Battery technology: AGM vs LFP

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IT'S A TENET OF POLITE DISCUS-sion in the motorcycle community that you don't bring up the synthetic vs. natural oil debate, despite the fact that nearly all commercially available oils we use in our motor vehicles are at least *semi*-synthetic to start. Only slightly behind that on the scale of "We don't discuss politics, religion or *these* things" is the type of battery that is best to put in your motorcycle. There are a lot of myths surrounding batteries, and this article will attempt to explain away some of them, especially those attached to AGM and lithium batteries.

All batteries work in the same fashion and contain the same basic components, which are an anode, a cathode and the electrolyte. Electrons produced by the electrolyte flow from the anode to the cathode, creating the electrical power we use to start our motorcycles and power our add-on devices like heated jackets and GPS units.

First up is that one battery is "better" or "best" for your motorcycle. The truth is that as long as the battery does what it's supposed to (start your motorcycle), lasts as long as you expect it to (usually three to five years) and fits your budget, *that* is the best battery for your motorcycle.

Second: gel batteries and AGM batteries are not the same thing. Both are lead-acid batteries, but their similarities with old car and motorcycle batteries that had to be periodically topped up with distilled water largely end there.

Gel (or gel-acid) batteries keep the electrolyte (the solution of sulfuric acid and distilled water) suspended in a silica paste. Absorbed glass mat (AGM) batteries are a more advanced form of battery, but are often confused with gel-acid batteries because of misinformation or misunderstanding, as their electrolyte is absorbed

Even when you use the proper charger for your battery, follow the manufacturer's instructions. Improperly charging your battery can result in catastrophic damage, as seen here, which could result in fire, injury and/or death.

into fiberglass plates, or mats. It's often easier to simply refer to both gel and AGM batteries as one or the other, but they are significantly different.

Gel batteries add sand (silica) to the electrolyte solution to turn it into a thick paste, thus creating a spill-proof battery that can be installed at just about any angle. Gel batteries are well suited for deep cycle use and generally have a long life. They're not as susceptible to internal corrosion as wet cell batteries, so they usually last a long time. The biggest disadvantage to gel batteries is that they can be damaged by high temperatures, which can harden the gel and cause it to shrink away from the plates inside the enclosure, thus adversely affecting the battery's performance. Gel batteries unfortunately do not function well below freezing (32 F / 0 C).

Gel batteries are quickly and easily damaged by overcharging, which dries out the electrolyte paste and creates pits or holes in the gel that degrade its function. Special chargers are available to keep gel batteries properly topped up.

It might be confusing, but the AGM battery is *also* a sealed lead-acid battery, it's just that its electrolyte (the sulfuric acid + distilled water mix) is suspended in a series of plates made of polyester and/or fiberglass. This not only keeps the electrolyte evenly distributed throughout the battery no matter what angle it's at, but it prevents any leakage or spilling if the bike is anything other than upright.

One of the reasons AGM batteries work so well for motorcycle applications is because the cells are constructed under pressure and remain in their compressed state inside the battery housing. This is why AGM batteries are smaller than traditional wet lead-acid batteries, and also means that they handle vibration better, resulting in a battery that can handle the rigors of even the most off-roady of off-road motorcyclists. In addition, AGM batteries recharge more efficiently because of how the electrolyte is distributed, which means that when properly cared for, an AGM battery will last much longer than a traditional wet lead-acid battery.

On paper, AGM batteries appear to be the best for motorcycles because of their low self-discharge rates, hearty construction, low susceptibility to sulfation, ability to function in low ambient temperatures, and resistance to damage and failure when deep cycled. AGM batteries require a purpose-built charger, however, as they are easily damaged by improper charging practices. I've been using an OptiMate charger for a number of years with excellent results, as all my motorcycles have AGM batteries in them.

The reason many people confuse gel and AGM batteries is because they are similar in many of their characteristics. Their chemical processes are identical, in that oxygen produced by the positive plate is absorbed into the negative plate, which subsequently produces water (instead of hydrogen); this is why we don't have to top them up like a wet lead-acid battery.

Lithium-*iron* batteries are a variation on the lithium-*ion* batteries used to power consumer electronics like laptop computers and smartphones. Their chemical notation, LiFePO4, means that for every atom of lithium (Li) present, there is one atom each of iron (Fe) and phosphorus (P) as well as four atoms of oxygen (O4). When phosphorus and oxygen exist together in a 1:3 or 1:4 ratio in the same molecule, that molecule is called a phosphate. A lithium-iron battery contains inorganic phosphates, while organic phosphates are used in herbicides, insecticides and nerve agents. Organic phosphates are toxic to most insects and animals, including humans. For the remainder of this article, we'll refer to lithium-iron batteries as LFP, which stands for lithium ferrous phosphate, the easy-to-say version of LiFePO4.

LFPs are currently the safest, most fire-resistant and most powerful form of rechargeable lithium-based battery, but because the technology is new, they are difficult and expensive to manufacture. The biggest benefit of the LFP battery is that its discharge rate remains consistent almost until it is completely discharged, providing a steady, reliable source of power. The disadvantage of this is that you get almost no indication that the battery has reached the end of its functional service life. One day it works perfectly, the next day it's worthless.

When it comes to myths and LFP batteries, there are many going around, so let's take a look at them and see if we can get into the differences between AGM and LFP.

Myth: Lithium batteries are lighter than AGM batteries.

This isn't a myth, it's true. Lithium batteries tend to be smaller in size and lighter in weight than AGM batteries used for the same application. A typical AGM battery for a BMW motorcycle weighs about 15 pounds, while a lithium battery for the same application weighs just under five pounds. While this may be attractive for a race bike, where every ounce is critical, an R 1200 GS weighs 580 pounds with an empty gas tank! Saving ten pounds on a 600-pound motorcycle should probably not be the primary consideration for choosing a battery.

Myth: LFP and AGM batteries are the same.

If this were true, we'd call them the same thing. They're quite different, and in fact, not understanding these differences can result in a damaged battery. A fully charged AGM battery will show a voltage of about 12.8 volts. An LFP battery that reads 12.8 volts, measured across the terminals and with no load on the battery, is down at least a full volt from its fully charged state. This is why a lithium battery reading at 12 or 12.1 volts will have trouble starting the motorcycle.

Myth: An LFP battery won't start my bike if it's cold outside.

A clear disadvantage of LFP batteries is that they often have difficulty starting a motorcycle in cold weather. One way to get around this problem is to turn the ignition on, wait for 30 seconds or a minute, and then try to start the motorcycle. It may take a few attempts to start the bike with a LFP battery when the weather is cold, so patience is often rewarded. A better solution is to combine the above with keeping your LFP battery on a proper charger.

Myth: An LFP battery has a higher capacity than an AGM battery.

A standard AGM battery will have six cells of about two volts each, while a standard LFP battery has four cells of about three volts each. In other words, both are 12-volt batteries. However, when you look at battery capacity, the number to look at is called "amp-hours" (Ah), which lithium battery manufacturers derive from a "lead equivalency" (PbEq) rating. A battery with a PbEq of 20 may only have six amp-hours of capacity, which is actually less than an AGM battery—up to four times less! What happens as a result is that a rider may charge their GPS, comm system, Go Pro camera, cell phone, etc. and end up surprised that their LFP battery is dead after just one or two days.

The solution to this is to check out the true amp-hour rate that some LFP battery manufacturers are starting to list on their packages. A standard Odyssey AGM battery for a bike like a K 1600 GTL has 16 amp-hours of capacity, so compare an LFP battery to that.

Myth: It's impossible to overcharge a lithium battery.

Maximum voltage for an LFP battery is 14.6 volts. Higher voltages will damage the cells, degrading their ability to be recharged. More importantly, damaged cells in a lithium battery may overheat when recharged, which could not only damage the other cells in the battery, but could, in rare cases, start a fire and do far more damage.

Myth: Lithium batteries must be kept fully charged at all times.

LFP batteries tend to function best when kept between 13.05 and 13.6 volts, but if they are discharged below 10 volts, that

messes with the chemical balance in the electrolyte. An LFP battery discharged below 13 volts is unlikely to even start the motorcycle, which would lead many riders to try to jump or bump start the bike. This is a mistake; the unique charging requirements of an LFP battery (see the next myth) mean that bump starting the bike and engaging the motorcycle's onboard charging system is likely to damage the LFP battery's cells, causing them to eventually overheat and possibly catch fire.

Myth: Any charger will do for LFP batteries.

If you buy an LFP battery for your motorcycle, don't cheap out on the charger. It is critically important to buy a charger that is optimized for use on LFP batteries for a number of reasons. The most important reason is that the proper charger "understands" the LFP battery's unique charging requirements, which are not the same as those for a lead-acid battery—and that includes AGM batteries, which use the same basic electrolyte as your grandfather's vintage pickup truck's battery. Bikes with "always on" electronics (clocks, alarms, etc.) will discharge an LFP battery fast; remember that while the lead equivalency may be high, the actual amp-hour capacity is low, and while a good LFP battery charger can bring a discharged battery back from as low as one volt, it has to be done properly, by using low current until the LFP is above 12.8 volts, when it can then be hit with higher current for faster charging. A lead-acid battery charger uses high current at low voltage, which could easily damage that expensive LFP battery.

Both AGM and LFP batteries benefit from being on a charger when the motorcycle is not being ridden, but it is more important for the LFP batteries, which also MUST use a purpose-specific charger. If you have a mix of AGM and LFP batteries in your motorcycle fleet, that means you need more than one charger, and don't mix them up. In the words of Ghostbuster Dr. Egon Spengler, "That would be bad."

It's important to note that BMW Motorrad does not spec LFP batteries for their new motorcycles; they continue to use AGM batteries, even on the standard S 1000 RR. While I'm certainly not opposed to updating my motorcycle with new technology, the battery is one of the things that I don't mess around with and tend to stick close to the OEM specs. Nobody wants to look down while they're riding and see flames between their legs.