Water/Alcohol Injection

By J Nuijen

We all know that the way to squeeze more power and better fuel economy out of an internal combustion engine is to raise the compression. The problem is that the more you raise the compression the more chance you have that your mixture is going to ignite instantaneously and at the wrong time and, instead of putting a smooth power pulse to the piston, it will create a detonation that will be destructive to the engine. Another problem with high compression is high combustion temperatures that cause production of oxides of nitrogen, one of the destructive constituents of smog.

Engineers have fought with the problem of detonation since the 20’s and have come up with all kinds of clever solutions. One of the first solutions was to add tetraethyl lead to the gasoline to slow down the rate at which it combusts. GM made some experimental engines using large doses of “lead” with compression ratios as high as 15 to 1. Unfortunately, it was discovered many years ago that lead is very damaging to the environment and the lead had to be removed from gasoline. Compression ratios had to come down; fuel efficiency dropped, and so did power.

Another approach to being able to raise the compression is to cool the intake charge. This can be done in a number of ways. On supercharged (including turbocharged) engines compressing the air that goes into the cylinder heats that air, so an intercooler is employed. The intercooler cools the charge after it is compressed. The original intercoolers were nothing but fins on the intake manifold. More recently they have been radiator-like devices know as air-to-air intercoolers. That’s what’s on most diesel trucks today. Jaguar’s R series of V-8s use a water-cooled intercooler that is very compact and has its own cooling system separate from the engine’s cooling system. One of the cleverest intercoolers in recent memory was the one on the Ford Lightning pickup of a few years past. It used the air-conditioning system to cool the intake charge and only operated under high boost conditions. It took up almost no space and was very efficient.

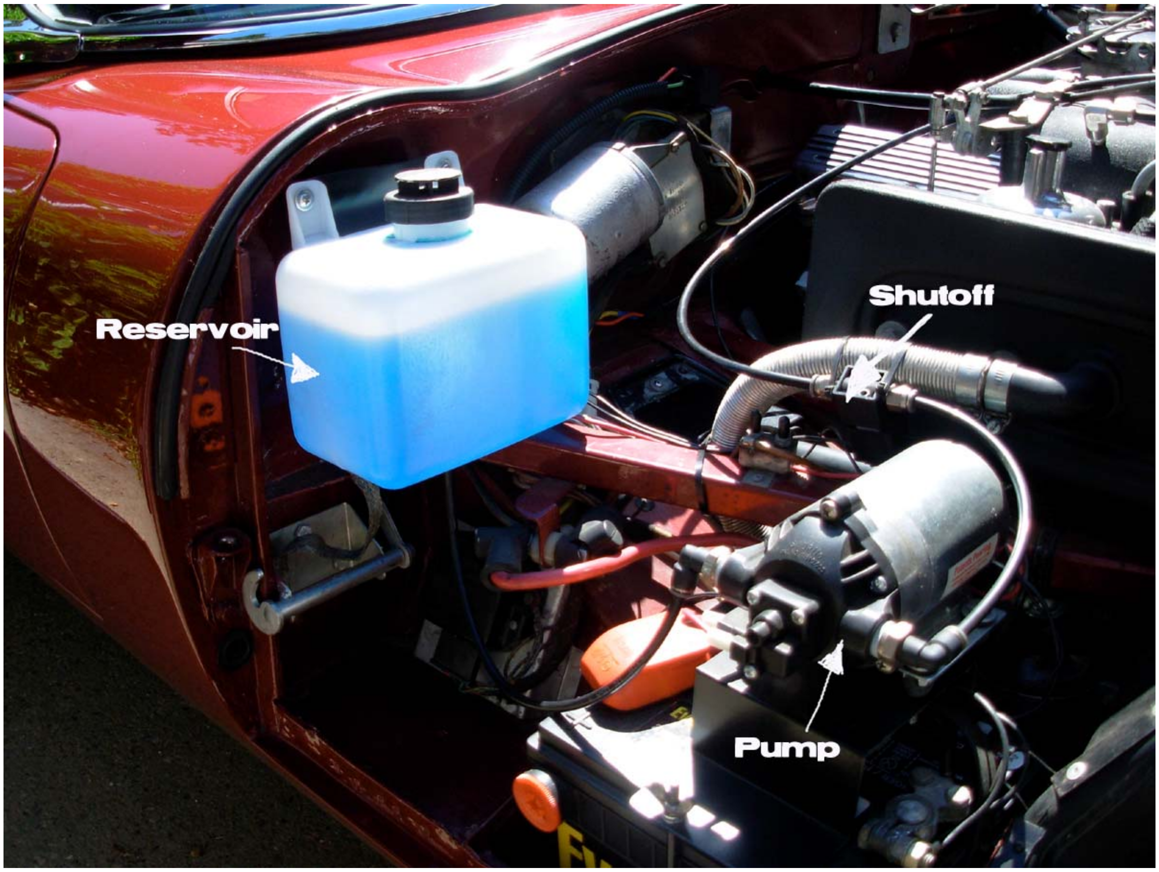
Still another approach is to put something into the intake charge that cools it. This can be done anywhere along the intake track, or in the combustion chamber itself. Raw gasoline, if it isn’t overdone, can do this. That’s why a carbureted engine can produce more torque than the equivalent engine that is port-fuel injected. This phenomenon is exploited to its fullest in the 950 hp NASCAR engines that use a dinky 600 cfm carburetor.

If you aren’t limited by rules there are fluids much better than gasoline that can be used to cool the intake charge. Plain water works amazingly well, especially on air-cooled engines that run very high combustion chamber temperatures, esp. around the exhaust valve. Adding methanol to the water or using straight methanol works even better because of alcohol’s latent heat of vaporization cooling effect. Methanol is a great fuel by itself, used for years at Indianapolis and in drag racing. An engine running on a rich mixture of methanol doesn’t even need a radiator!

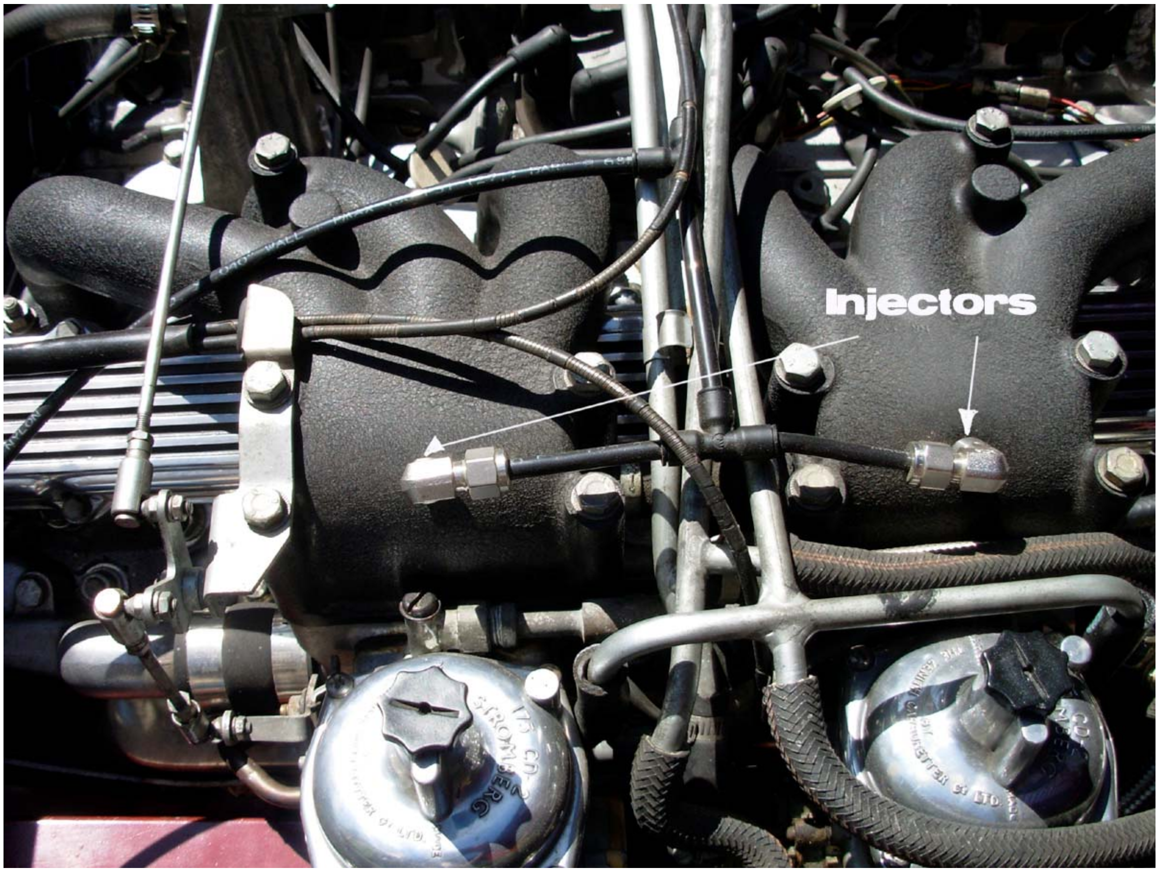
The origins of using some fluid to cool the intake charge are lost in obscurity, but the fighter planes of the 30's and 40's used it to nearly double their horsepower for short periods of time and early jets used it too. The technique also works on diesels, esp. turbocharger diesels, which can run as much as 150 pounds of boost and produce astronomical combustion temperatures. Oldsmobile used it in 1962 when they turbocharger their 215 cubic inch, all aluminum V-8. Ford has recently "discovered" this trick and is experimenting with injecting ethanol to achieve a, quote, 20% boost in power and fuel economy.

I have an early high compression V-12 with many miles on it. For years I have had to either retard the timing, use a fuel additive, or mix unleaded racing gasoline with the best premium I can buy. My problems are compounded by the fact that a fair amount of oil is getting past the rings and valve guides. As you probably know, oil in the combustion chamber lowers the octane rating of the charge. That's what a diesel thrives on. Oil under pressure ignites all by itself.

When Jaguar originally designed the V-12 leaded fuel of 100 octane was the norm. By the time it got into production the phasing out of lead was underway and octane ratings plummeted. By 1973 the V-12's compression ratio was reduced to 7.8 to 1. In 1980 Jaguar came out with a modified V-12 head and called the engine the HE for High Efficiency. Believe it or not the engine had an 11 to 1 compression ratio (12 to 1 in England and Europe where they still had leaded fuel). This was possible because the combustion chamber had a deeply pocketed exhaust valve and the spark advance was severely limited under high load conditions.



Getting back to my V-12, a few years ago I installed a water/alcohol injection system made by Snow Performance (www.snowperformance.net) and modified by me with the help of Snow. The system is really designed for blown engines and is activated by a pressure switch when boost goes beyond a certain level. The basic system consists of a reservoir (looks like a windshield washer tank because that's what it is), a high-pressure pump (about 125 psi) and injectors in the intake manifolds. All the plumbing is either plastic or stainless steel because alcohol is corrosive. The injectors are simple orifices that are sized to meet the horsepower requirements of the engine. In my system the pressure switch is replaced by a vacuum switch and a positive shutoff switch is installed between the injectors and the pump to insure that high manifold vacuum doesn't drain the reservoir when the pump isn't on. Under light load conditions a gasoline engine has high vacuum in the intake manifold and there is little danger of detonation. When you floor the throttle for maximum power the intake vacuum drops close to zero. This is when you need charge cooling. The vacuum switch turns on the pump and a mixture of water and methanol is injected into each intake manifold. The injectors can be anywhere after the throttle plate. I chose the location on top of the manifolds because it was the easiest to install. Straight water works, but I still get some detonation when the engine is really hot. In the pictures you can see that the fluid in the tank is blue (you can see that if you are reading this on our website because it is in color). It looks like windshield washer fluid because that's what it is. It's winter windshield washer fluid that is about 30% methanol and sells for about $1/gallon at Wal-Mart. You won't find this fluid in the



Bay Area at anytime of year because methanol is harmful to the environment when squirted on the windshield. You will find it in the winter in the Tahoe/Reno area where normal windshield fluid freezes and the methanol prevents that. My system lacks one thing that would make it more convenient to use. When the engine is not running or is being cranked by the starter there is, of course, no manifold vacuum. Normally the pump would turn on and flood the engine with water/alcohol. I have an on/off switch for the system to prevent this. A better solution would be a rpm switch that would allow the system to come on anytime the engine exceeds a set rpm, say 1000 rpm. Such switches are available. Someday I will install one. Total cost of the system, about $500.

At this point you might be asking yourself, "Why don't we just run our cars on alcohol if it has so many advantages." Historically, there are four reasons why most cars don't run on alcohol, although Brazil has had a long romance with ethanol powered cars, which continues to this day. The first thing against alcohol is that an engine won't start on it when the weather is cold. You need a starting fluid of some kind. In the dim past ether was used, but today gasoline is blended with the alcohol. That's the reason behind E85, which is really E70 in Minnesota in the winter to make sure a car will start on the coldest mornings. The second thing against alcohol is that it has less energy per gallon than gasoline. Methanol is about 60% of gasoline and ethanol is about 70%. So you need to burn more to get the same power. Even today, when you take the lower heat content into account, gasoline is a cheaper fuel than alcohol. The third thing against alcohol is that it

DOES mix with water. It actually goes looking for water and pulls it out of the air. Pretty soon the energy content of the fuel is even less and the engine might not even run. Gasoline does not absorb water. It settles to the bottom of the tank and is either separated or gets into the engine and has to be removed. The last negative for alcohol, that it is corrosive to mild steel, copper, brass and natural rubber, is no longer a factor. None of these materials are in the fuel system anymore because all gasoline today contains some alcohol.

As always I invite your comments, criticisms, and corrections. jtech@jags.org