CONVERTING GASOLINE ENGINES TO RUN ON ALCOHOL

Part 1 - Carbureted Gasoline Engines

This outlines an approach to engine modification generally applicable to four-stroke carbureted gasoline engines. (Not covered are fuel-injected, two-stroke, or diesel engines.) While it cannot give specific calibrations, due to the wide variety of engine configurations, it offers a sense of the scope of the task and provides a place to start.

This presents specific information for the conversion of an air-cooled Volkswagen engine (circa 1980).

It is understandable that people may want to use an older engine for this experiment. There is the risk, however, of problems due solely to worn-out parts developing after the car is converted. It is important to be able to distinguish these from problems that may be due to the ethanol or to an error in modification. So it is recommended that the engine selected for modification be in the best condition possible.

The first question to consider in approaching engine conversion is whether there are any materials in the fuel system or related systems that will be damaged by ethanol. It would be most unfortunate to pour ethanol in your tank and have parts of the carburetor dissolve.

Metals commonly used in fuel systems are usually ethanol-compatible. Magnesium is known to suffer severe corrosion when in contact with ethanol. Fortunately, it is rarely found in fuel systems. Among non-metals, cork does not fare well with ethanol. Polyurethane and fiberglass-reinforced polyester have also been known to deteriorate in ethanol. Avoid plastic fuel filters - the glass ones are preferable. Aside from these items, non-metal problems with ethanol are unlikely.

Take your fuel pump and carburetor apart and clean them; soak them for a month in 180-190 proof ethanol. (If you can't afford to have your car apart that long, pick up used parts from an auto wrecker.) Likewise, soak a fuel filter and a piece of fuel hose. Agitate the container from time to time. When the time is up, look for pitting or corrosion of metals. Check non-metals for softening, hardening, cracking, or change of size, shape, or weight.

If preliminary tests indicate materials problems, consult your local auto parts store, carburetor specialty shop, racing supplier, or machinist regarding suitable replacements.

It may be that some fuel system parts will deteriorate slowly in service. Be alert for this possibility as you are running the vehicle on ethanol. Also, impure fuel can cause unanticipated difficulties. Beware especially of overly acidic fuel (pH less than 6)

It is also important to watch parts peripherally related to the fuel system that may be exposed to ethanol vapors, such as vacuum advance diaphragms, automatic transmission modulators, and power brake assist units. Problems here are unlikely but worth watching for.

Because ethanol is a dirt loosener, it will free dirt that has accumulated throughout the fuel system. For this reason it is important to install a fuel filter before the pump, and another between the pump and the carburetor. Use the cleanable type, and check it often in the first weeks of ethanol use.

Finally, note that ethanol spilled on the vehicle paint finish may have adverse effects. Paint softening and wrinkling have been experienced in some cases.

The carburetor meters the flow of fuel to the cylinders and mixes the fuel with air. Because ethanol supplies less energy per unit of volume than does gasoline, fuel-metering jets must be enlarged to allow the proper amount of fuel to pass.

There are many carburetor designs in use, and it is not possible here to give specific directions for all. It will be necessary for you to experiment in the context of the guidelines provided here.

Start by calculating the factor by which your jets must be enlarged. The formulas indicate that jet diameters for gasoline should be multiplied by 1.27 for pure ethanol (200 proof). Most people, though, will be using 180-190 proof. Unfortunately, the formulas do not seem to give accurate answers for hydrous ethanol. Start out about five per cent larger than the figure you calculate.

Obtain a carburetor rebuild kit, which will include a detailed diagram of your unit. Clean and overhaul the carburetor since you will have it apart anyway. Identify all fuel metering jets, including: main jet, pilot (idle) jet, and accelerator pump nozzle.

Most jets are stamped with the orifice diameter in metric or English units. On a metric carburetor, a number such as 120 means 1.2 mm.; on most U.S. units, 50 indicates .050 inch. There are exceptions; check with a carburetor shop to be sure. Convert millimeters to inches by dividing by 25.4.

Multiply your jet sizes by the conversion factor. Obtain new jets of the proper size, if available, from a parts or racing equipment supplier. Often they will not be available, and you will have to drill out the old jets yourself. Determine the proper drill bit sizes. Obtain the bits and a pin vise from a tool supplier. Do not use an electric drill. Carefully enlarge the jet, wash it, and blow it clean with compressed air.

Some carburetors incorporate a staging adjustment for the accelerator pump. This controls the duration and quantity of fuel injection from the pump. In addition to enlarging the nozzle, lengthening the pump stroke may help.

Because ethanol is 7 to 8 per cent heavier than gasoline, it may be necessary to adjust the float setting to maintain the proper level of fuel in the float bowl. Otherwise the fuel level will be too low. Bend the float up slightly or use a thinner gasket under the needle seat. As an alternative, find a slightly heavier float.

On cars with automatic chokes, adjust the choke unit to a winter setting. When the engine is running again, adjust the idle and mixture screws.

Carburetor modifications, especially jet sizing, will be a matter of some trial and error. With jets it is better to start small and work up. If you go too far, you can buy a new jet and try again. You can judge your results by comparing power and CO emissions with gasoline operation. Both should be similar. Power is also affected by other factors, as we shall see.

Below 60-65 degrees F., ethanol will not vaporize sufficiently to form a combustible mixture. The simplest way to start a cold engine is to inject a more volatile fuel into the intake manifold or carburetor. Gasoline and propane are good candidates. Straight ether is not recommended, but there are ether formulations - used for starting diesels--in which the tendency of ether to explode all at once is modified.

A gasoline cold-start system consists of the following components: Fuel tank. A one-gallon motorcycle tank will do. Install it in the trunk where it is well protected in case of accident and away from engine heat. Secure it well.

Fuel line. A metal tube runs from the tank to the engine. Install it so nothing rubs against it. An in-line fuel filter should be installed near the tank.

Pump. An electric or manually controlled pump should be installed in the line where convenient. You will need a switch or other control on the dashboard. Beware of pumps not designed for gasoline, such as windshield washer pumps. The plastic and rubber parts may degrade when used with gasoline.

Nozzle. Connect the fuel line to a small nozzle with an opening about the size of the accelerator pump orifice in the carburetor. This nozzle can be installed in the air cleaner, pointing straight down the carburetor throat, or in the intake manifold.

A propane system is constructed as follows: Fuel tank. Buy a propane-torch kit, which includes the tank and a pressure control valve. The orifice in the tube, after the valve, should be drilled out somewhat to allow an adequate flow of propane. Mount it away from the engine compartment.

Control valve. Propane is stored at high pressure - over 200 psi - so a special electric valve is required to control it. This is available from a valve supply shop. It is recommended that the valve be brazed to the neck of the pressure control piece to insure against leaks. A switch on the dashboard, preferably with a warning light, is wired in to activate the valve.

Fuel line. Tightly clamp a fuel hose to the electric valve and connect it directly to the intake manifold or carburetor in a convenient place.

Note: With either the gasoline or propane system, inject fuel for just a few seconds, while starting the cold engine. It will run on ethanol alone almost immediately.

Preheating engine coolant is an alternative approach. In engines that incorporate a water-heated manifold, a small electric water heater installed as close to the manifold as possible will improve cold starting. Such heaters are often used on gasoline engines in cold climates and are commercially available. Of course, you have to plug it into the wall and wait.

Improved spark quality, as discussed below, also aids in cold starting.

SPARK QUALITY

Because the ethanol fuel-air mixture tends to be poorly vaporized under some conditions, it is useful to use a better ignition system than the conventional breaker points triggering system provided until recently on most cars. Factory electronic or high-energy ignition is satisfactory. But if your car does not come with this type of system, it is worth obtaining an aftermarket capacitive discharge or electronic ignition unit. These can be installed easily, and they increase the voltage at the spark plugs and keep the plugs cleaner.

Some difference of opinion exists on the question of spark plug heat range. It is best to start out with the plugs designated for your engine. For hot weather and long distance driving, though, it may be beneficial to use plugs one or two levels colder. If you do, check the plugs to be sure they are not being fouled by oil.

IGNITION TIMING

Other conditions being equal, the proper timing for an ethanol engine is five to eight degrees advanced from the optimum gasoline setting. But as you make changes described in this chapter, you will change factors that affect the proper timing. Improved manifold heating and increased compression ratio require retarding the timing. So does enriching the fuel-air ratio. With a moderate increase in compression ratio and manifold heating, ignition timing will be more like three to five degrees advanced from the ideal gasoline timing.

Gasoline engines without emission controls (through 1967) come with optimum spark timing.

On most 1968-70 cars, timing was retarded to reduce emissions of oxides of nitrogen (NO_x). Ethanol combustion produces much less NO_x than gasoline, so it is acceptable to advance the timing more on these cars to regain the efficiency and drivability lost to retarded timing.

Starting in 1971, automakers used a variety of devices and concepts - some of which include spark-timing controls - to reduce NO_x. How you adjust the timing on these cars will depend on the components of your emission control system and is beyond the scope of this book.

A gasoline engine will knock if the timing is too advanced, but not so with ethanol. Unless you have use of a dynamometer, the best way to check your timing setting is on the highway. Time your acceleration from about 30 to 55 MPH with a three-degree advance, and keep advancing the timing until you get the fastest acceleration time. The minimum spark advance for best power is your goal

COMPRESSION RATIO

Ethanol's high octane rating allows a much higher compression ratio (CR) than can be used in a gasoline engine. A typical gas engine these days has a CR of about 8.5 to 1, while a reasonable goal for a converted engine would be 10 or 11 to 1. Increased CR improves engine efficiency. Modified engines in this country have run as high as 14 to 1, but pre-ignition, reduced efficiency, and increased emissions can become problems at such high ratios.

There are two usual ways of increasing the compression ratio.

Piston replacement. Stock pistons with flat or dished tops can be replaced with domed pistons, which reduce the size of the combustion chamber and thus increase CR. They are often available from racing suppliers. If money allows, this is the preferred alternative.

Cylinder head machining. Milling the cylinder head surface also reduces the combustion chamber volume. Possible piston-valve interference and rocker arm geometry problems must be taken into account. On a V-engine, intake manifold alignment with the heads must also be considered. Consult an experienced machinist.

In either case, determine engine bore and stroke, and the combustion chamber volume before and after, to calculate the change in compression ratio.

FUEL VAPORIZATION AND ENGINE WARM-UP

To operate properly, an engine must be provided with a fuel-air mixture that is mostly vaporized. A gasoline engine is designed to provide adequate heat to the intake manifold, from exhaust or cool-ant, to vaporize the fuel; ethanol requires about five times as much heat to vaporize the proper fuel-air mixture than gasoline does.

The best engine configuration for manifold heating incorporates the intake and exhaust manifolds together on the same side of the cylinder head, allowing heat to flow readily from the exhaust to the intake manifold. Typical of this design is an in-line 6 and, in fact, the Dodge/Plymouth slant-6 has proven to be an excellent engine to modify for alcohol use.

On the other hand, in an engine with the intake and exhaust manifolds far apart, fuel vaporization is less satisfactory. Examples of this type are cross-flow head designs (intake and exhaust on opposite sides of the head), air-cooled VW, and V-engines.

Unless steps are taken to improve fuel vaporization, performance and fuel economy will suffer, and wear will increase. Several approaches to improving fuel vaporization can be considered. The best one will depend on your specific engine design.

Take water from the cooling system and route it through a ¼" copper tube wound tightly around the intake manifold runners. Then provide a return to the cooling system. You must choose the pick-up and return points to provide a pressure differential, so that the water will circulate through the tubing rather than just sitting there.

A similar approach can be taken with exhaust gas. Install a pipe fitting in a high pressure area in the exhaust manifold, near the head, and conduct the hot gas through a ½" copper tube to the intake manifold. Braze the tubing to the intake manifold runners, and then connect the tubing into a low-pressure area of the exhaust system, preferably below the muffler. You may wish to pick up exhaust gas at several points with several tubes from the exhaust manifold.

Alternatively, route the copper tubes inside the manifold runners. It may be necessary to use tubing smaller than ½". The tubes must run continuously through the manifold so that no coolant or exhaust gas is cycled into the fuel mixture. Drill holes for tubing entrance and exit, and after installing the tubes, braze the holes shut.

The advantage of this variant is that heat is available to vaporize the fuel mixture more quickly than if the manifold must be warmed first. The disadvantage is that the tubes reduce the volume of fuel mixture flow to the engine, which reduces power at full throttle.

If your car has a water-heated intake manifold, it may be possible to increase the flow of hot water through the manifold heater. This can be done by increasing the size of the water entrance and exit ports, or otherwise modifying the manifold. Also, installing a hotter thermostat will help here. This also improves fuel vaporization within the combustion chamber.

Most engines have a heat-riser control valve. You may be able to modify the controls on it to increase manifold heating. Above all, make sure that the valve is working properly. Often it gets rusty and sticks in one position.

Many engines have a thermostatic control or flapper valve on the air filter intake, to admit hot air under certain circumstances. You can adjust the control to provide hot air to the carburetor more of the time.

Fill in the gaps. Write down the specific changes you will make to the fuel and ignition systems. Devise a plan for cold starting and raising the compression ratio that best suits your engine.

After you have converted the engine, repeat the tests you did in preparation for conversion. And don't be afraid to keep tinkering. A little adjustment here and there may improve performance a lot.

Let's go over the facts again, generalize the cars and cover the three major changes (main jet, idle jet, and timing), and we'll also go on to cover some other areas that may be of interest to those who want to go further to increase the efficiency of their alcohol-burning engines.

MAINJET CHANGES

The first thing you'll have to alter is the main metering jet in your carburetor. In most carburetors, this is a threaded brass plug with a specific-sized hole drilled through the center of it. This hole is called the main jet orifice, and its diameter dictates how rich or lean the air/fuel mixture will be when the car is traveling at cruising speeds. Naturally, the smaller the hole is, the less fuel will blend with the air and the leaner the mixture will be. As the orifice is enlarged, the mixture gets richer.

Since alcohol requires a richer air/fuel ratio, it's necessary to bore out the main jet orifice when using ethanol fuel. The standard jet size in MOTHER's alcohol-powered truck was .056" ... in other words, this was the diameter of the jet orifice. In order to operate the engine successfully on alcohol fuel, it's necessary to enlarge this opening by anywhere from 20 to 40%.

Start your conversion by gathering all the tools and hardware you'll need to complete the job. A screwdriver, an assortment of end wrenches, vise grip pliers, a putty knife, a pair of needle-nose pliers, and a power drill - with bits ranging in size from a No. 51 (.067") to a No. 46 (.081") are usually all you'll need. To make your job easier, though, you might want to refer to a Motor, Chilton, or Glenn auto repair manual for exploded illustrations to guide you through the necessary carburetor disassembly and reassembly. (A second alternative would be to purchase a carburetor rebuilding kit for your make and model car ... which will not only supply you with a working diagram, but provide gaskets, seals, and other parts that may get damaged during the strip-down process.)

You may also need to purchase several main jet assemblies from your auto dealer (if the carburetor you're converting has a removable main jet), since you'll probably want to experiment with different air/fuel ratios.

In order to take the carburetor apart, you'll first have to remove its air filter housing and all its hoses, tubes, and paraphernalia from the engine. Then disconnect the throttle linkage from the engine and any choke linkage rods that aren't self-contained on the carburetor body. (If you've got a manual choke, remove its cable and tie it out of the way.)

You'll also have to unscrew the fuel line from the carburetor inlet fitting and remove any other hoses that fasten to the unit, including vacuum and other air control lines.

When the carburetor is free from all external attachments, remove it from the manifold by loosening the hold-down bolts at its base, and turn the unit upside down to drain out any gasoline that may be in the float bowl. Remove the carb's air horn (you may have to unfasten the choke step-down linkage rod) and locate the main jet. (Some carburetors have the jet installed in a main well support, while others mount the brass fixture right in the float bowl body.)

Once you've removed the main jet, you can prepare to enlarge it. First measure the diameter of its opening by slipping a drill bit of known size into the hole (this bit should fit snugly, of course). In some cases, the size of the jet is stamped in thousandths of an inch right on its face, so you don't have to go to this trouble. When you know what the standard jet size is, you can calculate the additional enlargement necessary to operate the engine on alcohol.

For example, MOTHER's truck originally had a .056" main metering jet. In order to increase that opening's diameter by 40%, we first had to multiply .056" by .40 (which yielded .022"), then we had to add that additional .022" to the original .056" ... this figured out to a total diameter of .078". The nearest size drill bit to this is a No. 47, which is .0785" in diameter ... this was the bit necessary to bring the jet to 40% over its original size.

Hold the jet with your vise-grips and carefully bore out its central hole (if possible, use the jet-holding body of the carburetor itself as a mount while you drill). Be sure to do your drilling as nearly straight as possible, and clean any brass residue out of the carburetor and its components after the operation is over.

There are some carburetors that do not use fixed-size jets alone, but also utilize what is known as a "metering rod". This is usually a thin tapered or stepped brass rod that's suspended within a brass jet orifice, which may or may not be removable. The fuel is, in this case, drawn through the space between the rod and its brass "housing". Depending on how far the throttle is opened, the metering rod is lifted out of the hole ... and - since the rod is thick at its "base" (near the top), and progressively thinner at its tip (toward the bottom) - the farther it's drawn out of the hole, the more fuel is allowed to flow between the central rod and the opening.

The conversion on this type of metering system is basically the same as the fixed-jet conversion. To enlarge this orifice, you can either remove the metering rod and very carefully drill out the brass jet (take it out of the carburetor if it's removable), or take the tapered brass rod to a machine shop and have it turned down slightly (the same effect can be accomplished less accurately by sanding the rod down with emery cloth). If you choose to drill the jet to a larger dimension, the diameter should be increased anywhere from 10 to 32%.

With the fixed-jet type of carburetor, the diameter of the jet orifice can vary from about 20% over standard to 40% larger - or even more - depending on the engine's size, its compression ratio, and the vehicle's weight. Probably the best way to determine what is right for your needs is to experiment, since many instruments used to measure the proper air/fuel ratio don't register correctly when the engine is burning alcohol.

By planning on a diameter enlargement of anywhere from 35 to 40% at first, you'll be perfectly safe, since the engine will tolerate this size easily. If you go too much larger than this, you'll probably just be wasting fuel. On the other hand, by going too small, you may find that you'll lose power ... or even worse, that you may burn valves because of an overly lean mixture.

On the other hand, it is true that a lean mixture - to a point - will result in improved economy with hardly a noticeable loss in performance. With MOTHER's vehicle, the absolute limit was a 19% enlargement in jet size ... although the truck does run slightly better with a 25% larger-than-standard main jet. You may find, as we did, that your vehicle performs well with a smaller jet opening than the suggested 35-40% increase but to be on the safe side, periodically check your spark plugs, especially after an extended drive. If they are white in color, or otherwise appear to be subject to excessive heat (look for hairline cracks on the center electrode's insulative jacket), this is an indication that your engine is burning too lean ... and the jet must be enlarged.

IDLE ORIFICE CHANGES

Most carburetors will require additional idle circuit enlargement in order for the engine to run at slowest, or idle, speeds. This is because the circuit that's fed by the main jet operates fully only when the throttle plate within the throat of the carburetor is opened past the idle position. When the plate is in the idle position, the air/fuel mixture is allowed to enter the manifold only through the idle orifice itself ... which, if it isn't large enough, will not provide the needed amount of air/fuel blend to keep the engine running.

On some engines, it may only be necessary to loosen the idle mixture screw at the base of the carburetor in order to provide the correct amount of fuel, since this threaded shaft has a tapered tip which allows more mixture to pass as the tip is backed off. On other engines, it's possible that the seat itself, into which the tapered screw extends, must be enlarged in order to accomplish the same thing.

In most cases, if the seat has to be bored out, it can be enlarged by 50%, using the same method of measurement as was detailed in the main jet section. This will allow a full range of adjustment with the idle mixture screw, even if you should want to go back to gasoline fuel. (When drilling, be careful not to damage the threads in the carburetor body.)

As a precaution against the idle screw's vibrating loose from its threaded opening, you can shim the idle mixture screw spring with a couple of small lock washers ... this will prevent the screw from turning even if it's drawn out farther from the seat than it normally would be.

POWER VALVE CHANGES

Most modern auto carburetors have what is known as a power valve that allows extra fuel to blend with the air/fuel mixture when the accelerator is depressed, in order to enrich the mixture under load conditions. This vacuum-controlled valve is spring loaded, and shuts off when it isn't needed in order to conserve fuel.

The power valve used in the carburetor illustrated is somewhat difficult to alter and, besides, is sufficient for alcohol use in its normal configuration if it's working properly. However, there are other carburetors - specifically the Holley and Ford (Autolite or Motorcraft) brands - that have easily replaceable power valves which are available from auto parts stores in various sizes. If you use a power valve with a 25% or so greater flow capacity than the one that originally came with the carburetor, your air/alcohol mixture will be sufficiently enriched when your engine needs more power.

ACCELERATOR PUMP CHANGES

In addition to a power valve, almost all automotive carburetors utilize an accelerator pump. This is a mechanically activated plunger or diaphragm that injects a stream of raw fuel directly down the throat of the carburetor when the accelerator is suddenly depressed. The fuel is injected through a small orifice located in the throat wall at some point above the carburetor venturi (the point at which the throat narrows).

The reason the accelerator pump is incorporated into modern carburetors is that as the accelerator is pressed and more air/fuel mixture is drawn into the cylinders, some of the liquid particles in the blend tend to stick to the walls of the intake manifold, effectively leaning out the mixture by the time it reaches the combustion chambers. The extra squirt of fuel that's added by the accelerator pump makes up for this initial lean condition.

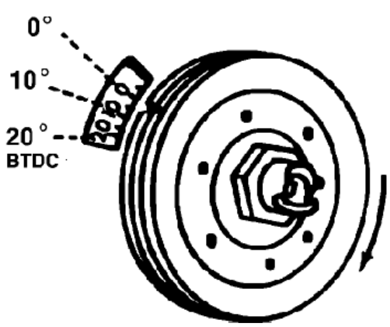
In order to adapt your accelerator pump to use alcohol effectively, you'll probably have to enlarge the size of the injection orifice slightly (anywhere from 10 to 25% is fine ... if you go larger than that, you'll risk the possibility of altering the pump pressure enough either to turn the fuel stream into a dribble or to empty the pump reservoir before the pump has made a full stroke).

As an alternative to enlarging the hole, you may be able to simply adjust the stroke length of the pump arm in order to feed more fuel. Most carburetors installed on Ford products already have a provision for seasonal adjustment, so it's just a matter of putting the pump on its richest setting. Other carburetors, too, have threaded rods that can be adjusted to accomplish the same thing.

CHOKE ALTERATION

Although it's not absolutely necessary to adapt your car's choke system to burn alcohol fuel, it has been our experience that a manually operated choke is more desirable on an alcohol-powered car. If your vehicle's engine is already so equipped, fine. If not, you can purchase - for about $7.00 from any auto parts store - a manual choke conversion kit that will allow virtually any automatic choke to be adapted for manual control.

IGNITION TIMING



In order to take advantage of the great antiknock qualities that alcohol fuel provides, you'll have to advance the engine's ignition timing by turning the distributor housing opposite to the direction in which the rotor spins (the housing is held in place by a bolted clamp).

Normally, an engine using gasoline has its timing set so the spark occurs at anywhere from 8 deg BTDC (Before Top Dead Center) to TDC (Top Dead Center). Since alcohol has a higher "octane" rating, you can advance the timing considerably more than this. (In the case of MOTHER's truck, we adjusted it to operate at approximately 22 deg BTDC without any sign of pre-ignition, even under load.) Of course, care should be taken when you adjust the timing on your vehicle, since a 22 deg advance might be excessive for your car. Remember, it's not safe to be just short of detonation, since inaudible knocking can also damage the engine ... the best procedure is to set the distributor timing at least two degrees retarded from the point of detonation.

COMPRESSION RATIO CHANGES

Increasing the compression ratio of the engine will be impractical for most people, because of the expense and work involved ... however, this modification will do a great deal to improve engine performance and economy. Just like a timing advance, a compression ratio hike will take advantage of the potential that alcohol has to offer as a fuel. Optimally, the ratio can be increased to 14- or 15-to-1 ... but even a nominal increase - to perhaps 12-to-1, a figure that some manufacturers have already offered in the past for premium gasoline use - will result in a vast improvement over the standard 8- or 8.5-to-1 that most manufacturers incorporate into their engines today.

If you intend to convert an automobile that already has a compression ratio of 10-to-1 or better, it probably won't pay to make any internal changes. However, if the engine you're considering needs an overhaul, it would be wise to modify it regardless of its compression ratio.

The most inexpensive way to increase your compression ratio is to install a set of high compression pistons. The forged units are designed to pack the air/fuel charge tightly into the combustion chamber for increased power, and have special relief notches built into their heads for valve clearance. Be cautioned, however, that some engines may not tolerate a 15-to-1 compression ratio with standard connecting rods and bearings ... these components, too, may have to be replaced with high-strength competition grade parts.

Another way of increasing compression ratio slightly is by "milling" (planing) the surfaces of the cylinder head and/or block. With some engines, this may result in only a 1/2-point ratio increase ... with others, slightly more. It would be best to check with your local engine rebuilder or automotive machine shop to determine exactly what you'll gain with your particular model engine before you go to the trouble of dismantling it.

A third - and perhaps the most versatile - way of effectively increasing the compression ratio is by installing a supercharger or turbocharger. These units, although ranging in price from $800 to over $1,200, provide a pressure boost in the combustion chamber proportional to the engine's RPM. Hence, compression would not be excessive during engine start-up as it would be with the other methods.

You should encounter no problem with a severe compression ratio increase, unless you decide to switch back to gasoline fuel ... and in this case, you could install a water injection system that would allow you to operate the car even on regular fuel without fear of detonation.

FUEL PREHEATING

In extremely cold climates, it may be necessary to preheat your alcohol fuel before it enters the carburetor float bowl. This can be accomplished easily by splicing into the fuel feed line - near the point where it passes the upper radiator hose - and installing a fuel heater at this location.

You can fabricate a fuel heater in a matter of minutes by first locating a 5" section of copper or other metal pipe with an outside diameter equal to that of the inner diameter of your upper radiator hose. Then find several feet of soft copper tubing that will slip snugly inside your fuel feed line. (If your fuel line is steel, you'll have to cut it and splice in two short sections of the appropriately sized neoprene hose.) Wrap the soft tubing several times around the middle of the large pipe section (the number of coils depends on how warm you want the fuel to become, but anything from three to eight wraps will suffice), and solder it in position if possible.

To install the unit, just clamp it in place between the existing radiator hose and another short section of hose connected to the radiator neck, and attach the fuel line to the inlet and outlet of the copper coil. As the engine reaches operating temperature, the hot water flowing through the engine's cooling system will heat the coils and the fuel passing through them.

AIR PREHEATING

Most trucks and autos have air filter housings which are designed to allow heated air from around the exhaust manifold to channel through a duct and enter the carburetor when the engine first starts from a cold state. As the engine warms up, a flap within the air cleaner "snorkel" shuts off this supply of warm air and allows ambient air from the engine compartment to enter in its stead.

This flap is usually either thermostatically or vacuum controlled ... but either way, you may find it helpful during the winter months to leave this valve closed to the cold outside air. This can be done either by disconnecting the bimetallic thermostat spring that controls the flap and installing a small spring of your own that will hold the valve in the required position, or - if the flap is vacuum activated - by connecting an existing permanent vacuum line to its control fitting. (You can, of course, remove the control line entirely, plug it up, and hold the flap closed with a spring if you wish.)

THERMOSTAT CHANGE

In order to get maximum efficiency from your engine, you may need to change the thermostat within the engine block. Thermostats are available in various heat ranges from 140 to 200 deg F, and these temperatures indicate how hot the engine coolant will be allowed to get before the thermostat opens to initiate the cooling process. (A thermostat is designed to hold the coolant within the cylinder head till it achieves the desired temperature ... at which point the heated liquid is allowed to escape into the radiator to be cooled, and is replaced by a fresh supply of cool fluid. Depending on the engine's operating conditions, the thermostat may cycle open and shut regularly over the span of a few minutes.)

If the water in your vehicle isn't getting warm enough to provide hot air through the heating system, you should replace the thermostat with a higher-rated unit. By the same token, the intake manifold of your engine should be warm to the touch when burning alcohol. If it's cold - or iced over - the alcohol most likely isn't being given a chance to vaporize sufficiently, and therefore is not being used efficiently. By using a hotter thermostat, you'll be able to warm up the entire engine, including the intake manifold.

COLD WEATHER STARTING

Since alcohol doesn't vaporize as easily as does gasoline, cold weather starting can be a problem ... especially if the engine itself is cold. To alleviate this undesirable situation, MOTHER's research staff has designed a combination cold-start/dual-fuel system that'll work with any car.

All it requires is a five-gallon fuel storage tank with a fuel filler neck brazed into its top (we used an old propane bottle), an auxiliary electric fuel pump, some steel brake or fuel line, neoprene hose, an elbow, a length of copper pipe, a small metering jet, and several needle valves, tees, and hose barbs. (Details and illustrations of the installation are shown in the article reprints from MOTHER NOS. 59 and 60, which are included in this workbook.)

The five-gallon tank is mounted in some safe place on the truck or automobile and used to store gasoline. This cache of petroleum fuel serves a dual role: When it's needed for cold starting purposes, the electric pump is activated momentarily from inside the car and a fine stream of gasoline is injected down the throat of the carburetor. And, in the event that your alcohol supply is unexpectedly depleted on the highway, the gasoline stored in the small tank can be routed into the carburetor normally for emergency use.

INITIAL USE OF ALCOHOL FUEL

An engine altered as outlined in this chapter will run well on alcohol. Nonetheless, there are certain things to be aware of as you begin to make use of the new fuel. First, remember that the alcohol will act as a cleansing agent ... and - as such - will not only clean out your tank, fuel lines, and filters, but will also purge your engine's internal parts of built-up carbon, gum, and varnish deposits.

In effect, what this means is that suddenly a lot of filth will be floating around in your fuel ... and it may be enough to clog your fuel filter to the point of not allowing any fuel to pass. By the same token, loosened internal engine deposits can foul the spark plugs badly ... so if your vehicle begins to function poorly soon after your conversion, check these two areas first.

In addition to the fact that alcohol is a cleaning agent, it is also a solvent ... and this means that certain types of plastics used in the fuel system of your vehicle may be attacked by it. Actually, most of the plastics deterioration problems associated with ethanol fuel are caused by the substances used to denature it - such as acetone or methyl ethyl ketone - rather than the alcohol itself. If you manufacture your own alcohol and denature it with gasoline, as federal regulations now permit, deterioration problems will be reduced to a minimum.

Most vehicles manufactured prior to 1970 used stainless steel or brass components in their fuel systems ... hence there is little chance of parts failure. In cars that use plastic components, however, there are several areas of potential deterioration: [1] Within the fuel tank, both the float and the strainer on the fuel intake tube may be plastic ... replace them if necessary. [2] The fuel lines themselves - if they are the clear, flexible type - may also soften ... you can install neoprene hose in their place. [3] The fuel pump diaphragm may also be subject to failure ... either replace it with a piece of spring steel, or replace the entire pump with an electric gear-type model available from your auto parts store. (Jaguars and Alfa-Romeos also use all-metallic pumps if you're willing to pay the price.) [4] Plastic in-line fuel filters should be replaced with metal ones. [5] Many modern carburetors use plastic float needles, seals, and floats ... you can usually purchase the equivalent carburetors - but ten years older - from an auto wrecking yard for about $5.00. These should contain metal components, and can be salvaged for parts.

Of course, not all plastics are subject to corrosion, and neither are all types of rubber. Generally, butyl rubber (like the type used in inner tubes) should be avoided. Neoprene, however, holds up well even at higher temperatures, and might only present a problem (because of swelling) if it's used as a tip on carburetor float needles. Automotive plastics vary greatly in their composition ... the table below indicates the performance of various types of plastic substances.

One final thing to be aware of when burning alcohol in your vehicle is that the new fuel does not contain the additives which the engine has become used to over the years ... specifically the leads which help to lubricate the valve seats. Of course, any car built in 1975 or later is already equipped with hardened valves and seats, so there should be no problem with them ... but even vehicles of other years (with the possible exception of large-block 1972-1974 Ford products) can tolerate alcohol fuel safely.

One reason for this is that water in the alcohol acts as a "cushion" and lubricant for the valves ... but if you are still wary of using alcohol fuel in its pure form, you can add up to 1% kerosene or diesel fuel to your alcohol supply. This will provide the lubrication of petroleum fuels with a minimum of pollution.

Part 2 - Injected Gasoline Engines

Since some vehicles are equipped with fuel injection rather than carburetors, we will briefly touch on the use of alcohol with that system. There are two important factors in a fuel injection setup: injection timing and control jet diameter. Fortunately - since many systems now use an electronically controlled timing sequence - injection timing is not critical in a fuel injected engine. Neither performance nor economy improve substantially by either advancing or retarding the injection timing process.

Control jet diameter, on the other hand, is an important factor. If you increase the size of the control jets (which are the equivalent of the metering jets in a carburetor), the engine will operate well on alcohol fuel. An increase of 15-20% is all that's necessary to accomplish the conversion. (Ignition timing should, of course, be advanced as explained previously.)

An interesting feature of the fuel injection system is that it doesn't require any gasoline during the cold weather starting process to fire the engine up. Since the fuel is injected at a pressure of about 250 PSI, the alcohol fuel is sufficiently vaporized to ignite easily within the combustion chamber.

Any additional changes if needed should be done as described in the Carbureted Engines Area.

Part 3 - Diesel Engines

Because of the fact that diesel engines do not use conventional spark ignition systems, it's difficult for pure alcohol to ignite within the combustion chamber. This, coupled with the fact that diesel injector pumps won't tolerate water, could be a problem ... especially if the alcohol used was not nearly pure.

Fortunately, there are several other ways to utilize homemade ethanol in a diesel engine by introducing vaporized alcohol to the engine along with diesel fuel. Probably the simplest way is to mount an automobile carburetor right on the diesel's air intake manifold and supplement the diesel fuel with alcohol metered through that piece of equipment. Of course - just as in a conventional gasoline engine - as incoming air rushes down the air inlet tube, it will pick up alcohol vapor metered through the carburetor ... which should have a controllable throttle to match tractor load.

Another way to use ethanol in a diesel engine is to install fuel injectors into the intake manifold to accomplish the same result. This system would require a separate pump that would have to be timed in order to inject alcohol at the proper moment.

A vaporizer - like those found on propane fuel systems - can also be used to add alcohol to the diesel fuel system. This, again, provides the diesel intake manifold with ethanol vapors that help combustion.

Since a diesel engine has closer tolerances and is more costly to repair than a conventional gasoline engine, you should take extreme care when altering and running diesel equipment on other than pure diesel fuel. If you don't consider yourself competent to work on diesels, find someone who is ... since the diesel fuel injector pump must be adjusted to provide less flow when alcohol fuel is used, plus the fact that a lean mixture condition - and even increased horsepower outputs - can damage a diesel engine in short order.

Turbocharged diesels can be equipped with what is known as an "aquahol" injection system, to be marketed by the M & W Gear Company of Gibson City, Illinois early in 1980. This setup injects a fine mist of alcohol and water in a 50/50 ratio directly into the engine's air intake, which results in a lowering of fuel consumption and a tolerable increase in horsepower.

DURABILITY OF VARIOUS PLASTICS: ALCOHOLS VS. GASOLINE

	Ethanol	Methanol	Gasoline
Conventional Polyethylene	good	excellent	poor
High-density Polyethylene	excellent	excellent	good
Teflon	excellent	excellent	excellent
Tefzel	excellent	excellent	excellent
Polypropylene	good	excellent	fair
Polymethylpentene	good	excellent	fair
Polycarbonate	good	fair	fair
Polyvinyl Chloride	good	fair	poor

Excellent: Will tolerate years of exposure.

Fair: Some signs of deterioration after one week of exposure.

Good: No damage after 30 days of exposure, should tolerate several years of exposure.

Poor: Deteriorates readily.

NOTE: All tests were made with liquids at 122 deg F

Part 4 - The Success Story

Suffolk, United Kingdom - July 28, 2004

The description might sound like a bad joke, but the DM139 LMP1, Judd V10 is fast and black and "green" all over. So fast, in fact, that the Nasamax racing team placed 17th out of 26 cars to finish at this year's Le Mans 24 hour race with the DM139, which runs entirely on bio-ethanol fuel. It was the second year the team qualified for international motor sport race, but the first year the drivers took it to the line to become the first team to place with a car run on alternative fuels.

"It's very interesting out there. There are people flying off all over the place, perhaps a few who are new to Le Mans," night driver Werner Lupberger said.

The Kent, England based team has a core of experienced scientific and racing personnel who belong to an international racing program designed to promote low-emission renewable fuels. Motor sport racing is a big industry and a big fuel consumer, and not what many people think of as environmentally friendly.

Development partners for the green fuel venture are Applied Sciences Technologies (ASTEK) and Cosworth Racing. ASTEK is a research and development company that specializes in renewable and sustainable technologies. They have developed technology for the use of alternative fuels in internal combustion engines, and methods for the production of bio-ethanol from cellulosic materials. Fuel for the DM139 engine is made from sugar beets and potatoes grown in Northern France.

Cosworth Racing is a division of the Ford Motor Company, and they designed, developed and manufactured the XDE engine used by the Nasamax team. They are renowned for their Formula One engine development for teams such as Jaguar and Jordan as well as for the WRC Rally program.

"This is the first time for years Cosworth Racing has been involved on a factory support basis in sports cars. It also marks the first time we have used renewable fuel, bio-ethanol, in a racing engine and it is very exciting to be spearheading this technology," said Nick Hayes, Managing Director for Engineering at Cosworth Racing.

Cars that qualify for the LeMans have to meet race regulations, so the Nasamax team had to work on ways to meet the regulations while ensuring the DM139 could compete with the other cars in terms of tank capacity and fill rate during refueling. Bioethanol fuel contains only 75 percent of the energy of the same volume in gasoline, so the car needed 135 liters of tank capacity to carry more of their 200 proof fuel than a standard racecar.

Information on the team's Web site used a comparison of coffee and espresso to explain why a greater volume of ethanol (coffee) is necessary to run the DM139 for the same amount of time as a car run with fossil fuels (espresso). An espresso carries a certain amount of caffeine in a small quantity of drink, while regular coffee will carry the same amount of caffeine but in a greater quantity of the drink. If caffeine intake were the goal, then a person would need to drink more coffee than espresso. If fuel combustion is the goal, then a driver needs more ethanol because the efficient fuel burns up faster than fossil fuels.

Engine performance with ethanol was everything the team could have asked for, but regular racing setbacks kept the car from moving up any higher in the race ranks. Regular tire changes, a starter replacement and a persistent misfire made the team lose laps.

"We lost time trying to find the misfire and eventually we had to just get on with it," McNeil said. "It's frustrating as we know what lap time we could have had, and we know it would have put us safely in the top ten, even the top six. However, these were the usual setbacks any car could have in racing, and we have still shown that this fuel can be competitive in the top level of international motor sport. To do so with a new racing car to completely new regulations is also a major achievement for the whole team. We will be back next year."

The three drivers completed a total of 316 laps around the 8-mile race circuit at Le Mans. McNeil estimated they lost about 41 laps to pit stops for the misfire. Le Mans takes place every year in the Sarthe region south west of Paris, and has always been a showcase for the debut of new technologies in the harshest competitive environment in motor sport. The 8-mile circuit is a mix of permanent track and roads.

Information for this story courtesy of Nasamax public relations