Alcohol Fuel – For Golf Course Use

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DWINDLING FUEL supplies are now a reality. No longer can we order fuel and expect it to be delivered upon request, and the future holds no promise of an easy solution to this dilemma. The only sure fact is that in order to survive we must develop economical fuel sources or cease to exist at our present level. Personally, we enjoy our present status and wish to maintain the existence we have come to know.

In 1979, we went without fuel several times and our golf course operations suffered. We decided that the best way to overcome this problem was to manufacture our own fuel. While there is nothing new about this idea, it was new to us, and we began investigating the prospect of producing fuel for golf course use. Our objective is to develop a renewable and economical source of fuel for our golf course maintenance vehicles. Gasoline is no longer cheap or plentiful, and worst of all, future supplies cannot be guaranteed. There is, however, a clean, efficient fuel which can be used in existing gasoline engines. This fuel is ethanol, or grain alcohol. Unlike gasoline, we need never run short of ethanol because we can manufacture it from corn, potatoes, beets, apples, or most any vegetable or small grain crop that we can grow on our own land.

Ethanol has other advantages over gasoline, too. While both fuels are similar in horsepower ratings and mileage tests, ethyl alcohol burns cleaner than gas because it contains no nitrogen, sulphur, or lead to pollute our atmosphere. The only emissions from ethanol-fired engines are water and carbon dioxide, and both are required for growth by living plants. Basically then, ethanol emissions return to the atmosphere to help grow the plants that make it possible to produce this fuel.

Another advantage of ethanol over gasoline is that while oil refineries have to find ways to dispose of toxic by-

Co-author Rob Coulter displays the equipment designed by the authors. The apparatus: left — cooling coil, center — still, and right — mash cooker. The still is a freon tank, the cooling coil is a section of 8" pipe and the mash cooker is a kitchen steam cooker.

products, the spent mash from ethanol production is a superior livestock feed for which there is a ready market. Due to the growth of yeasts which convert starches and sugars to alcohol fuel, the distillers dried grain solids (DDGS) which remain after the used mash is dried are much higher in protein and vitamins than the original feed grains. Livestock fed on DDGS gain 10 percent to 20 percent more weight than those fed on conventional grains.

Another advantage of ethanol fuel is its chemical stability. Unlike gasoline, ethyl alcohol does not break down, become gummy, or mix with lubricating oils, causing residues to build up in an engine. Nor will it explode like gasoline when ignited by a hot spark or flame.

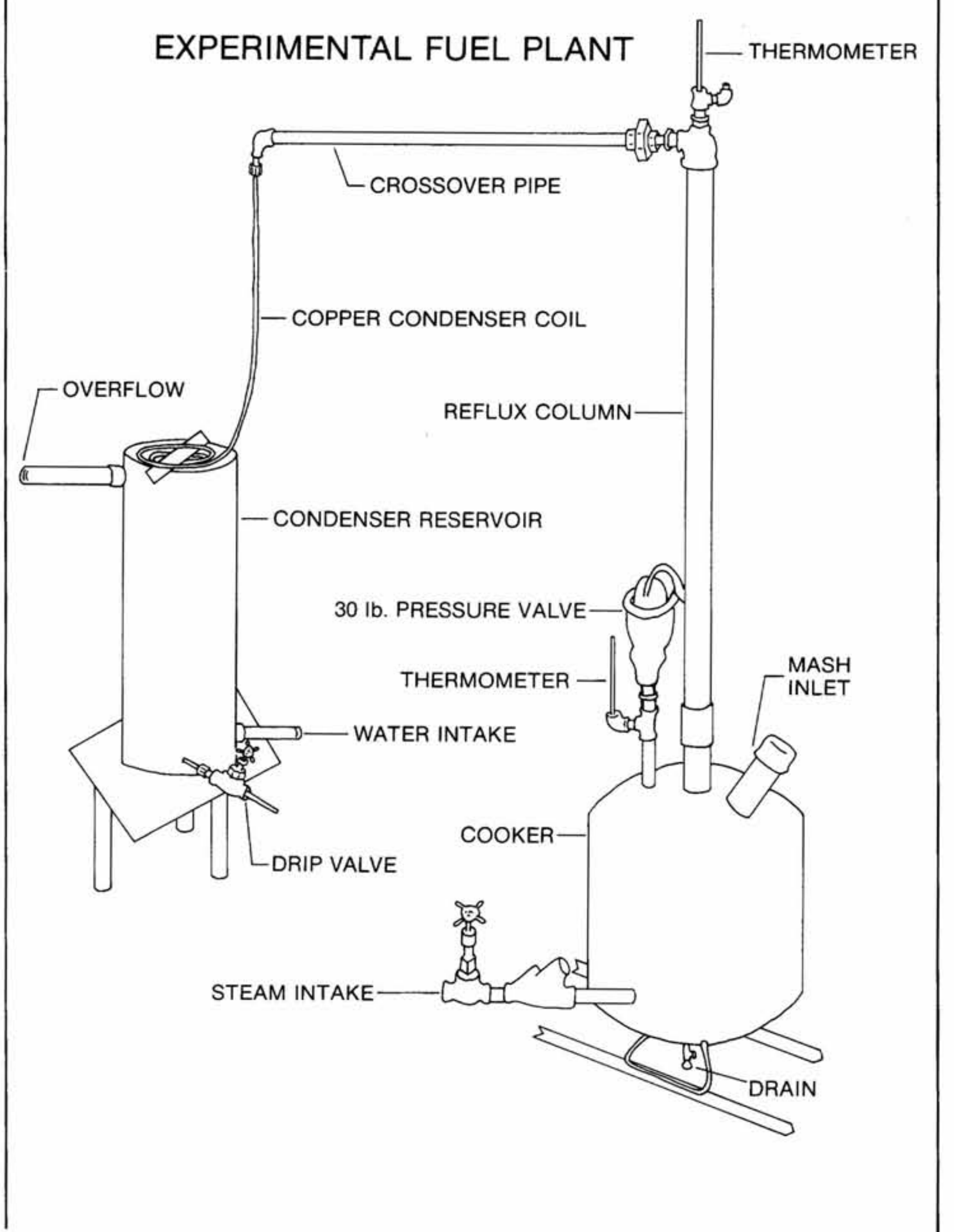
AT THIS POINT it is logical to ask, "If ethanol from farm crops is such a desirable, inexhaustible source of fuel, why has it not been developed more fully?" The answer lies in the economic trends of the past century. In the 1880s, Henry Ford designed the quadricycle, one of his first horseless carriages, to run on pure grain alcohol. A longtime proponent of farm-produced fuel, Ford even featured an adjustable carburetor in his Model T which could be converted to run on either gasoline or alcohol. During those early years of the automotive age, however, alcohol fuels were never commercially developed because of intense competition from gasoline, which was then refined from inexpensive domestic crude oil. Over the years, improved technology in gasoline refining and newly discovered oil reserves kept the price of gasoline relatively low, while very little was being done to improve on commercial alcohol fuel production. Ethanol as a fuel has been virtually ignored in the United States, with exception of the Depression years, the Second World War, and the race cars at the Indianapolis 500.

Although the technology of a modern ethanol plant can become rather complex, the process of converting food grains to fuel is well understood and consists of three basic steps: cooking the mash, fermenting the mash, and distilling the ethanol product.

Cooking the enzymes changes the plant starches to sugars. Fermentation is the process in which yeast microorganisms change protein residues in the spent mash. Distillation is the act of separating the 10 percent or so of alcohol in the mash to obtain a fuel alcohol that is 160 to 190 proof. We will discuss each of these steps and how we can perform them, using corn as an example.

The initial step, cooking the mash, serves the purpose of preparing the corn so that it may be utilized as food in the yeast phase. Yeasts multiply rapidly in a suitable medium, giving off ethanol as a toxic waste product which eventually kills them after the liquid reaches around 10 percent alcohol concentration. However, yeasts are able to feed only on simple sugars and cannot utilize the complex starch molecules of the corn grain unless they are broken down into their sugar components. This chemical breakdown is accomplished by cracking the corn kernels, cooking them in boiling water, and as the water cools, stirring in enzymes which convert the long starch chains to one- or two-molecule sugars. A pH adjustment is usually required for proper enzyme action. The early ethanol producers (moonshiners) obtained their enzymes naturally by malting or sprouting grain and then drying it before milling. This method was tedious and time-consuming. Today's enzymes cooking time for a batch of mash can be two hours or less.

ONCE THE MASH is cooked, and therefore all the corn starch is converted to sugar, the fermentation process begins. Fermentation is the process in which yeast feeds on sugars in the mash, giving off ethanol and carbon dioxide gas as end products of digestion, and leaving a high-protein residue in the mash. For the yeast to grow best, the



mash should be in an anaerobic environment at a temperature of 80° to 90° Fahrenheit and should contain no more than 20 percent sugar (over 20 percent sugar will kill the yeast). Baker's or brewer's yeast is used for ethanol production. Under ideal conditions, 80° to 90° F. with agitation, the yeast will work its magic in two and a half days. As long as a week may be required for the yeasts to use up all the sugar in the mash in a less than ideal environment.

If the batch was properly proportioned and fermentation is complete, a hydrometer reading will indicate that the mash contains at least 8 percent to 10 percent alcohol. The mash at this stage is ready for the final step in becoming ethanol fuel, which is distillation. Some day a superior method for refining alcohol fuel may be discovered, but at present, distillation remains the most effective technique for concentrating the alcohol in the mash to obtain a useful fuel product.

Basically, the distillation process takes advantage of the difference in the boiling point of ethanol (173° F. at sea level) and that of water (212° F. at sea level). Heating the mash by fermentation to a temperature between these boiling points vaporizes most of the alcohol along with some of the water. If this vapor is caught and condensed, the resulting liquid will contain a much higher concentration of ethanol than did the original mash. By re-distilling this product, an even more concentrated alcohol solution can be obtained, up to about 195 proof. However, because of a quirk in the chemistry of an alcohol-water mixture, completely pure 200 proof alcohol can never be obtained by simple distillation.

After study of the known technology of alcohol fuel plants, we constructed an experimental model for ethanol fuel production on a small scale. The batch-type apparatus we designed is capable of reducing no more than three gallons of mash to alcohol and water in one run. Even so, we are able to produce a quart or more of high-proof ethanol from each batch. The batching and cooking of the mash can be performed in ordinary cooking pots, and the fermentation vessels are simply five-gallon plastic pails with airtight lids which have been fitted with air locks for escape of carbon dioxide gas. One rather unusual feature of the distillation plant is the use of steam heat (5-10 pounds steam at about 300° F.) to vaporize the alcohol from the mash.

(Left to right, clockwise, starting at top) Enzyme, beaker, yeast, fermentation vessel, acid for pH adjustment, hydrometer, alcohol fuel, and temperature gauge.

WE HAVE PRODUCED alcohol from our experimental plant and have realized 160-proof alcohol. We are now testing this product in an old F 8 tractor. It works, but as yet we don't have it refined to the point of using it every day.

We have found that the cost of producing alcohol from corn is about $1.23 per gallon. As the price of gasoline has stabilized recently and supply now is no problem, I do not remmend manufacturing alcohol at this time. If we are faced with another round of increasing prices in gasoline and the price rises to above $1.40 per gallon, then the production of alcohol for golf course use will become attractive. We are continuing our experiments and will be ready to produce our fuel if economics or supply so dictate.

One word of caution: You must have a permit from the U.S. Department of The Treasury, Bureau of Alcohol, Tobacco, and Firearms and your state department of agriculture, before you produce alcohol. The reason — alcohol for fuel is also alcohol for consumption, and without a permit, that is moonshining — and moonshiners tend to get harrassed.

If, in light of the preceding information, you feel the urge to experiment on your own with alky fuel systems, there are a number of informed research organizations and publications available to help you. One of the largest and best organized groups is the National Alcohol Fuel Producers Association, an information exchange network between educators, researchers, fabricators, and alcohol fuel producers. The mailing address is NAFPA Headquarters, 1700 S. 24th Street, P.O. Box 2756, Lincoln, Nebraska 68502. Membership is $75 per annum, but is well worth the price to someone who is seriously interested in alcohol fuel production. Another information clearinghouse in the National Gasohol Commission, Suite 5, 521 S. 14th Street, Lincoln, Nebraska 68508. Several states, including Virginia, are full members of the Commission, and on request, you may obtain a list of members from your particular areas serving on the Board of Directors. The Commission also answers inquiries to specific questions and will send the price list for a fairly complete selection of the published literature on fuel alcohol production.

A NUMBER OF other groups have become involved in fuel alcohol research, notably *The Mother Earth News*, Hendersonville, North Carolina. Starting with a series of magazine articles, *The Mother Earth News* staff has gone on to develop an alky-fueled road show which conducts a series of one-day seminars all over the eastern U.S. There are many other good journals, books, and institutes, too numerous to mention here, which have sprung up that may be more appropriate to your particular needs. The point is, information and the technology to make alcohol fuel a reality are already available. The technology on which we now depend so heavily for golf course maintenance requires a dependable, economical liquid fuel. Perhaps for some in the golf industry, alcohol fuel will eventually become an appropriate alternative to gasoline for meeting our liquid fuel needs.