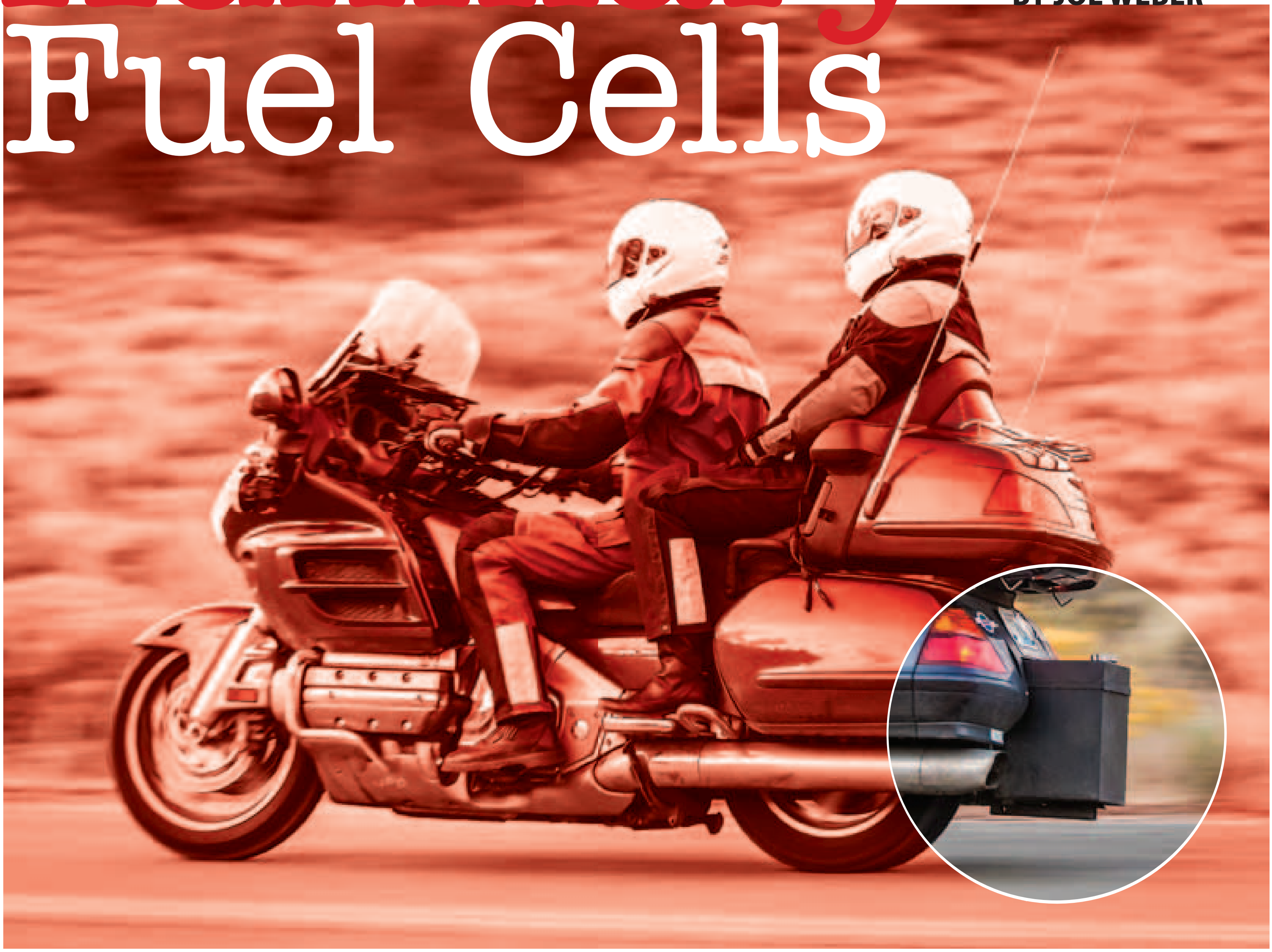
Auxiliary Fuel Cells

BY JOE WEBER



We can often find what we want without ever leaving our home, even having what we seek delivered right to our door. For the most part, searching for parts and accessories no longer requires a trip to town or visiting a retailer or specialty shop. However, finding a custom-made auxiliary fuel cell for our long-distance bike is not one of those things.

It's A Process

After an exhaustive search of the available options, I accepted the premise, "if you want something done right, do it yourself," and set out on my quest to design and build my own auxiliary fuel tank. Like all great odysseys, I set out knowing what treasure I hoped to find, but had only a general idea of what course to plot. My first functional fuel tank was akin to a waypoint as I continued to make improvements to each successive fuel cell project. Three designs and ten tanks later, I still haven't reached the end. The goal now is to take what I've learned and apply it to developing a tank that will fit several different motorcycles.

There is no map for making a fuel cell or list of ten easy steps to follow, in part because the solutions are so varied and so specific to the bike and owner they are designed to fit. Even though the destinations may seem disparate, the waypoints are often the same. Sharing my experiences might help someone more easily navigate their own course.

Learning Curve

A word about terminology: In auto racing, gas tanks are referred to as "fuel cells." If you shop for an off-the-shelf solution to a fuel storage device for your bike, fuel cells designed for auto racing are an inexpensive option. However, if you are looking for assistance fabricating one, you may want to use the term "gas tank" or "fuel tank." Calling a fabrication shop and asking to have "fuel cell" made might lead to confusion as the person you're speaking to will likely think you are talking about

1400 MILES ON A TANKFUL

This GoldWing must be the ultimate tourer — it carries 37.3 gallons of fuel and even has an on-board toilet!

BY ANDY FORD

THEY say everything is bigger in Texas – and this GoldWing super-tourer with its huge 37.3-gallon fuel capacity is the best proof there is.

Touring fanatic Morris Kruemcke fitted six extra petrol tanks to the 1500 Honda so he can spend all day in the saddle, covering up to 1400 miles after a single fill-up.

And so he doesn't even have to stop to answer the call of nature, Kruemcke has fitted his supertanker with an on-board toilet!

The furthest he has gone without filling up is 1200 miles from Montana to Kansas.

And he claims he's ridden 960 miles from his home in Houston, Texas, to Daytona Speedway in Florida – without putting his feet down!

Travelling salesman Kruemcke, 51, spent £5500 on the Wing and then fitted £2000 worth of extras.

■ KRUEMCKE: Touring nut

"I decided to make a touring bike to end all touring bikes. Now it's a real home from home," he said.

"I love touring and have ridden 1000 miles or more in a day 75 times. That's dead easy – the difficult thing is to do it without stopping."

Kruemcke has spent up to 17 hours in the GoldWing's saddle, so he's added creature comforts including:

■ An on-board toilet made of a plastic bottle and hosepipe. It fits between the tank and seat and drains out under the left-hand pannier.

■ A hands-free cellular phone.

■ Police radar detectors.

■ Triathlon bicycle-style handlebars so he can lean his weight on his elbows.

■ Ventilation tubes running from the fairing to the back and front of the seat to keep him cool in the saddle.

■ Racks for bottled water, Gatorade sport drink and food.

■ A scanner for monitoring speed-cop patrols' conversations.

■ A CB radio.

■ A full stereo system.

Kruemcke added: "The only guy who has ever beaten me in a long-distance event was a Brit – Steve Attwood in the Iron Butt Rally – but he's a hard guy. There's no rider in America who can beat me.

"I can keep going at a steady 60mph, monitoring police channels – and I don't have to stop.

"The relief-tube toilet sounds like a joke, but is important. If you are going to survive in the desert on hot days you need lots of liquid – and that liquid has to come out.

"I would never offend anyone by using it in traffic."

When Kruemcke stops to fill up he has to undo seven fuel caps. The extra tanks are:

■ 3.3 gallons in the right pannier.

■ 3.7 gallons in the left pannier.

■ 4.5 gallons on the right pillion footpeg.

■ 4.5 gallons on the left pillion footpeg.

■ 10.8 gallons on the pillion seat.

■ 4.9 gallons in the top box.

The standard fuel tank holds 5.6 gallons – making a total of 37.3 gallons or six times the standard fuel capacity.

He said: "When I pull away with full tanks the bike feels very wobbly and top-heavy. But on our long, straight roads and using the fuel which is carried the highest first, you soon forget about the weight."

'My bike is the tourer to end all tourers'

■ MILE-EATER: Non-stop touring is this Wing's forte – its 37.3-gallon tanks give it a 1400-mile range and an on-board toilet makes all-day riding possible

■ EASY RIDER: The Honda features triathalon-style bicycle bars for extra cruising comfort

■ TANKS A LOT! Kruemcke's GoldWing has six fuel tanks

As much as we loved Iron Butt Rally veteran Morris Kruemcke and his ability to push the limits on everything he touched, your fuel cell needs to be practical. Morris's nickname was the Exxon Valdez and we all know what happened to the Valdez!

PHOTO COURTESY OF DUCATI TORONTO

PHOTO BY DALE "WARCHILD" WILSON

a device that converts chemical energy into electrical energy. In any event and for purposes of this article, I will use the terms interchangeably.

Chances are this project will be much more difficult than you imagine. Inexperienced builders of auxiliary tanks are usually surprised by the complexity and cost of the undertaking. There are many subtleties of proper auxiliary tank design that are time consuming and expensive to learn by trial-and-error. Finding an experienced builder to work with is a good idea if you are new to auxiliary tank design.

Decisions, Decisions, Decisions

One of the first things to consider is where the tank will be mounted. A common mistake people make is first imagining the shape of the tank. It's easy to do because designing the shape is the fun part. People break out cardboard, cut foam into elaborate shapes, stare at photos of their bike and make drawings and doodles of tanks. Figuring out how to mount the masterpiece is often put off until later, but attaching the tank to the bike is a critical safety consideration and should not be an afterthought.

Keep in mind that increasing fuel capacity is a trade-off — something is gained and something is lost. Pertinent questions to ask yourself when starting might be, how will I pack my bike when traveling? What gear do I consider essential? Will I be traveling alone or with a passenger?

Let's consider two unique examples where luggage and passenger were unnecessary considerations. The first is a Ducati 1098 ridden by Gary Eagan who had Fuel Safe containers custom fitted and mounted in a pair of Multistrada saddlebags. The second is a Honda CBR1100XX Super Blackbird belonging to the IBA's Chief Technical Inspector, Dale "Warchild" Wilson. He used this bike on his Hell Week ride, when he did a Bun Burner Gold — 1500 miles in under 24 hours — seven days in a row.

Two important considerations in these examples were capacity and center of gravity. Luggage and passenger placed no limits on the design considerations. The desire to lower the center of gravity necessitated the use of auxiliary fuel pumps.

When weighing what is lost and what is gained, safety must always be considered. Motorcycles have a miniscule crumple zone when compared to other vehicles and all of that is either in the front or rear of the bike. By mounting the tanks on the sides, these riders have accepted a slightly greater risk of rupture in a side-impact crash. The addition of any tank is inherently less safe, so the degree of added risk is an important consideration. But I should point out that these kinds of tanks are not unsafe if properly designed.

When considering what could be jettisoned in favor of additional fuel, a passenger might be offended to make the list. Riding two-up with luggage leaves few options for auxiliary fuel tank placement. A "tail-dragger" or tank mounted behind the rear wheel seems to work for inseparable pairs.

This mounting option seems to be best suited for touring bikes for which trailer hitches are available. A trailer hitch frame provides an ideal mounting platform for a tail-dragger fuel cell because it is usually designed to distribute the "tongue weight" of a trailer over several locations. In addition, the weight of the extra fuel is low on the bike and even though it is behind the rear wheel, it tends to have little effect on the handling of

Auxiliary Fuel Cells

PHOTO BY TOM AUSTIN

heavier bikes, especially when carrying a passenger. Tail-draggers are more vulnerable to impact from the rear and, as with side-mounted fuel cells, the lower placement of this mounting option also necessitates the use of a fuel pump.

The most common placement of auxiliary fuel tanks seems to be directly behind the rider. There are a number of configurations, including replacing the rear seat with the fuel cell, mounting the fuel cell on top of the rear seat, or mounting it over the tail of the bike. Mounting a tank behind the rider often allows for a gravity-feed system that simplifies plumbing by eliminating the need for an auxiliary fuel pump. The design of the mounting brackets is also easier since a number of anchor points on the rear subframe or grab rails can be utilized. However, mounting auxiliary tanks on rear racks should generally be avoided because few racks are designed to carry that much weight. Structural failures of rear racks are a common problem when they are used to carry fuel cells.

When mounted above the pillion position, the auxiliary tank is exposed least to damage and less vulnerable than even the rider. On the other hand, the added weight of the fuel is high, thus raising the center of gravity, and possibly affecting the bike's handling, especially at low speeds. Internal baffling of

PHOTO BY TOM AUSTIN

fuel cells mounted in this location will reduce the effect of fuel sloshing. For adventure touring and sport touring bikes, it may be desirable to design the mounting system for easy removal of the tank when extended cruising range is not required.

Aesthetics are an important design consideration for many riders. In the following photo, Rich Beard was aiming for four gallons of volume when designing a tank for his Concours C14. This capacity was arrived at after carefully considering his personal riding style. Participants in competitive LD rallies might prefer to maximize volume as the Iron Butt Rally rules allow for a maximum capacity of 11.5 gallons of fuel, including the fuel contained in any filters or fuel lines between the fuel cell and the main tank. However, maximum fuel capacity typically comes at the expense of both aesthetics and handling performance.

PHOTO BY RICH BEARD

Design and Material Considerations

An important consideration not yet mentioned is cost. All design decisions such as material selection, shape and tank attachment affect cost. Whether you are relying on your own skills or the assistance of a fabrication shop, your options increase with the depth of understanding of various types of metalworking. More options generally translate into a more elegant, ingenious design or a simple, cost effective design. The best designs succeed in all of these areas.

Commercially available tanks are available in aluminum, steel, polyethylene, fiberglass and carbon fiber. However, aluminum is by far the most common material for custom fuel cells. When aluminum sheet is used in place of steel sheet, it needs to be 40% thicker to be as strong; even with the added thickness, aluminum is still 50% lighter than steel. Another advantage of aluminum is that it doesn't need to be coated to provide protection from corrosion. Although aluminum is more expensive than steel, material costs are an insignificant fraction of the cost of a custom fuel cell. Welding aluminum is more challenging than welding steel, and owning the equipment to weld aluminum is only the first step. Proficiency comes after hundreds if not thousands of hours of welding and that expertise is worth a premium. This is another reason to work with an experienced fabricator.

The shape of the tank can also dramatically affect cost. The easiest way to illustrate this point is to compare an egg and a cube. It is said that an egg is nature's perfect container. This shape would be incredibly strong and a very safe shape for an auxiliary fuel cell. There are no sharp edges that might tear into a rider in the event of a crash. Figuring out how to attach this

PHOTO COURTESY OF TOUR TANK

shape to a motorcycle is a little more challenging too, which is why it's easier for fabricators to construct tanks as a cube.

Incorporating bent sheets in a design can reduce the amount of welding required and make it possible to match the existing contours of the motorcycle on which the tank is installed, but bending 90 degree corners can significantly weaken the aluminum and therefore best avoided. If a custom tank design begins with the attachment bracket and the bottom sheet(s), the rest of the shape often follows naturally. However, CAD can be a valuable tool when designing more complex shapes.

Conclusion

Finding a fabrication shop can be time consuming, but it's worth it to invest the time. A shop willing to take on a relatively small project may lack the expertise to meet expectations. A shop with sophisticated tools and skilled workers may be unwilling to take on a small project. A fabrication shop with an impressive website might be up to the task, but communicating via email or phone is only effective once you know exactly what it is you want. If you have a detailed drawing, you may be able to save quite a bit of money. In my experience it's best to visit the shop, talk face to face with the people doing the work and see examples of their work. Taking the time to become familiar with local fabrication shops might be the most important investment you make. Finding the right balance of expertise and accessibility can make a huge difference to the outcome of your project.

In a time when nearly everything is ready-made, there is less of an incentive to have something custom-made. I'd encourage this opportunity to be creative. Although not comprehensive, this article is meant to be more of a travel guide with advice and tips to help navigate you through the auxiliary fuel tank maze. Don't be discouraged if you think this is overwhelming — it's all part of the journey.

Other Design Considerations

BY TOM AUSTIN

ONCE THE BASIC size, shape and mounting location have been determined, there are a number of other factors that need to be considered in the final design that many inexperienced fuel cell builders overlook. The most common mistake in auxiliary tank design is not leaving vapor space above the liquid level of a full tank to account for thermal expansion. Gasoline volume increases 0.07% per 1 degree Fahrenheit increase in temperature. When you fill the tank, the temperature of the gasoline is usually a little lower than the daily mean temperature of the location where you purchased it; 60˚F is a typical temperature for fuel dispensed from underground tanks in areas with maximum daily temperatures in the 70-80˚F range. If the gas sits in the sun inside a black fuel tank, it could easily get to over 100˚F. The volume change going from 60˚ to 100˚ is 2.8%. To be on the safe side, a minimum of 5% of the interior tank volume should be above the maximum fill level. You can accomplish that by either installing a short "fill pipe" that terminates about 5% below the height of the tank or making sure that the gas cap is inset to the same depth. Without sufficient vapor space, a full tank will expel fuel out the vent when parked in the sun.

Other common problems that inexperienced builders make include:

- Using vents that are not flush with the inside surface of the tank and become submerged when the tank is full (leading to more fuel being expelled from the vent);
- Failing to locate vents on the highest point of the tank;
- Failure to filter the vent line to protect the tank from dust ingestion;
- Installing fittings for draining the tank that are not located at the lowest point on the tank;
- Locating the gas cap so that it is not at the highest point with the motorcycle on either the side stand or the center stand;
- Failing to use baffling to control fuel sloshing; and
- Using mounting systems that are not designed to facilitate quick removal when necessary to perform service.

Even if the fabricator you use is an experienced welder, he may not be familiar with the fuel cell-specific design considerations listed above. Make sure you have covered all of these issues before finalizing the design of a custom fuel cell.

PHOTO BY BILL SHAW