Introduction to gasoline model aircraft engines
Updated November 2007

Gasoline engines are now popular for use on larger model aircraft. They have the advantage of long life, low cost of operation, and adaptability to larger sizes. Making the transition from glow fuel engines to gasoline will be easier with an understanding of the basics of using small gas engines.

Why Gasoline? Is it right for me?

A glow fuel engine consumes roughly twice the amount of fuel that is used by a gasoline engine of the same size. The practicality of glow engines stops with aircraft above about 15 pounds. At that point the amount of fuel that must be carried, and the cost of that fuel, become significant problems. A 1.80 cubic inch glow engine will consume 1.5 to 2 ounces of fuel per minute. That works out to something like 1 ½ hours of flying on a gallon of fuel. At $15 per gallon (rough price of a gallon of glow fuel at the local hobby shop) it’s costing about $1.50 for a 10 minute flight.

Warning! Gasoline is highly flammable and can be dangerous if not handled properly. Follow all the recommendations on the gas can and at the gas pump, keep a fire extinguisher handy at all times, and do not allow gas fumes to accumulate in a closed space. Gasoline can explode and kill you. A stray spark can cause a disaster.

For models weighing less than 10 pounds total, a glow-fueled engine is almost certainly the right choice. In smaller planes the power and simplicity of glow engines cannot be beat. The cost of the fuel, and the weight, are insignificant drawbacks. A .40 size engine uses so little fuel that the cost is negligible, and the extra weight of a gas engine’s ignition system would be a major drawback.

From 10 to 15 pounds, it’s a toss of the coin, which one do you like. The gas engine costs a bit more to start with, and probably weighs a little more, but not so much more that it is not practical. The costs of fueling a large (1.20 and up) glow engine can be a drawback, where the cost of gas is almost zero.

When you get past 15 pounds, there’s no choice to be made, gas power is the only practical choice. There are a few large multi-cylinder glow engines, but for every day flying they are not practical and are used mostly with scale aircraft requiring realistic looking engines, usually radial or opposed twin.

So to summarize, if you want to fly giant scale, you will need to become familiar with gasoline engines.

How do I select a gas engine?

There is always a small loss of power when using gasoline as a fuel over alcohol, which is the primary ingredient in glow fuel. Alcohol/air mixed at the optimum ratio produces roughly 10% more energy when oxidized (burned) than does gasoline, and it takes almost twice as much alcohol by volume to mix properly with an equivalent amount of air. So you get a little more power from an engine but consume twice the fuel. And Nitromethane can be added to alcohol to increase power further, this is not true with gasoline.

So we need to use a larger (displacement) engine with gas to get the same power as a glow engine. The equivalent to a 1.8 cubic inch glow engine (30 cc)* will be approximately a 2.4 cubic inch, or 40 cc, displacement. This is a very rough equivalence, but the relationship will hold for engines of similar type.

There are good and not so good engines in both categories. With gasoline, there are three types of engines.

a. Purpose built engines specifically designed for model aircraft and UAVs.
b. Hybrid engines that use industrial parts with purpose built foundations.
c. Converted industrial engines like chain saw and weed-eater engines

Examples of engines in category "a" are 3W (from Germany) ZDZ (Czech republic), and DA (Desert Aircraft, American made).

Engines in category B include Brison, Zenoah, older BME engines, and a half dozen less well-known brands.

Recently there has been a large influx of inexpensive Chinese engines in small and large displacements. Most of these fall into category B, hybrid engines. And most of these Chinese hybrids are extremely cheap, both in price and quality. For the most part I recommend that you stay away from the really cheap motors. These fall into the "throwaway" category, if something goes wrong it's probably cheaper to throw it away than to try to repair it, especially if your time is worth anything. Poor machine work, poor quality materials, and poor design usually mean an engine that will be very frustrating.

Some of these engines are very good, specifically the 3mm TOC-53 and the DL-50. These are both category A engines, built specifically for model airplanes. They are both more or less copied from other successful engines. The TOC-53 uses parts that are similar in most respects to the 3W 106, the same cylinder, piston, etc. While it is different in many respects, the TOC-53 looks like it could be in the 3W catalog. The DL-50is patterned after the DA-50. Some parts will even interchange, though there are also significant differences.

Engines in group c are really not suitable for applications requiring high power to weight ratios, they are generally restricted to sport models. There are lots of converted Ryobi and Homelite 2 stroke engines around, but they don't produce power to weight in the same league as the other types of engines. We want to select an engine for our plane that will provide the best flight characteristics and installation available.

Interestingly, we really don't care about the displacement of the engine, that's something that is totally irrelevant to engine selection. What we care about is physical size, weight, vibration, cooling and suitability for use. Pay close attention to the weight of an engine and its power output, almost everything else is irrelevant. We do want to be concerned about physical size and how much vibration is generated, but in 2007 most of the purpose-built gas engines available are of excellent quality and are not considered "shakers".

What's available?

Assuming we are staying within groups a and b, there are still several engine type variations on the market. Let's discuss what's available before getting into how to choose.

Things to select from include ignition type (magneto or electronic or hybrid), induction method (piston port, reed valve, rotary valve), carburetor location, (side, bottom, or rear) and exhaust location (side exhaust or rear exhaust).

Briefly, here's what this all means.

Electronic ignitions. In ignitions, electronic ignitions are separate boxes, powered by batteries and triggered by a magnetic pickup on the crankshaft. They are easy to hand start and are very lightweight. They take more time to install (though it's not hard, just more stuff to do) and are generally the easiest to live with. They tend to be slightly less reliable than magnetos but are still very reliable if properly maintained. Most competition type giant scale airplanes use electronic ignitions. Electronic ignitions (in almost all cases) have the advantage of automatic ignition timing advance, which allows optimum timing at all speeds. Without some type of spark advance mechanism (electronic or mechanical) the engine will either be hard to start (fully advanced) or will be down on power because the spark is retarded.

Magneto ignitions are simpler, a bit heavier, and usually require some starting method like a spring or electric starter. A magneto generates its own power by moving a magnet past a coil. To do this the magnet must be moving at more than just hand cranking speed. Magnetos are very reliable but generally are not favored by competition pilots. A Zenoah G62 is a good example of a magneto equipped engine. In many cases (like with the G62) there are kits to convert from magneto to electronic ignition. Magnetos usually have fixed spark timing, although there are a few engines (Fuji is notable) that have magnetos with advance mechanisms. Fixed spark timing means the engine will have ideal spark timing at only one RPM, usually full power. This hampers efforts to achieve easy starting, maximum power output and a smooth low idle.

A hybrid system uses a battery booster to make hand starting possible, but then uses a plain magneto when running. These have not gained great popularity.

For the most part in 2007 magneto equipped engines are no longer viable because of the weight and inflexibility involved. An exception is in warbirds, scale and tow planes where weight is not a concern and where they normally fly it full throttle most of the time. For aerobatic type planes electronic ignition with automatic timing control is the only way to go.

The right engine for the job.

Let's go at this one item at a time. First, the engine must fit in the plane. That's a given. In some very tight installations like scale warbirds that model a plane with an inline engine (like a P51 Mustang) there's very little room. You must be very careful with installations like these, lots of things can be wrong. In this case your selection may be limited. Things to worry about include overheating, too much noise (you won't be very popular at some fields if you don't have a good muffler and that takes a lot of room).

So when you choose an engine for your new bird, take a few minutes and measure the cowl width, distance from the firewall to the cowl spinner face, look to see if there is room for the muffler you want to use, etc. A little planning here goes a long way. Often people choose an engine, and then later regret it because either it doesn't fit or it's too heavy and they spend hours and hours trying to accommodate that engine. Look before you buy. I recommend either asking someone who has done it before (often the airplane manufacturer will know what is a good fit and what is not) or wait until you have the plane and borrow the engine of your dreams and do a test fit. Or ask the vendor of the plane what engine they recommend, most of the time they will know what works best. You will save a lot of pain.

The second point is the engine must be suitable for the job. You don't want excessive weight in an aerobatic plane, but in a big scale WW I biplane you may need a lot of weight in front just to make it balance. A high performance high RPM racing engine is great for a giant scale pylon racer, but would be useless in almost anything else. The list goes on, and once again a little planning pays off big.

Single cylinder engines have become excellent values recently. DA and 3W have some excellent singles that are lighter than twins and just as smooth, possibly even smoother. In the past as a general rule singles shook more than twins, but that is no more. The larger the engine the more it shakes, However there are many excellent single cylinder engines and a few really bad twin designs, so nothing is cast in stone. If you need anything over 100cc, you'll almost certainly be forced into a twin. Below that many singles are excellent selections and will be roughly half the price of a twin. Consider the DA-85 to be equal in performance in the air to a DA-100 due to weight savings.

Since this document is aimed primary at the aerobatic flyer, here is what is generally done.

3W sells a line of single cylinder engines that have various configurations, these are excellent engines though they tend to be heavy. 3W also sells an excellent line of twins, however these engines tend to be a little heavier and also wider, sometimes requiring openings in the cowl to clear the spark plug caps. 3w makes both bottom carb and rear carb versions, look before you buy to be sure the engine will fit in your plane. But they are very good engines, smooth and powerful. Recently 3w has release some lighter weight engines, the 106cc twin for example. But watch out, many 3w engines. are **HEAVY.** Dealer support with 3W in the USA can be hit or miss. Some people have excellent results, others report less than stellar experiences. Caveat Emptor.

Desert Aircraft builds the only (as of today) 100% purpose built American made engines. They are light and very powerful, and smooth. Excellent engines with excellent support. The DA singles are excellent values.

The Zenoah G62 has been a very popular engine with this scale airplane and sport-flying crowd. It can be a good aerobatic engine and benefits from a conversion to electronic ignition. The G62 has the unique characteristic of being widely available both new and used. You can do much worse than to buy a used G62 and convert it to electronic ignition and a lightweight muffler.

Zenoah also makes a very nice 80cc twin. It uses magneto ignition and is a bit heavier than its competitors, but it’s powerful and reliable and very available.

For the most part I recommend against purchasing new Zenoah because for the money there are better solutions on the market, but they last seemingly forever and are quality products.

Installation

Ok, you have your plane (hopefully a WildHare ARF) and your engine. Now what do I do?

Mounting the engine is fairly straightforward. Most installers will bolt the engine rigidly to the firewall. Be sure that firewall is strong and properly glued in. Use minimum 10-32 screws to hold the assembly to the firewall. Bigger engines need bigger bolts.

If you have a rear-carb engine you will need to plan for access to the carb so you can set up the throttle and choke linkage. Gas engines require the use of the choke for starting, so think about how you will open and close the choke before you start bolting and cutting. A little planning….

You will also need to plan for emergencies. You need a kill mechanism.

What?

What happens if for some reason you cannot use the throttle? Sounds silly, but it happens to every one of us sooner or later, the throttle linkage comes loose or the servo fails and we're stuck flying around until the plane runs out of fuel. If you are unlucky enough to have a throttle failure at partial power setting with a full gas tank, you could be out there flying for an several hours, plenty of time to run down the receiver batteries which will cause a crash.

Before you have this tragedy, install some kind of kill mechanism. This can be a servo actuated ignition switch, an electronic ignition switch, a fuel cutoff, or my favorite, a servo actuated choke. This solves two problems, how to operate the choke with the cowl on and how to kill a runaway engine. I use a standard servo to operate the choke, it costs about $10 and weighs almost nothing.

Fuel system

The fuel system on your gas engine is different from your glow engine. Not more complicated, actually simpler, but different.

You will use the same type of tank (Du Bro makes a nice selection) but you will not need as much capacity. For a 40cc engine you will need about 12 ounces for a 15 minute flight. Larger engines need more fuel. My DA-85 engine burns about 2/3 of the 24 oz. tank in a 12 to 15 minute flight.

Gas engine carburetors have a built in pump that draws gas from the tank. The pump operates off the pressure pulses from the engine crankcase. Don't worry about it, it's all automatic, you don't need to do anything.

The pump allows you to locate the tank almost anywhere that is convenient, no need to keep it close to the engine. Normally you would want to locate the tank on or close to the airplane's CG. By doing this the plane's balance does not change as the tank empties.

You must use a gasoline resistant stopper in the tank. The ones for glow fuel will dissolve in gasoline. Same with tubing, don't use silicone tubing. Use Tygon hose for gas, it doesn't get hard, it's transparent so you can see what's happening in the line.

Gas fuel line doesn't need to be as large as for the equivalent glow engine. Gas engines only burn about half the volume of fuel, remember?

The tank on a gas engine is not pressurized; just leave an open vent line to the atmosphere. You might want to put a loop of vent line from the tank vent, around the rear of the tank, and then out through the lower front somewhere. This way if you tip the model over nose down with the tank full you don't drain gas out the vent. Remember that gasoline kills grass, dissolves asphalt and paint, and is generally unfriendly. It also smells bad, so the less spilled the better.

Use a fuel dot or inline filler to fill the tank. Wild Hare has a custom made fuel dot that we supply with our hardware kits.

Ignition and radio interference.

Time was when spark ignitions and radios did not get along at all. Modern ignitions and radios have no problems if all is installed properly. I have used both PCM and FM receivers with spark ignitions without problems. Just follow some simple rules.

**Note about 2.4 Ghz. Radios. The manufacturers claim that these radios are immune to interference from ignitions and metal-to-metal contact. Good news, but it does not hurt to follow the rules anyway.

First, consult the ignition manufacturer's instructions and read them.

There should be at least a 12-inch separation between any radio components and any ignition parts, though this is a rule of thumb that is frequently violated. I normally put my throttle and choke servos in front close to the engine and ignition with no adverse effects.

Use no metal parts to make engine control linkages. At a minimum use nylon clevises to insulate the engine from the throttle or choke pushrods.

Make sure there are no metal-to-metal contacts that can rattle around when the engine starts and is running. Metal pushrods in a metal hole, metal clevises, etc. can cause radio noise and interference.

Absolutely the spark plug cap must be in good condition so as not to allow any sparks to jump out to ground. I had a cap with a pinhole in it, when I got in wet grass sparks would travel through the pinhole and moisture to ground.

Make sure the ignition system is well grounded to the engine. The plug lead will have a grounded cap or a ground pigtail. The best place to ground is to the base of the spark plug; use a work type hose clamp for this. Second best is to a screw into a fin on the cylinder head. Do not solder a terminal on the ground wire, crimp it on. Solder will melt.

Mount the ignition box and ignition battery in foam rubber to protect them from engine vibration. This is important; the ignition can be damaged easily.

Speaking of batteries, use a good 4.8 or 6-volt battery, NiCD or NiMH, unless otherwise specified by the manufacturer. A single cylinder engine will use up an 800-mah battery in about an hour. Twins use twice as much energy. Decide how long you want to fly and select your battery pack. Do not use a voltage higher than specified by the manufacture, it does no good and can damage the ignition. Avoid using a voltage regulator if possible, electronic ignitions may not get full performance with an inline regulator. Better to use a simple unregulated Nimh or Nicd battery pack.

Throttle and choke control

When using a gas engine (or for that matter any engine) it's important to use a good quality servo for the throttle linkage. Sloppy throttle management can make a plane harder to fly.

Don't just grab any old used servo for the throttle. While it doesn't take a lot of force to work the throttle, it's important that the servo linkage is tight and free of slop, and that the servo itself is precise and free of slop. A good ball bearing nylon-gear servo will do nicely. Don't try to save $5 here and buy a non-ball nearing servo, it can cause the throttle to be imprecise at that worst possible times.

And don't allow any metal-to-metal contact, particularly do not allow a metal pushrod to make electrical contact with the engine, it can act as an antenna and radiate interference.

If you choose to use a servo to drive your choke, this is where you can use your worn out servos. The choke is an all-open and all-closed affair; it has a snap that forces it one way or another. In this case it's important that the servo's travel matches that of the choke lever, otherwise what will happen is the servo will be resisting the choke spring and will draw excess current. A worn out servo is easier to adjust in this case.

Ideally adjust the travel to be approximately correct, then use your computer radio and adjust the endpoint travel (ATV is a common term) so that the servo doesn't buzz in either the open or closed position.

Don't have a computer radio? Get one. You're in the big leagues now. Get a decent radio.

* Throughout this document I use cubic inches and CCs interchangeably. They mean the same thing, they refer to the amount of air that moves through an engine in one revolution or combustion cycle, but they have different scales. One cubic inch is equal to 16.4 cubic centimeters (cc). 10 CCs equals .061 cubic inches. Therefore a 50cc engine is 3 cubic inches. Engine displacement measurements are rarely exact, assume that any reference to size means "approximately".