank. The problem is remedied by manual agitation (jumping up and down on the bike) to remix the phases. This can, however, lead to curious stares or comments by other motorists. I don't intentionally ride when the temperature drops below 40 degrees, but am sometimes caught by surprise when I drive home late at night.

Methanol is a poor lubricant. I sample the oil for contaminants every six months (send to analysis lab) watching for excessive chromium or iron from the rings or cylinder bores. Neat (pure) methanol has zero lubrication properties, which accelerates piston ring wear (as I learned in only 23K miles). I now add a small amount (less than 1%) of castor oil or coconut oil - organics that are soluble in alcohol. These are least expensive when bought in bulk from Health Product suppliers. I have also used Redline ™ alcohol fuel additive, which although expensive, only requires a concentration of 0.2%.

Materials compatibility is often cited as a problem with methanol. Indeed, I went through three wet-type fuel pumps, because I eventually failed to key the ignition every day to run the pump, which would remove the corrosion that builds up on the motor commutator. There is no lack of elastomers (for hoses and seals) that are methanol compatible (even good old polyethylene), but materials that are compatible with *both* methanol and gasoline are rare. I've had best luck using Nitrile rubber, but even with a dry-type racing fuel pump, I'm on my third motor shaft seal – all failures occurring after I had to run on gasoline to get home from longer trips.

Where do I get methanol? I maintain a safe/legal methanol fuel storage facility at my home. Over the past ten years, I have had fuel sponsorships from Methanex and Verizon. The bike can also run on ethanol or E85, although emissions aren't quite as clean and efficiency is a slightly lower. E85 is not available in the San Luis Obispo area. More important, ethanol derived from corn is not a sustainable fuel, which defeats the primary objective of the project.

The vehicle modifications are within the capabilities of a student with good electrical and automotive skills. Cal Poly now has a limited fuel sponsorship from the Methanol Foundation providing free fuel for students and faculty willing to modify and monitor their vehicles. I also currently have a grant proposal to the US DOE pending for the development of a very-small-scale biomass-to-methanol pilot plant on campus that will utilize existing farm residues to produce fuel. Please contact me if interested in getting involved.

Additional Photographs

Back to Prof. MacCarley's home page.