BUILDING INSTRUCTIONS EDF 50-55mm MICRO AFTERBURNER

Afterburner suitable for a 50-55mm EDF

The theory and way of function of an afterburner is simple; by adding heat to the gas flow directly behind a jet engine exhaust in a separate chamber the gas flow velocity increases and thrust rises. This is also true if an electric fan is used to generate the gas (air) flow. The efficiency of such a device will however be far less then for a jet engine setup since the air pressure behind an EDF is so very much lower, almost insignificant, compared to the pressure behind a jet engine.

The ability to produce and withstand pressure varies greatly between different fan designs. There for the choice of fan is critical for the efficiency of the afterburner. This afterburner is tested with the “WeMoTec micro fan” which happens to be fairly good at handling back pressure. With the WeMoTec fan the afterburner gives about 10% extra boost. A real afterburner produces typically 40% extra boost.

Since 10% extra thrust is a quite small contribution it is very important that the afterburner related extra weight is kept to a minimum. Using the materials and techniques presented in this kit, the extra weight sums up to about 37g (1.3oz) without the exhaust tube and fuel. Properly handled this system is reliable and safe. How ever, remember:

Only start the afterburner with the electric motor running at its max rpm!
If you start the afterburner with the electric motor turned of a fire will be started!

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Facts:

- Trust increase with WeMoTec micro fan typically 10%
- Weight without exhaust pipe 35g (1.3oz)
- Fuel butane gas (summer time) butane +propane, LPG (winter time)
- Total thrust with WeMoTec micro fan, mini AC 1215/9, 3s LiPo 1800mAh: Peak 5.2N (1.15lbf)
- System briefly tested with 4sLiPo: Peak 7.6N. (1.7lbf) 65k rpm –WARNING! This exceeds manufacturers’ maximum allowable values.
- Internal drag losses related to the afterburner: approx 2% with special designed paper laminate tube.
- The servo which controls ignition / gas flow must be able to pull min 1.3kg/cm (18ozf/in)
The kit contains:

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<td>1 pc Electrical wire PTFE-isolated 700mm</td>
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<td>1 pc PVC-hose 3mm diameter L300mm</td>
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<td>1 pc Stainless steel 0.1mm 150x50mm</td>
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<td>2 pcs Brass tube 1.5mm diameter L10mm</td>
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You need:

- WeMoTec 50mm micro fan or equal with suitable brush less motor, ESC, battery etc.
- 1 servo min 1.3kg/cm (18ozf/in)
- Sewing tread
- CA-glue
- White (wood) glue
- Drilling machine
- 2, 3.5, 4, 10-mm drills (non-critical diam.)
- Soldering iron
- Soldering tin
- Hobby knife
- Small wood saw
- A pair of scissors
- Ear and eye protection!
- Butan gas
Flame holder / exhaust tube.

Gas tank support / ignition / fuel control unit.
Fuel pipe. Time: Pre-made.

The fuel pipes purpose is to transport the fuel into the afterburner and vaporise the fuel in a even and controlled manner.

The fuel pipe consists of one 150mm long aluminium pipe, 3mm in diameter. The pipe is shaped around a 20mm cylindrical object. Then five holes 0.5mm in diameter is drilled straight trough the pipe, which result in a total of ten 0.5mm holes.

The fuel comes out through ten holes, five on each side of the circular shaped part of the fuel pipe.

Flame holder. Time: 40 min.

The flame holders purpose is to create a turbulent area in which a stabile combustion can take place. The flame holder also function as a shelter, protecting the glow wire from the high speed air stream.

The flame holder consists of two pieces of stainless steel foil, 0.1mm thick, which is cut out with scissors and there after bent into right shape.

Cut out the construction templates enclosed with this manual for the flame holder and the flame holder mounting and glue them on the stainless steel foil using the white wood glue.

Cut out the two pieces with some sort of scissors, do NOT use any tool that consumes part of the steel foil in the process. Drill the 3.5 mm hole in the mounting piece. Note the triangular hole in the middle. This is where the fuel pipe will pass trough later on. When you are done cutting, remove the paper template paper and gently grind all surfaces with emery.
Pre-shape the flame holder around a 10mm drill.

Then shape the flame holder into a tube, 17mm in diameter so that you have one flame holder blade in overlapping, see picture.

**Soldering.**

To be able to solder the stainless steel you need soldering fluid (included in kit) Surfaces that is to be soldered together should always be slightly grinded with emery before soldering fluid is applied. The fluid should be applied moments before the soldering begins. Ordinary electronic soldering tin can be used in this project. Warning! The soldering fluid is corrosive! Protect your eyes and skin! Wash away leftovers from the metal parts when the soldering work is done.

Use the pipette or a brush to apply the soldering fluid and start soldering the flame holder.
Bend the flam holder mounting piece around the fuel pipe and solder the mounting piece in the upper part so that it looks like the picture.

The distance between the flame holders blades outer point and the fuel pipes circular section should be 15mm. Place the parts so that the 15mm measurement is achieved and solder the flame holder mounting in position on the flame holder. Note that the fuel pipe should be in place when you start soldering.

The fuel pipe should pass through in between the two flame holder blades that have a triangular hole in between themselves.

**Glow plug.**

*Time: 25 min.*

The glow plugs purpose is to ignite the fuel in the afterburner with the fan is running at its maximum rpm.

The glow plug consist of two 10mm long brass pipes 1.5mm in diameter, two electrical wires, plastic epoxy and an 115-120mm long piece of glow wire (works together with 3s LiPo, 11-12volt) 0.3 mm diameter, 19.1 ohm/meter. The pieces are soldered/kneaded together.

Solder the electric wires to the brass pipes. Knead a small amount of plastic epoxy and put the brass pipes and a short length of the electric wires inside. Make sure that the brass pipes reaches out 2-3 mm from the plastic epoxy.
Squeeze-mould the plug inside the flame holder. Push out the glow plug **before** the epoxy is completely hardened. Make sure that the brass pipes are visible at all times.

Applying some sort of lubrication, like candle-grease, inside the flame holder before squeeze-moulding the plug makes it easier to push out the plug.

Shape the glow wire around a 4mm drill. Z-shape the ends to achieve a secure electric connection. The two ends of the glow wire must make good contact with the brass tubes.

The right length of the glow wire depends on your system’s power source voltage. 115-125mm is appropriate to 11-12v, 3s LiPo. Higher voltage = longer glow wire and vice versa.

Be careful so that the sharp edge around the 3.5mm hole don’t peel off the insulation on the electric wires when you pull them through the hole.

**Exhaust tube.**  
Time: 35 min.

The exhaust tube’s purpose is to guide the high speed air stream created by the fan to the rear and to transform the pressure created by the afterburner into increased efflux velocity. The exhaust tube should also create a suitable environment which enables a stable combustion to take place. The critical design feature to achieve a stable flame is the enlargement of the tube surrounding the flame holder.
Exhaust tube assembly.

The tube material can be adjusted to fit a 50-55 mm EDF.

The easiest way to make sure that the tube will fit around the WeMoTec fan is to use the fan housing as guide in the suction end of the tube. In the outlet end use a cylinder with 41mm diameter. Draw a line that shows the overlapping border. Remove the extra material, but leave a 6-8mm overlapping strip.

Join the tube with CA glue at four spots which you can reach with your fingers from both the inside and outside of the tube. Adjust the tubes diameter and let the glue cure.

Once the first glue spots have cured apply glue along the hole length of the seem. This technique minimize the risk of deforming the tube.

When all the glue have cured it is a god idea to spray the exhaust tube with 2-3 thin layers of paint since the tube is sensitive to moisture in present condition.

Mounting the flame holder.

Make a mark on the tube where the flame holder mounting and the electric connections to the motor should be placed. The flame holder mounting hole starts approx 70 mm from the exhaust tubes front end.
A electric machine like the “Dremel” make cutting and drilling work much easier.

Make sure that the flame holder blad tips stretches outside the fuel pipe diameter before you mount the flame holder into the exhaust tube. This is critical for the afterburners function.

The flame holder should be centred in the exhaust tube. The picture shows what the fan will “see”.

It is important to make it possible to access the flame holder in order to change the glow wire. There for you have to construct some sort of dismountable mounting for the flame holder. One way of making a simple dismountable, low weight, mounting is to use melt glue. The glue can later on be re-heated and removed. The fan unit can be mounted to the tube with short screws.
Gas tank / ignition fuel control unit.

The purpose of the ignition control is to deliver current to the glow plug at a given moment. The purpose of fuel control is to turn on/off the fuel. The system consists of two plywood pieces 2mm thick, one 22mm long PVC/hose 5mm diameter, 0.5m sewing thread, one 80mm long piece of piano wire 1mm diameter, one micro switch, one pearl soldering tin, one micro servo (min 1.3kg/cm not included) and one small spray can 22x80mm which will serve as fuel tank. A 3mm diameter PVC hose connects this unit to the after burners fuel pipe.

Cut out the construction templates enclosed with this manual for the gas tank support piece and the servo support piece. Glue the paper patterns on to the plywood and saw out the two pieces. Drill the two 2mm holes. Cut off a 22mm long piece of the 5mm diameter PVC hose. Wind the thread 20 times around the hose in one end, leaving 3mm clearance towards the end. Glue the thread with CA glue.

Fasten the hose on top of the gas tank support piece with the same CA-sewing technique.

Curve the piano wire to the shape shown on the paper template enclosed with this manual.
Assemble the servo support piece, the piano wire and a servo using CA glue. In this example Blue Birds BMS 371 micro servo is used. Torque: 1.5kg/cm, weight: 8.4g, dimensions: 24x11x24mm.

The servo axel should line up with the gas tank support piece.

The servo arm is cut off in one end and grinded to create a radius. The 7mm measurement relates to the use of BMS 371-servot, it may vary slightly between different micro servos.

The micro switch is mounted with CA glue in the location seen on picture. The servo arm should be able to travel as usual having precise clearance above the micro switch metal arm.

Fasten the gas tank. Rotate the servo arm so that it touches the gas tank bottom. Outline the position of the servo arm over the micro switch metal arm with a permanent pen.
Within the ink mark a pearl of soldering tin shall be soldered into place.

To enable the soldering tin to get a grip onto the micro switch stainless steel arm it is necessary to first apply soldering fluid. The soldering fluid very accurately governs the shape of the area which the soldering tin will cover and get a grip on. There for it is important to only apply soldering fluid exactly where you want the soldering tin to be placed, in this case only within the mark you made.

Once the tin is melted, quickly build up a pearl, approx. 1.5mm thick.

The function should be like the pictures shows. You will probably need to make some adjustments using a fine graded file.

In this position the current should be off.

In this position the current should be on.
Adjusting fuel and ignition system.  

Connect the servo to your receiver. In the ideal simple case this afterburner is used in a model controlled with ailerons, elevator and motor control (ESC). In such case you simply use the side rudder channel to control your afterburner. Using a 4 channel radio this means that you use the same stick on your transmitter to control the electric motor and the afterburner, which is very convenient.

The servo response should be as follows:

**Picture 1** The transmitter stick is position is neutral. The fuel flow is **OFF** and the current to the glow plug is **OFF**.

**Picture 2** The transmitter sticks position is 30% to the right. The fuel flow is **OFF** and the current to the glow plug is **ON**.

**Picture 3** The transmitter sticks position is 60% to the right. The fuel flow is **ON** and the current to the glow plug is **ON**.

**Picture 4** The transmitter stick is position is 100% to the right. The fuel flow is **ON** and the current to the glow plug is **OFF**.

It is important that the current to the glow plug is turned off once the afterburner is fired up for two reasons: 1 the glow wire will not last long if it keeps on glowing during the burn. 2 The glow ignition system consumes a considerable amount of energy which would do much better use running through the electric motor rather then keeping the glow plug glowing.

Adjustment possibilities: The fine tune knob on your transmitter, re-shape the tin pearl, aluminium tape on the bottom of the gas tank, re-shaping the servo arm. Correctly adjusted the system becomes reliable and have a high repetitive accuracy. There for it is well spent time fine tuning the system.
The fuel tank / fuelling.

Small 22 x80mm spray cans, typically "car lock spray", is suitable for this afterburner. It can be filled with 15g gas.

To fuel it up you need a 16 mm piece of the 5mm diameter PVC-hose.

To make it possible to fill the small tank completely you have to fill it in 2-4 cycles. Between each cycle you let a small amount of gas out from the small gas tank. This lowers the temperature and pressure in the tank which make fuelling easier.
Starting procedure.

Do not light the glow plug with the electric motor turned off.

When the transmitter stick is in the position were the glow wire is lit it is important to pause for about 1-2 seconds in order to give the glow wire time to reach the right temperature. Be sure to turn the glow plug off after about 1 minute to avoid overheating.

The glow plug is connected via the micro switch directly to the main battery pack. The glow plug has to be mounted in a slightly tilted position so that liquid gas reaches the gas tank when the gas pipe is fully inserted into the glow plug. 

Use a short piece of the 5 mm PVC-hose to create a tight connection between the fuel pipe and the glow plug. See arrow.

Use the 3 mm PVC-hose to connect the gas tank with the afterburners fuel pipe. Make sure the fuel hose does not have sharp turns which could restrict the fuel distribution.

A glow wire of right length should glow yellow-orange when lit with the electric motor running at max rpm to achieve reliable ignition, see picture. If it glows red (too long glow wire) it will not last for long. If it glows white (too short glow wire) it will not start at all.

When the transmitter stick is in the position were the glow wire is lit it is important to pause for about 1-2 seconds in order to give the glow wire time to reach the right temperature, before starting the gas flow.

Do not light the glow plug with the electric motor turned off.

WARNING!
The electric fan is running at its max rpm.
The afterburner may only be activated when:

Use eye and ear protection!