PART 2

AVGAS VS. MOGAS IN LIGHT-SPORT AIRCRAFT

Downsides and upsides

BY CAROL AND BRIAN CARPENTER

LAST MONTH IN PART 1 of this article, we looked primarily at the downsides of using 100LL fuel. In this article, we will look a bit more in-depth about the use of auto fuel or mogas as it is often referred to.

We identified in the previous article that Rotax allows the use of avgas as well as mogas. However, it was clear that in all the service bulletin and maintenance manual information available from Rotax, there were significant concerns and operating recommendations to mitigate the negative side effects when using highly leaded aviation fuels such as 100LL. Working with the premise that Rotax favors the use of mogas over avgas begs the question: Why would we not always use mogas in our Rotax engines? Well, that's exactly what we're going to address in this article.

Methanol and ethanol are the two most common alcohols used in automotive fuel today. And like the bigger topic of avgas versus mogas, there are upsides and downsides to their use. First the upsides. Both of these alcohols have a relatively high octane rating, approximately 109 RON (research octane number) and 90 MON (motor octane number), which equates to approximately 99 AKI (anti-knock index). And due to their lower carbon-to-hydrogen ratios, these fuels have lower toxic emissions and improved engine efficiency.

Now for the downsides. Both fuels contain what are called halide ions. Halide ions are primarily responsible for the increased corrosivity of the fuels. Both from a direct chemical attack as well as increasing the conductivity of the fuels, which promotes increased galvanic and direct electrochemical attack. To make matters worse, ethanol is hygroscopic and readily attracts water from its surrounding environment. Whether you attribute the resulting corrosion primarily to the ethanol or the water is kind of a moot point when considering the final result.

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Figure 1 shows an example of corrosion within a Bing carburetor float bowl mounted on a Rotax 582. This condition is the result of only a few months of exposure to ethanol-based fuel. The oxidation of the brass caused the formation of deposits on most of the jet, but more significantly on the inside diameter of the main jet. This reduced the flow of fuel through the main jet. You can think of it as a partially clogged drainpipe reducing the flow of water in your sink drain. However, in this case, the reduced flow through the main jet caused a lean fuel-air mixture and subsequent seizure of the cylinder associated with this carburetor. (Figure 2) Regardless, it's safe to say that corrosion within your fuel system — whether it is in the fuel tank, fuel pump, fuel lines, or carburetor — is a high-risk bullet point that we would like to avoid. If you happen to have access to fuel without ethanol, consider

Figure 1

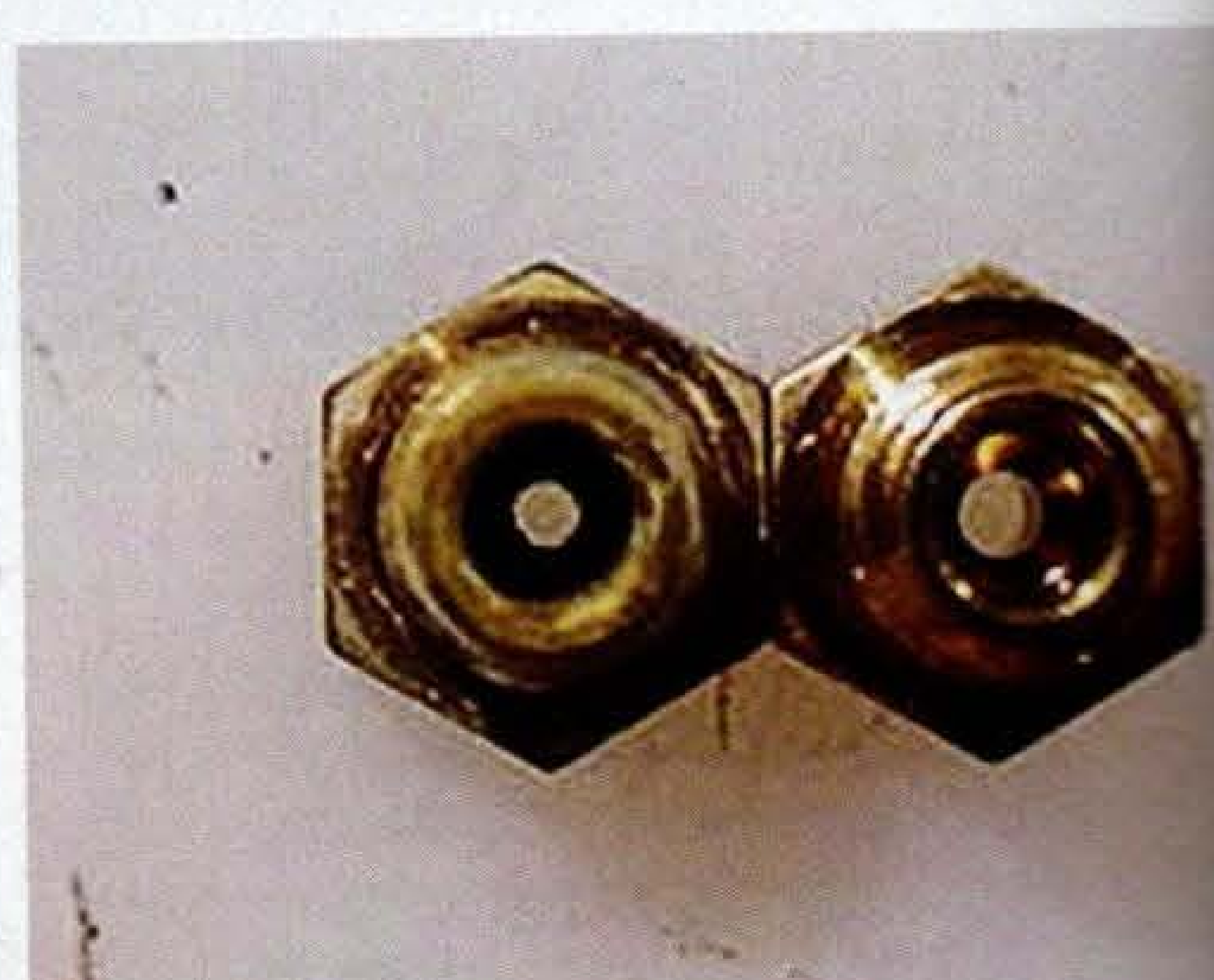

Figure 2: *Restricted jet on left, normal jet on right.*

yourself fortunate. Many operators of light-sport aircraft (LSA) are not so lucky. If you're having trouble finding non-ethanol fuel, check out *www.Pure-Gas.org*. Out of the 14,000 stations listed, only 20 show up for the entire state of California. Our little town of Corning is one of the lucky ones. When E10 first became the new normal, the Rotax engines were only authorized to use a maximum of 5 percent ethanol. It took Rotax many years to accept the new 10 percent ethanol standard, which it now authorizes in its maintenance manual. We only bring this up because, in recent months, we have seen the EPA fast-tracking modifications to legislation that would allow the use of E15 fuel to be sold year-round without any additional modifications to the Reid vapor pressure (RVP) requirements. It will be interesting to see how Rotax addresses the E15 fuel.

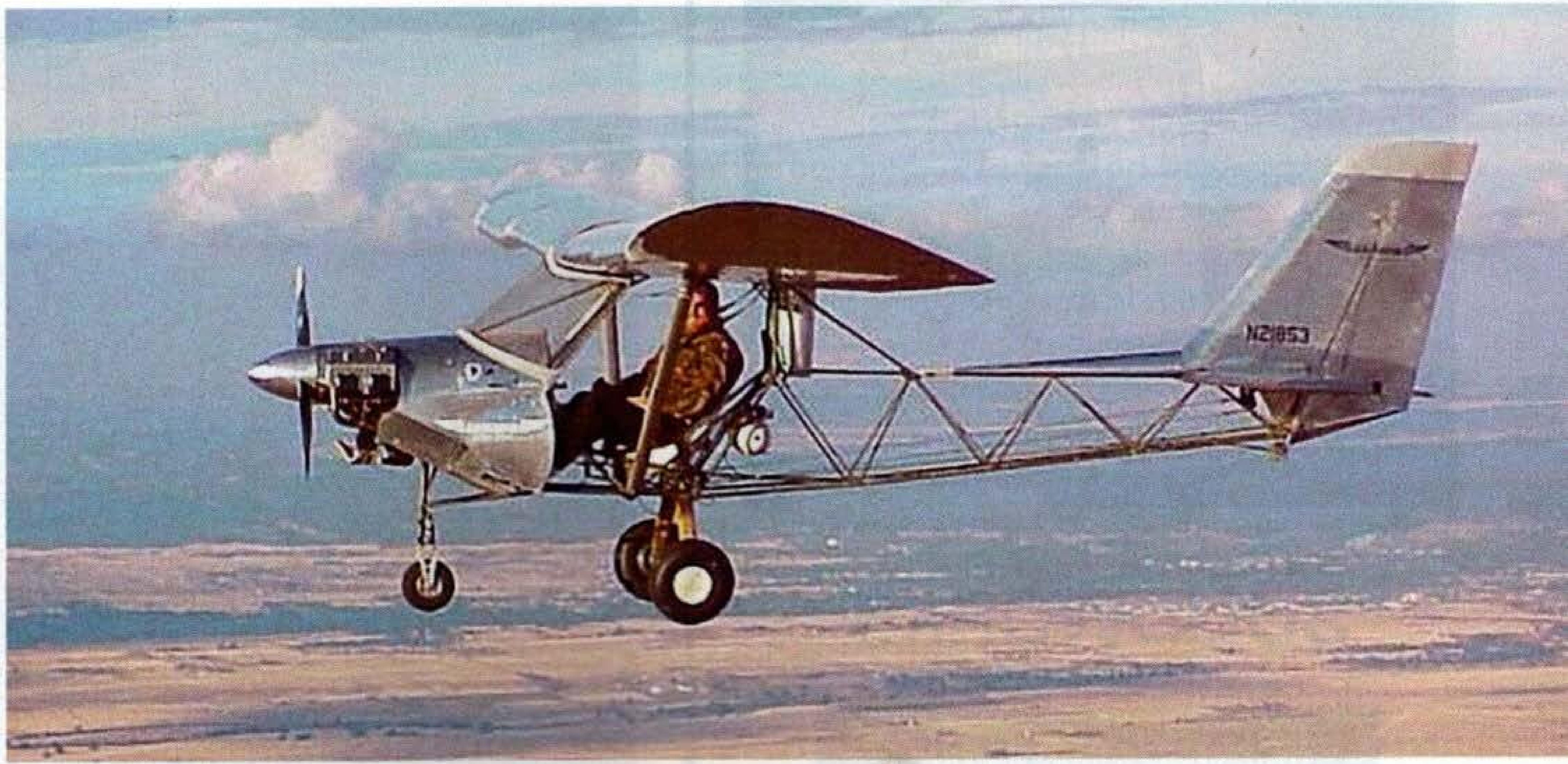

Figure 3: *A one-off airplane called the Ranger, designed and built by Brian Carpenter circa 1995.*

Both ethanol and the aromatic hydrocarbons that are in gasoline (such as benzene, toluene, and xylene) have shown to be incompatible with some polymers. Many of these aromatic hydrocarbons have been shown to react with a variety of polymers, causing swelling and in many cases breaking down the carbon-carbon bonds in the polymer that reduces its tensile strength. When we say polymers, we are talking about a wide variety of materials. However, for our purposes, it's primarily parts that are rubber and plastic within our fuel system as well the resins and epoxies used in composite structures. We had a great example of how these compounds affected rubber when we switched from 100LL to auto fuel in the Ranger aircraft. (Figure 3) The aircraft sat for nearly a month after the first introduction to auto fuel. When we were preparing to fly the aircraft again after this period of inactivity, we found that rubber on the fuel caps had swollen up so much that it was nearly impossible to remove them. After switching back to 100LL, the rubber returned to its natural state, and was there ever after, functioning as designed. In the early days of the auto fuel STCs, many aircraft we worked on experienced the same type of problems, but on a much more intense level. We often used to joke that the added maintenance costs would typically exceed the fuel savings for at least the first year. However, once all the hoses, gaskets, O-rings, and general fuel system components had been converted to components that were compatible with auto fuel, the vast majority of problems began to dissipate. And ironically, the bulk of these problems were directly related to owners using ethanol-based fuels, which were never approved fuels per the STC.

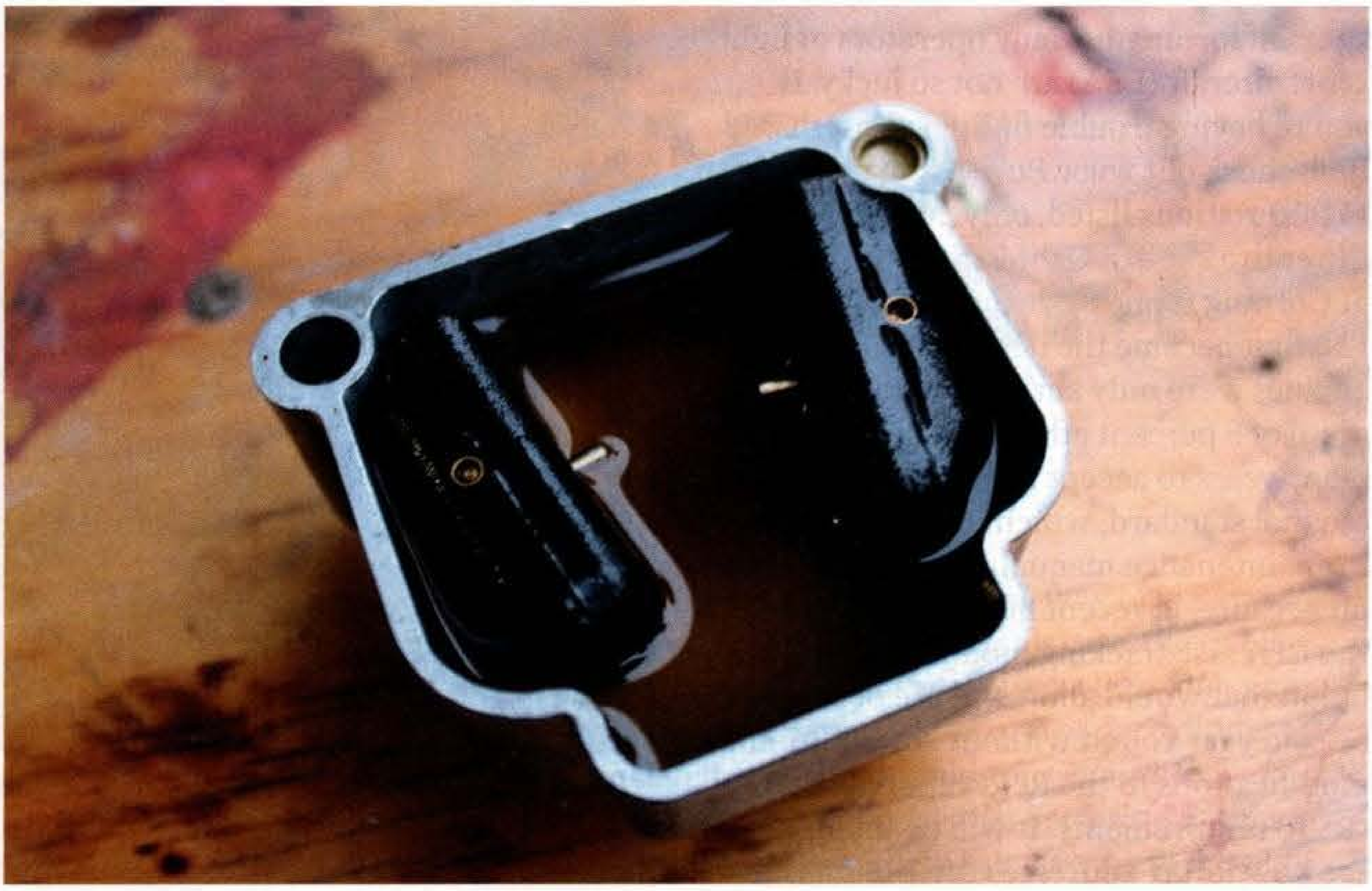

Figure 4

The one area that continues to haunt the LSA community is the use of auto fuel in conjunction with composite fuel tanks. Many of the older types of epoxy worked well with auto fuel up until the formulations changed and began to incorporate the use of ethanol and increased percentage of aromatics, even on the non-methanol containing fuel (E0). Oftentimes, it isn't obvious that there is a problem until several years have passed, and we start to see the results of the fuel degrading the composite structures. Manufacturers of new aircraft have started to take this to heart and are employing many new techniques to mitigate the effects of the new fuel formulations, including new types of epoxies and the use of fuel tank sealing compounds that are compatible with the myriad of chemical compounds found in modern fuels. Although new aircraft occasionally have problems, the vast majority of auto-fuel-related fuel tank problems relate back to the older aircraft. For many years now we've had a standard recommendation that if you have a composite fuel tank or, more importantly, a composite aircraft with a "wet wing," you should avoid auto fuel unless the manufacturer specifically authorizes its use. Figure 4 shows the float bowl off of a Rotax 912 where the fuel tank epoxy is reverting from a solid to a liquid state, then coating, sticking, and gumming up the fuel filter, fuel pump, fuel valves, and the carburetor. Who knows what kind of damage could have been done to the engine itself if it were able to run with fuel contamination of this severity. Even after flushing the fuel tanks several times and reverting to 100LL, the carburetors continued to need disassembly and cleaning several different times over the course of a month because of what was obviously contamination from the original epoxy problem. The other area that is really hard to pin down is the myriad of magic potion additives that owners experiment with. We are often suspicious when we see one-off problems that are related to the fuel system, especially when we know the aircraft owner has been watching way too many late-night infomercials. When you decide to take on the role of a chemist, who knows what you might end up with when combining all those different chemicals together. Remember, if the engine and airframe manufacturer does not recommend your favorite additive, you are now part of the research and development team for this particular product on your particular aircraft and engine.

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As a final thought about automotive fuel, we need to talk about its relatively short shelf life. Unlike aviation fuel, auto fuel may have a shelf life anywhere from 90 days to a year from the date of its blending. A great deal of this variable is dependent upon how the fuel is stored. Because aircraft fuel tanks are vented, they are exposed to the atmosphere allowing many of the different compounds within the fuel to evaporate or degrade. As the gasoline ages, it will become less volatile, making it harder to start the engine. More importantly, it may lose octane, which is our protection against detonation within the engine. This is where the proponents of fuel stabilizers begin their sales pitch. Although we are not against the use of fuel stabilizers, this falls under the category of additives, so we will almost always defer to the engine and airframe manufacturers for suitability. The general rule that seems to have permeated the LSA industry is that auto fuel has a reliable shelf life of about 30 days. One of the reasons for this relatively conservative number is all of the unknown variables that come into play that you have no control over, especially what has happened to the fuel between the blending and the time that you pump it into your airplane. Therefore, we typically buy from gas stations that are right on the freeway with relatively high turnover in fuel sales. Buying fuel from a mom-and-pop operation that has not bought a fuel load in six months puts you at a distinct disadvantage to start with. Interestingly, the statistics on premium gas is that it is only about 5 percent of total gas sales. This means that the premium fuel will have been sitting in the ground for a considerably longer period than the fuel that comes out of the regular pump. Also, gasoline that has been stored for a considerable period turns into a varnish-like substance that coats the internal components of a carburetor. Out of the hundreds of carburetors that we have torn down for troubleshooting, repair, or rebuild, the one universal characteristic seems to be varnish buildup that needs to be addressed. If you are using auto gas and don't fly often, it's essential you have a simple, easy, reliable, and safe way to remove fuel from your aircraft and get it into your car. This being said, the best way to remove gas from your airplane is to fly on a regular basis. It is also one of the best things you can do for your aircraft as a preventive maintenance item. And yes, if you need a note for your spouse explaining the necessity for this frequent flying on the basis of safety, we would be happy to provide that.

In Part 1 of this article, we talked about some of the pros and cons of the use of avgas. In this article, Part 2, we have addressed the same regarding auto fuel. In the next article, Part 3, we will tie this all together to give you some recommendations on what type of fuel you should be using and how to mitigate any of the downsides associated with each type of fuel. *EAA*

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