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The elements of glow-engine adjustment

Only 10 years ago, the idea that a meaningful percentage of model aviation enthusiasts would not have owned a glow-ignition engine would have occurred to only a handful of visionaries. The YS .61 shown used to power the author's sport workhorse Tiger 60. The old standby K&B 1-L glow plug was the ticket in the summer heat; when temps dropped below 70°, a hotter plug such as the Enya #3 improved idle reliability.

HI, GANG. The weather is a never-ending source of inspiration. This time it was a string of warm flying days that reminded me of airframe and engine setup adjustments that come with the hot days of summer. I made few adjustments to the airplane itself as weather changes, and most of them were part of the fine trimming needed for Aerobatics competition.

Since I haven't competed in years, I don't have much use for that sort of detail fussing, but changes in weather still require adjustments to keep the engine running powerfully and reliably. The need for reliable horsepower never changes.

Glow and, to a lesser extent, gas/ignition engines respond dramatically to substantial weather changes. As I mentioned, this subject came to mind with the onset of warm but tolerable flying weather, but this week has seen unrelenting 100° days that make you wait patiently for that little bit of relief just before sunset.

Despite the heat, it is the nature of the magazine business that this will be published in an issue labeled "October," that many of you will read in September. That is good, because many of the changes we make for hot weather have to be undone when summer ends. I might get ahead of the curve.

Language is a funny thing. The names we give things sometimes describe them very well, and other times they confuse you or hide what is actually happening. Take the term "Figure Skating," for instance. You might have seen it on television.

Did you know that the event took its name from the first round of the competition, in which skaters had to perform precise figures such as circles, figure eights, intersections, and combinations of them? Then the judges would walk out and closely inspect the skate marks in the ice to assign scores.

The entire "figures" round was dropped from the event maybe 40 years ago. It was mind-numbingly boring to watch. The "figures" have been gone since before half of the world's population was born, yet we still call the event by that name.

I guess it's what you'd call tradition. As far as I can tell, the real question is whether or not it should be called "artistic skating" or "athletic skating."

"Glow ignition" is a similarly misleading term. Thermal or thermocatalytic ignition is more descriptive, and in some languages that's exactly what glow ignition translates as. Yes, I've had enough of the vocabulary lesson too!

A properly controlled spark-ignition system is superior to glow ignition in all regards but one: weight. When it comes to flying, weight is the enemy. It always has been. For that reason alone, the combination of alcohol fuel and a hot catalytic metal glow plug has been dominant in aeromodeling starting nearly 60 years ago.

So much has changed since the advent of the glow plug. Gasoline engines with lightweight, reliable, electronically timed, capacitive-discharge systems are available, and even electric power plants threaten to topple the glow plug from its lofty perch.

But still, more glow engines are used at the flying field every day than anything else. Their care and feeding is an acquired skill, and it perplexes some of us aeromodeling "lifers" that some good pilots out there haven't learned it.

The glow plug is a deceptively simple device. Simplicity does not mean that all glow plugs are the same; one size does *not* fit all, as the old Frank Zappa song title suggests.

Picking the right glow plug makes an engine run better, but several variables must be juggled in a good-running combination. By paying proper attention to managing those factors, we can avoid unnecessary frustration.

This juggling act is far from difficult. You actually have a fair bit of flexibility in the variables, which are:

1. Compression ratio
2. Fuel and nitro content
3. Air density
4. Glow plug heat range
5. Fuel/air mixture or needle-valve setting

Of those, probably the most powerful is the needle valve. Any setup can be ruined by mishandling that dainty little thing. How can such a small item be so important?

In a glow-ignition engine, the "fire" is started when the fuel/air mixture is heated by compression of the fuel/air mixture. The heating of a gas that is suddenly compressed is described as "adiabatic." That means that there is little or no heat lost, at least in the short term.

The resulting sudden temperature rise is then enough to start the combustion process, with help from the catalytic action of the glow plug element. A "catalyst" is a substance (often a metal) whose surface takes part in a chemical reaction in a way that promotes the chemistry *without being changed in the process*. (More about this in a minute.)

The catalyst, in this case the hot surface of a platinum-alloy coil, lowers the activation-energy "hump," so that the

sudden compression heating is able to light the alcohol and nitro. This combustion process does not take place all at once; it is not an explosion in that sense of the word.

How many times have you heard the workings of an internal-combustion engine described as an "explosion"? Yet again, the words we use to describe things can confuse rather than inform. Combustion rate depends on the peak compression-induced temperature, type of fuel, and strength of the fuel/air mixture. Higher compression ratios tend to start the combustion process sooner and more quickly because of the greater compression heating.

That is especially useful when an engine is running at high rpm, because if it takes too long to light the fire, the engine won't run well at high rpm. Conversely, good low-rpm operation tolerates a wider range of compression ratios.

Nitro content has an interesting effect. For one thing, adding more nitro to your fuel behaves similar to adding compression; ignition occurs earlier, but the difference is that nitro prolongs the burn.

That is because nitro releases oxygen as it burns, allowing the remaining alcohol and nitro to burn hotter. This makes more horsepower, provided—and this is a big "if"—the fuel/air mixture is rich enough. If it is lean, combustion is quick and extraordinarily hot.

Combine a too-high compression ratio with too much nitro and a lean needle-valve setting, and you get the model airplane engine version of a thermonuclear meltdown. Nothing hurts my ears the way a death wail of tortured metal does.

The air density is a contributor too. Low barometer readings mean that there is less air to compress in the cylinder. Leaning the needle valve a little bit restores the proper fuel/air mix and the leaner mixture burns more quickly, so that the combustion still happens at approximately the right time. Still, this means less torque, even when the ignition is just right.

When higher-density air returns, failure to fatten the needle will make for more trouble. Low-barometer days don't *have* to mean lost performance. More about that later.

Glow plugs come in a variety of heat ranges. That mostly has to do with the plug construction. If there is a longer, skinnier path of metal between the platinum element and the relatively cool metal of the cylinder head, the plug's element will run hotter, helping promote the start of combustion.

The same is true when thinner-gauge wire is used for the element itself, especially in conjunction with a larger number of coils. The center of the wire runs hotter than the ends because of the heat-sinking action of the glow plug body.

If you hook up your glow driver to a plug and look at it in the sunlight, you'll see that only the middle glows hot enough to be seen until you create some shade with your hand. Cooler plugs generally have thicker elements with fewer coils.

If the catalytic element runs too cool, it does its job poorly. If it gets too hot, the surface gets corrupted. Tiny bits of metal from inside the engine bond to the surface of that expensive platinum alloy, and all of a sudden it isn't a good catalyst anymore.

As it turns out, that happens to all glow plugs with running time. And even before a plug burns out completely, you might lose the reliability of the idle or the needle valve will become inconsistent.

The telltale sign of a bad plug is the surface of the platinum wire having a lumpy grayish-white appearance rather than a shine. (Even a soft shine is okay.) This is tough to describe adequately, but I spent most of the evening a few days ago trying to take pictures of a worn-out glow plug with a magnifying glass and bright light. I needed a photomicroscope similar to the one I had at an old job for taking pictures of tiny microcircuits.

Eventually I gave up. I couldn't produce a picture that would help you tell the difference between merely used and used up.

In the case of extreme heat, and maybe slight engine vibration, the element will self-destruct. Sometimes it leaves the engine without much fuss, but just as often it makes it only halfway out of the exhaust port before the piston comes up and tries to chop it in half. The piston, ring, and cylinder liner usually loses this battle, and the resulting scratch kills the compression. Replacement parts aren't cheap.

If you blow glow plugs every 10 or 20 flights, it's time to change to the next-cooler-range plug or set the needle valve richer.

The needle valve is the 900-pound gorilla in all of this. If you set it a bit rich, the combustion process starts late and progresses extra slowly because the excess fuel has to be heated to get it to burn. I already described the consequences of an overly lean setting: even the glow plug element gets too hot to do its job properly.

What happens when the weather changes considerably, such as when comfortable spring days give way to the heat of summer and then back to fall? For one thing, summer heat means less dense air, both for the wings and engine with which to work. This means lost performance.

The first temptation is to regain that performance by leaning the needle valve *a bit* more. But higher temperatures already mean that the combustion process starts earlier and gets hotter, so even if you don't set the engine too lean, you will wear out glow plugs prematurely.

This happened to me recently. Two Saturdays ago I flew maybe a half-dozen flights with the old Tiger and its normally dead-reliable O.S. .91 four-stroke. On the first flight the next day, the engine quit as I did a spin.

Okay, I thought, I'll speed up the idle 100 rpm, and that problem will go away. But when it quit in the same place on the

next flight, I started looking for the real cause.

The throttle servo was steady, the engine mount was not loose, and the fuel flow was fine, so I removed the plug. Sure enough, it was frosty-white and a little bit lumpy in appearance. With the fresh four-stroke plug, I was back to a reliable 1,600 rpm idle.

A cooler-heat-range plug, in conjunction with a switch to 5% or 10% more nitro in the fuel might have been a good idea—provided I was careful to run slightly rich, because the Tiger's 9 1/4-pound weight hinders vertical performance in the summer heat.

That's what I often used to do with my two-strokes. When the weather got hot, I would "tip the nitro can" and set the engine rich before I started it. If it liked a hot plug in the cool weather, I'd change it for a plug that was one heat range cooler, in the heat.

If you look at listings for different glow plug manufacturers, you'll see that they are rated hot to cold. Between one brand and another, you are on your own: it's not in their interest for you to be able to easily compare them. Hmm.

I've mentioned the idle, but the other thing that changes with summer heat is the idle mixture. It typically has to be leaned out a tiny amount as warm weather hits, and it *must be* fattened back up when the temperature drops. Getting the idle mixture setting right tends to frustrate many; it isn't as easy as listening for the peak at full throttle.

If you are having problems with the idle to full-throttle transition, or with prolonged idling, a simple test will help you correctly set the idle mixture. Remove the cowl if necessary, but you must be able to reach the fuel line to the carburetor while the engine is running.

Set the high end, and then slowly reduce the engine to idle. At first you might have to settle for a slightly faster idle to keep the engine running, but that is okay. Pinch the fuel line for a full two or three seconds. This is unlike the full-throttle pinch test that some people do.

If the engine sags straight away, the idle mixture is too lean. If it speeds up immediately, the idle mixture is too rich. Proper idle mixtures will normally continue to run exactly the same for a good three or so seconds after you have pinched the fuel line, and then the rpm will rise no more than 100 or 200 rpm immediately before the engine quickly sags and quits. If it speeds up more than that, it is still too rich at idle.

If you have set the idle mixture this way and the engine still quits cold and rich or blubbers rich when the throttle is advanced to full, you probably need a hotter glow plug. This is where many pilots get frustrated; the choice of glow plug is often made by price rather than heat range.

When cool weather returns, the engine will need to be richened, both at idle and top-end, so don't trust the settings simply because they worked during the last outing. At the start of each flying day I suggest that you open, or richen, the needle the same three or four clicks (or one-quarter turn). After fully warming up the engine, listen carefully for the perfect setting while slowly leaning the mixture.

The worst that can happen is that you confirm the older setting. The best is that you catch a bad setting before it ruins an engine or airplane. The important thing is that you set the needle starting from an obviously rich condition. These engines respond strongly to small changes in weather, so take the time to develop that first-start engine-setting ritual.

If you want to spend some time reading about compression heating, visit the NASA Web site. In just a few pages it describes the relationship between the temperature, pressure, and volume of a gas.

If you want to delve more deeply into the subject, try the HyperPhysics Web site address. There you can read descriptions of how adiabatic compression produces even higher temperatures and pressures, but it starts to make use of more complicated math. MA

Sources:

Compression heating:
http://bit.ly/bEjWso

HyperPhysics:
http://bit.ly/9QeKVW