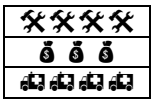
MAKING A MONSTER MAGNETIC STIRRER

V 1.00

Andy Tipler – 11/04/2020

RATINGS



PURPOSE

This project is to make a magnetic stirrer capable of stirring up liquids up to 6 gallons in volume in carboys and fermentation buckets.

DOWNLOADABLE RESOURCES

A ZIP file containing instructions and supporting files for making your own monster magnetic stirrer may be downloaded from the following web address: www.cheapskatehomebrewer.com/monster-magnetic-stirrer/.

This ZIP file contains the following files:

Monster Magnetic Stirrer.pdf	Build instructions (this document)
Control Panel.stl	File to 3D print control panel
Stirrer Enclosure.f3d	Fusion 360 drawing of the stirrer enclosure

DESIGN REQUIREMENTS

The stirrer should work with a range of stir-bars and vessels – from small flasks to large carboys and buckets. Control of stirring speed is required. An indicator light should indicate when the stirrer is running. The stirrer should be powered from a standard 12V wall adapter. The stirrer should be capable of running continuously for weeks without failure. The assembled device should not cost more than $30.

DESIGN APPROACH

The design is based on a standard 120mm computer fan upon which a pair of powerful magnets has been glued. A low-cost commercially available PWM (pulse-width modulation) electronic controller is used to drive the fan motor and allow adjustment of the speed. These components are mounted inside a large and robust wooden case.

LICENSING

INTRODUCTION

Sometimes you will find a need to agitate some of the fluids associated with beer (and wine and mead) brewing. A good example of this is, when making a yeast starter, prolonged stirring helps with the aeration and keeping the yeast in suspension. I suppose one could stand there all day with a plastic fork or something like that to stir things up manually, but I think most of us have more important things to do – like getting a beer and watching soccer or American football on the TV, mowing the grass or even taking your long-suffering lady wife out shopping.

A magnetic stirrer is a wonderful way to stir things up. You can buy ready-made ones, but I find these to be a bit wimpy. The stirrer we are going to build here is industrial strength – I have used it to mix things up in a 6-gallon carboy for weeks! It might be able to mix cement, but I'll leave you to try that out for yourself (that's a little joke).

A magnetic stirrer essentially comprises two sets of magnets. One set is attached to an electric motor which rotates at several hundred revolutions per minute (rpm). The other set is encapsulated inside a plastic stir-bar. The plastic used in the stir-bar is normally polytetrafluoroethylene (aka PTFE or Teflon™). PTFE is very inert and doesn't release any noxious compounds into the beer so it's ideal for this purpose. It's the stuff used to line non-stick cooking pans. I have a PTFE-coated non-stick shirt which is great for drinking as any beer spilt just runs off it (and onto my non-non-stick trousers).

For the electric motor, we can use a 12-volt fan of the type used to cool personal computers. An

inexpensive PWM (pulse-width-modulation) controller circuit bought off EBay can be used to control the speed. A common 12-volt 'brick' power supply can be used to power the unit. For the rotating magnets we will use some neodymium magnets. These are extremely powerful and can be bought in a variety of sizes. The ones I bought off EBay were 2" x 0.5" x 1/8" and had a 26lb pull – I had to be very careful where I put these. Anybody into body piercing should probably keep well clear of these magnets (especially if they buy cheap jewelry). I've seen two of these magnets shoot a few feet across a table to join each other because of the strong attraction – it would be rather painful if this occurred while a delicate part of your body was in the way. I believe such magnets can also be extracted from an old PC hard drive but I wanted to get some really big ones! The stir-bars can be bought ready-made from Amazon.com or EBay and should be chosen to suit the vessel being used. I bought a set with sizes going from ¾" up to 2". Finally, the housing was made from bits of wood and sheets of metal and/or plastic.

This is quite a complex project requiring the use of tools and some ability to wire up electrical circuits. However, no high voltage is involved, and success is essentially assured. However, if you really are not much of a handyman, then it's probably best to go out and buy a stirrer ready-made – you can always stick some stickers on it and bash it around a few times with a hammer to make it look homemade. If you do build this yourself, then you will be able to show it off to your friends, bask in their envy and wear your Cheapskate attitude with pride.

The following instructions refer to the stirrer I made. Most of the parts I had lying around already and so it was a big relief (especially to my wife) to finally find something useful to do with them. There is plenty of scope for creativity if your junk collection is different from mine. I'll highlight the points of extreme criticality.

Photo of the finished stirrer in action

MATERIALS

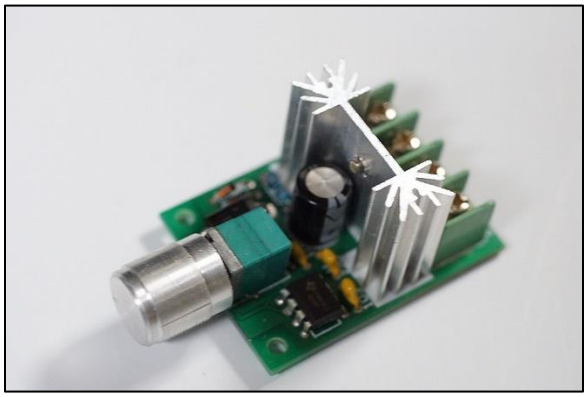
As mentioned earlier, a lot of the materials I used to make my stirrer were sort of lying around and waiting for a good home. There is plenty of scope to use alternative components to build your own stirrer but use the list of materials below as a guide – they have been shown to work.

Fan

This stirrer is intended to work hard and so a fairly powerful fan is required. The one I used is made by Delta (well known make) and the details are shown in the photo below. This is a 120mm x 120mm x 38mm fan that draws just less than 1 amp current. The fan speed is lower than many fans which makes it better suited for a stirrer. A smaller fan with higher RPM is probably not going to work very well. Most modern computer fans have 4 wires and are designed to work with the control signal separated from the power supply to the fan. With the electronic controller we will use here, the power supply itself is modulated – so don't use a 4-wire fan for this stirrer. Both 2-wire and 3-wire (the third, tachometer, wire will be unused) fans will both be suitable. This Delta fan has 2 wires.

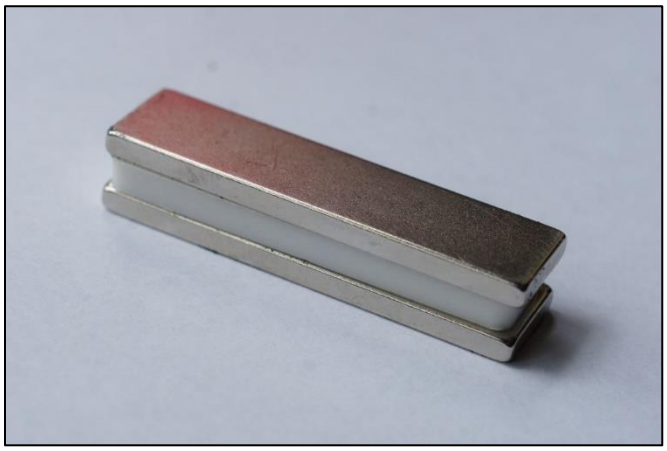
PWM Controller

A quick search of on-line vendors will reveal many PWM speed controllers. Make sure that the controller can supply 12V at sufficient current to drive the fan motor. These fans cannot be operated in reverse so don't get a controller with a polarity switch on it. The one I bought is shown below.



Magnets

As mentioned earlier, this stirrer uses some very powerful (and dangerous) magnets. These magnets are the main reason that the stirrer works so well. I suggest you use the same ones that I did – neodymium 2” x 0.5” x 1/8”.



Sample Vial

I used a 50-mL plastic laboratory centrifuge tube as an internal storage container for my stir-bars. This is completely optional but does help stop my stir-bars from getting lost (which they do very easily).

Silicone Caulking

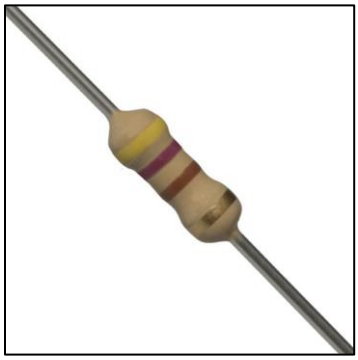
It's very important that the magnets don't fly off the fan while being rotated. I found the best way to glue the magnets to the fan blades was to use some silicone caulking that I've used to plug holes in windows etc. I unfortunately once bought some GE shares before they fell in the toilet, so buy this stuff and make me rich.

LED Indicator Lamp

Any simple 5mm LED should work. Choose your favorite color. I bought a fancy bezel to mount mine on the control panel.

Resistor

470Ω resistor to limit the current going to the LED.



Power Socket

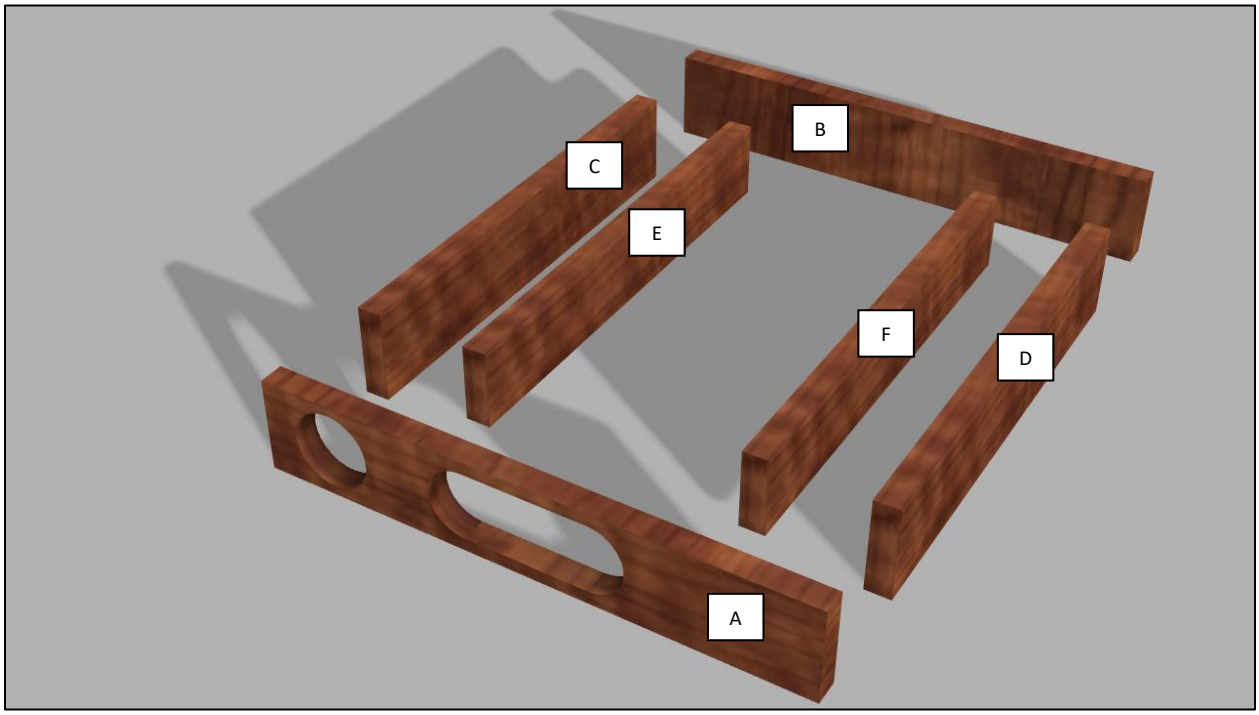
Standard 5.5mm x 2.1mm panel power jack socket.

12V Power Brick

Suggest a unit rated at 2A.

Wood

The stirrer frame is made from ½" (12mm) plywood. A piece of 5mm plywood is used for the bottom of the enclosure. My stirrer was built using pieces of this plywood cut to the dimensions in the following picture and table. A table saw would be very useful in preparing these pieces. If you don't have such a saw, see if one of your little friends can help. Some timber merchants may cut the wood for you for a nominal charge. Failing all this, you'll just have to saw up the wood the hard way😊



Piece	Length(mm)	Width(mm)	Height (mm)
A* & B	254	12	45
C & D	230	12	45
E & F	230	12	38**
Bottom	254***	254***	5

**Piece A requires further cutting – details given in the construction section.*

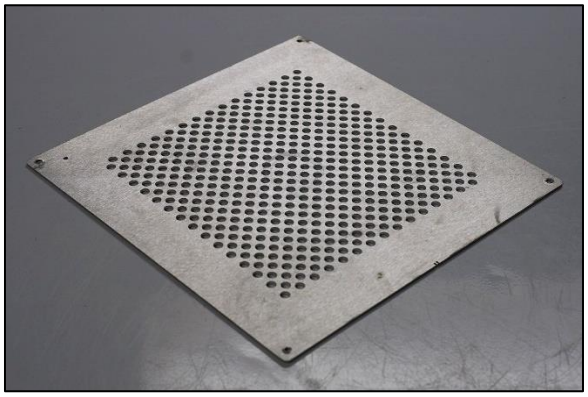
***Pieces E and F should be the same height as the fan being used. Adjust if necessary.*

****The size of the stirrer is 254mm (10") square – big enough for any homebrew carboy or bucket*

Top Plate

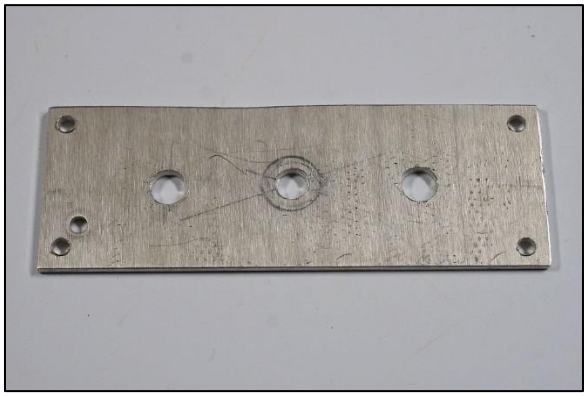
The top plate needs to support the vessel containing the liquid above the rotating magnets. A full 6-gallon carboy can weigh almost 60lb. It's important that this heavy weight doesn't push down on the top plate and bend it so that it pushes into the rotating magnets – it is very important that this doesn't happen or life gets really exciting really fast. Most commercial magnetic stirrers seem to use a thick aluminum plate to stand the stirred vessel on – so that's what I did. I had a big sheet of 10 gauge aluminum with an approximate thickness of 2.5mm that I cut to a 254mm square to fit on the top of the

frame. This sheet also had some perforations in it which looked nice and should help with ventilation. It seems to do the job very well. Alternatives would be a thick sheet of strong plastic or a thick piece of plywood. The magnets are very strong and will still rotate the stir-bar and inch or two above them.



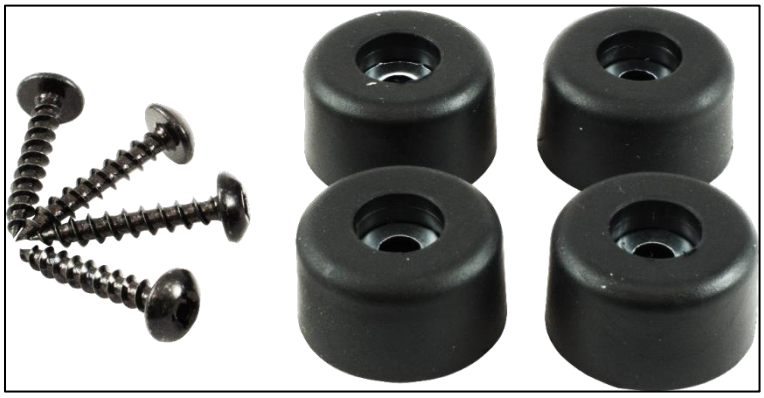
Control Panel

A small piece of the 10-gauge aluminum sheet was used to fabricate the front control panel on which all the electronics are mounted. Alternatively, this panel can be 3D printed and an STL file containing the printable design is included in the downloadable package.



Rubber Feet

Rubber feet are quite important for the stirrer. They help reduce vibration and stop the stirrer from walking around.



Other Stuff

Screws, wire, solder, etc.

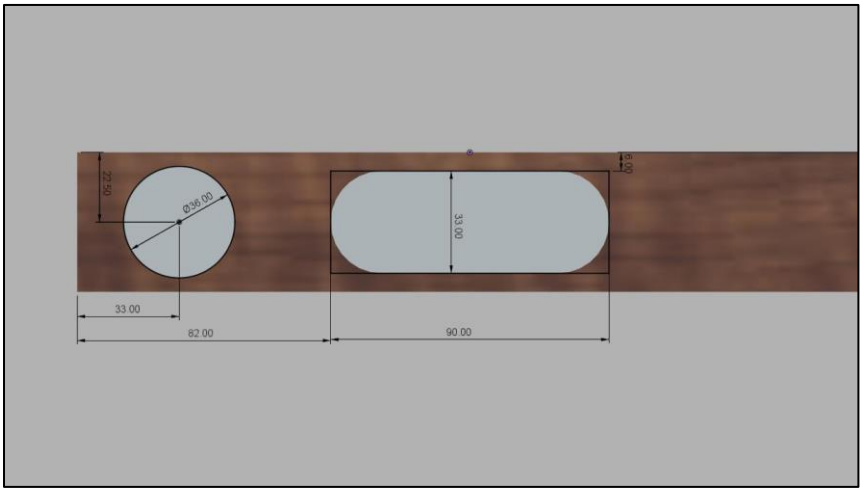
TOOLS

- Various saws
    - Table saw
    - Miter saw
    - Keyhole saw
    - Hacksaw
- Electric drill and set of bits
- 1¼" hole saw
- Screwdrivers
- Hammer
- Sash clamps
- Sandpaper
- Paint brushes
- Soldering iron

BUILDING THE ENCLOSURE

This step takes the most time to complete yet it's important to have a robust and functional enclosure if the stirrer is going to stir up 6 gallons of beer non-stop for weeks. It's worth the time and trouble to do a good job here.

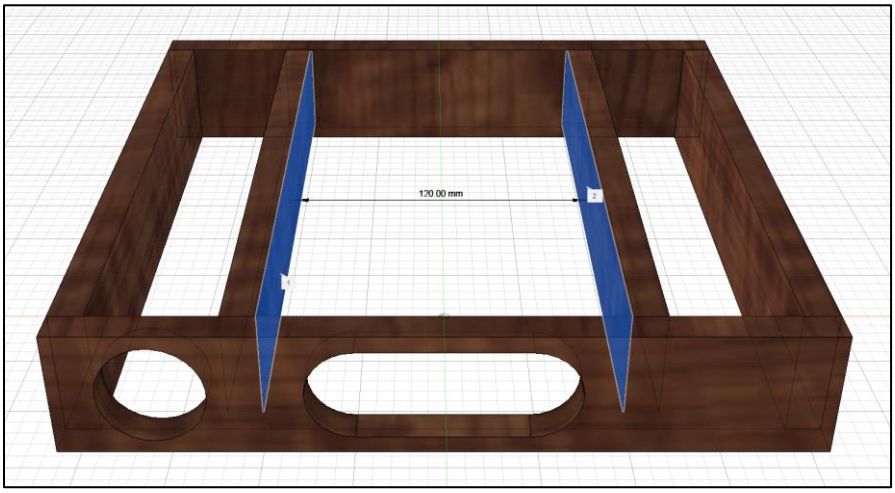
- Start by cutting the 6 pieces of wood to size as detailed in the table in the MATERIALS section. I used a powered table saw to cut the pieces to width and height and a powered miter saw to get them to length.
- The front piece (Piece A) needs to have some openings cut into it before the frame is assembled as shown in the drawing below. The larger cutout in the center is for the control panel and is unlikely to need adjustment. I used a 1” hole saw to cut out two circular holes and then a keyhole saw (or jigsaw) to cut between them.



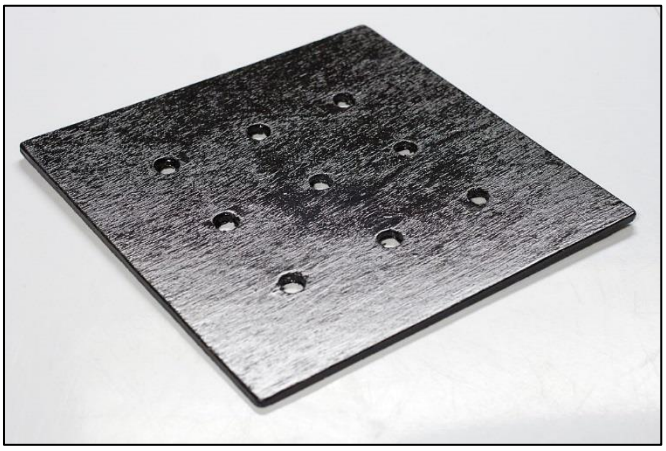
- The circular hole on the left is to accept a plastic sample tube that will hold the stir-bars (and stop them from becoming lost). The sample tube I used is a 50-mL centrifuge tube and is shown below. I used a 1¼” hole saw in a drill and a file to cut out this hole. If you use a different sample tube then the diameter of the cutout may need to be different. Of course, you can store your stir-bars elsewhere and not bother with this hole at all.

- Mark up the position of the two inner wood rails (Pieces E and F) where they meet the front and back pieces (Pieces A and B). It’s important that they be parallel, be located at the same distance from the center of the frame and be a distance apart so that the fan can easily (but not loosely) fit between them. The picture below shows the critical dimension.
- Now assemble the enclosure frame with brad nails and wood glue. The top surfaces of all the pieces of wood should in the same plane. It’s easier to achieve this by putting the frame together upside down on a completely flat surface and push all the pieces down onto that surface. The use of clamps

to hold the pieces in position while the glue dries is recommended. Check that the corners are all square and adjust if necessary. Leave overnight for the glue to dry. The frame should look like the picture below.

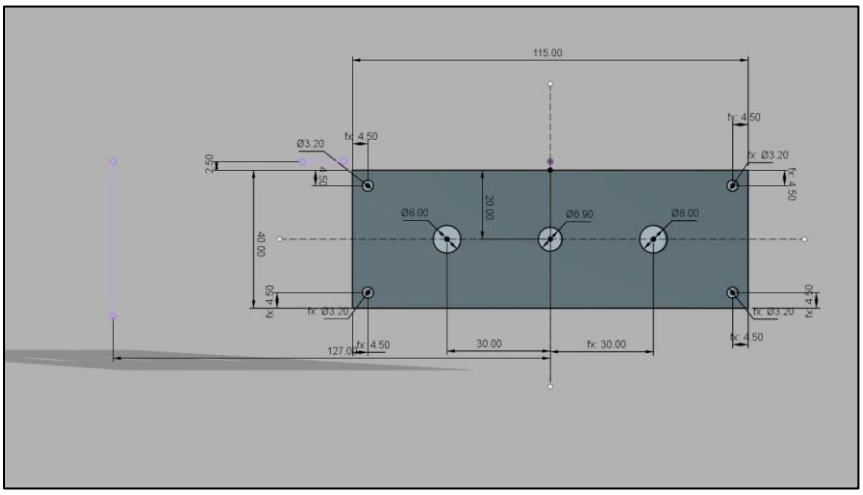


- Once the glue has set, chase the nail heads into the wood and plug the spaces above them with some form of plastic wood filler. Also fill in the holes and cuts in the wood where you made mistakes. Let the wood filler dry.
- Cut the wooden square panel for the base of the case to size. I used the table saw to do this. Drill a screw hole in each corner. I also drilled a few ½" holes around the center of the panel for ventilation.



- Sand down the external surfaces of the wooden frame and the base panel. Prime with a suitable priming paint and then finish with an enamel paint in your choice of color. I used black – mainly because I already had some and it looked rugged. There's no need to paint all the internal surfaces as they won't be seen. I suppose there's no need to paint the case at all and it can be left in its original rustic form.
- Screw the bottom plate to the frame using four small screws.
- Mount a rubber foot in each corner of the bottom plate using small screws.
- The control panel plate needs to be built next. This can be produced on a 3D printer using the STL file accompanying this document in the download package. Alternatively, a sheet of aluminum or

strong plastic can be cut to size with saws and holes drilled as shown in the following drawing. There's a hole in each corner to screw the panel to the enclosure. In the center are three larger holes. The left hole is for the LED and its bezel. The middle hole is to take the shaft from the motor speed controller board. The right hole is to take the power socket. Drill these holes with diameters to suit the parts you have.



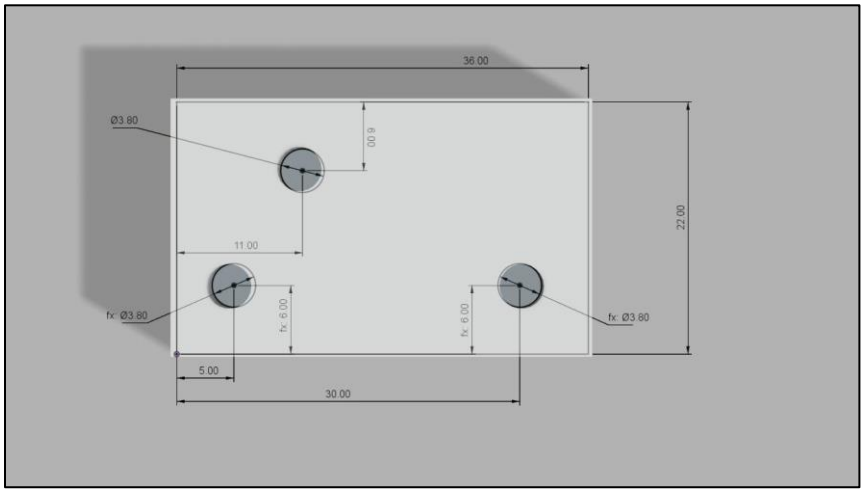
- When the control panel is finished, check that all the components will fit into their holes and that the panel can fit behind the cutout in the front piece of wood (Piece A). Put the control panel to one side until it's needed later.
- Insert the plastic sample vial into the hole on the left of the front piece of wood. Retain it to the wooden walls either side with staples or silicone caulking.

- Cut the top plate to size and drill a screw hole in each corner and countersink it. We don't want screw heads sticking up from the plate that can damage a glass carboy.
- Screw the top plate to the frame using small counter-sunk screws.
- Check that everything fits nicely and looks nice.

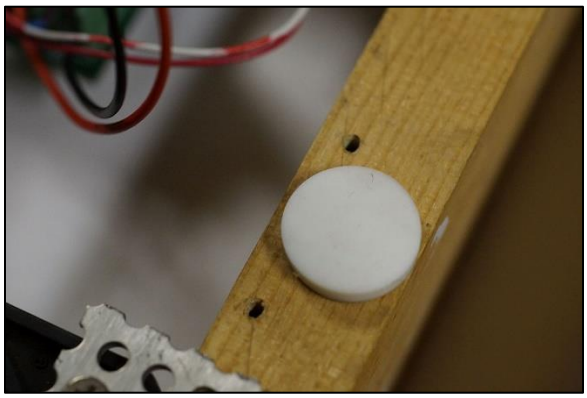
PREPARING THE FAN

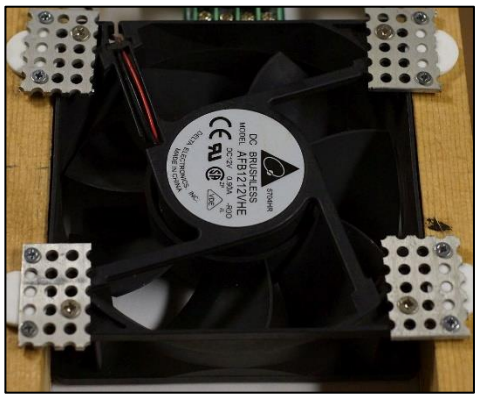
- Before doing any work on the fan, first connect it to the speed controller board, connect the 12-volt power supply and make sure that the fan spins and its speed can be adjusted. If it doesn't, check your connections and try reversing the connections to the fan – some only work in one direction. Disconnect the power.
- Put some blobs of silicone caulking across the diameter of the fan blades and push the two neodymium magnets into the caulking. Make sure that sufficient caulking is used to hold the magnets securely in place and that the magnets are arranged symmetrically and horizontally around the center of the fan. Any imbalance is going the make the stirrer shake like crazy. If the magnets come free while the fan spins, there's going to be some serious damage caused to the stirrer. There should be no lumps of caulking left above the fans which may catch the case.

- Leave the caulking to cure for a couple of days.
- Check that the magnets are properly located and that the silicone caulking has fully cured. Reconnect the fan to the speed control board and power and check that it spins without a lot of vibration. Disconnect the power.
- Remove the top and bottom plates from the enclosure.
- Prepare four small aluminum plates as shown below. Note that the screw plates I used were made from scrap material with perforations.



- Screw a plate into each of the screw holes in the bottom of the fan (opposite side to the magnets) as shown below. Suitable screws should be shipped with the fan.
- Locate the fan between the two wooden rails (Pieces E and F) and position it centrally in the frame. The power cable should be directed towards he front of the frame.
- Insert a piece of rubber sheet or a pad as a buffer between each screw plate and the wooden rails as shown below.
- Screw the screw plates to the wooden rails with two small screws.

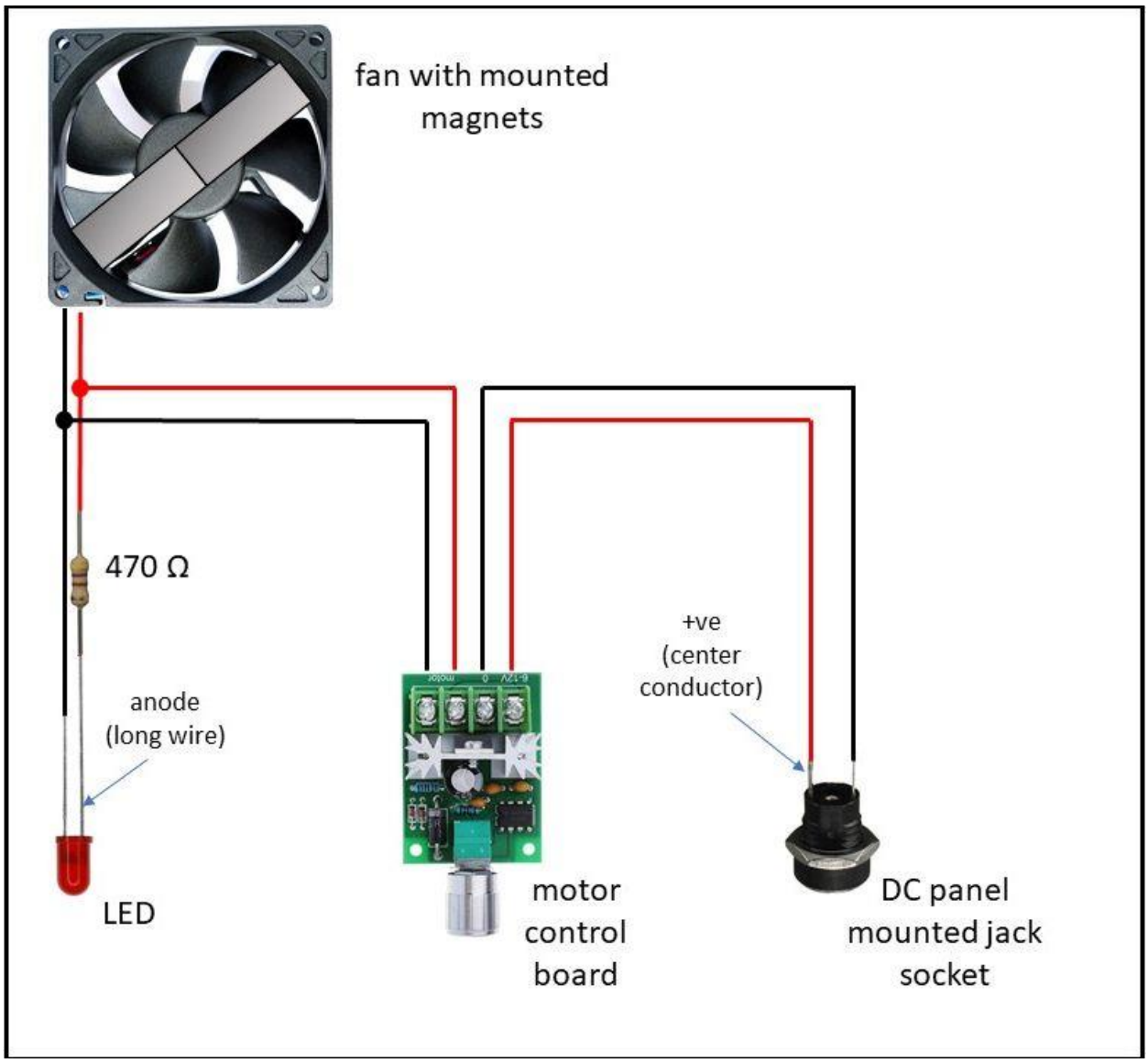




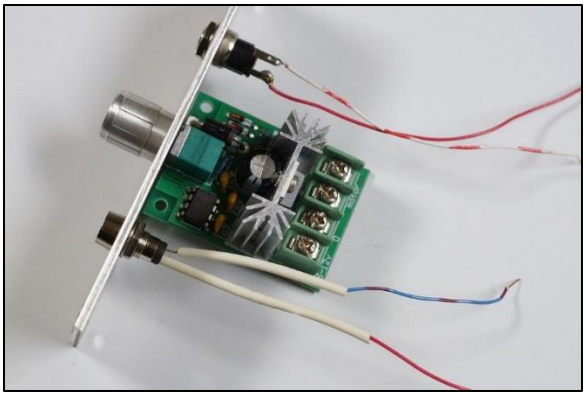
- The rubber buffers should lower the fan in the frame so that the rotating magnets do not impact the top plate when fitted – there should be a gap of about 2mm between the magnets and the top plate. Check that the fan blades with the mounted magnets spin freely and add or remove further rubber buffers until the gap is correct. The buffers will also help minimize vibrations coming from the fan.

INSTALLING THE CONTROL PANEL

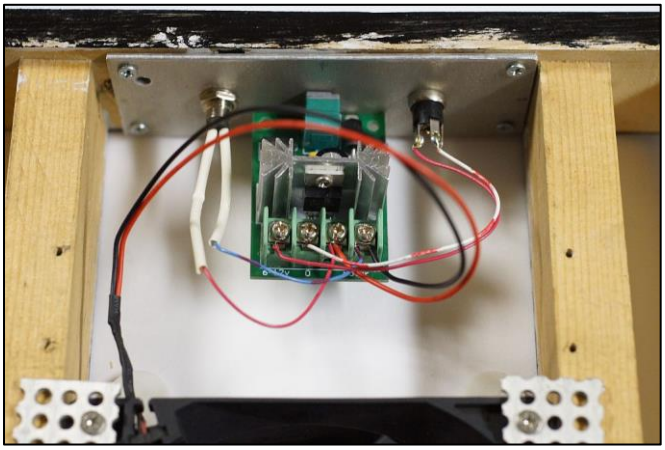
- Fit the LED in its bezel into the left hole in the control panel. Tighten the securing nut.
- Fit the power jack socket into the right hole in the control panel. Tighten the securing nut.
- Fit the motor speed controller into the middle hole. I mounted this board upside down to keep the metal heatsink away from the metal top plate. Tighten the securing nut.
- Connect everything up according to the drawing below.



- Assembly Notes
    - The wires and resistor to the LED and the wires to the power jack socket will need to be soldered.
    - Solder the 470 resistor to the anode (long pin) of the LED and then to a wire. Conjnect another wire to the LED cathode.
    - The positive voltage from the power supply will be connected to the central pin of the power jack socket. The negative will be connected to the outer conductor in the socket. Make sure these are connected correctly.
    - The panel should now look like the picture below.



- Screw the control panel to the inside of the front piece of wood, behind the cutout in the center as shown in the following picture.



- Connections to the motor speed control board will normally be by a screw terminal.
- Connect the LED and the serial resistor wires in parallel to the fan connections as shown in the circuit diagram above. Note the polarity of the connections shown in the diagram – it's not obvious by looking at the speed control board.
- Connect the wires from the power jack socket to the remaining two screw terminals.

- Check that everything is wired up correctly – particularly that the voltage polarity of the connections is correct. Use electrical tape and/or heat shrink insulation to insulate the wires and connections so that there aren't going to be any electrical shorts.
- Check the connections, again.
- Replace the top and bottom plates.

TESTING THE STIRRER FOR THE FIRST TIME

- Proceed carefully – any mistakes are likely to be spectacular! If the stirrer doesn't work as expected, turn it off immediately and check things out. Main things to look out for are:
  - Wiring errors – look for smoke.
  - Magnets flying off the fan.
  - Magnets rubbing on top plate

- To test the device, first turn the speed knob on the motor speed controller to the off position (fully counter-clockwise).
- Remove everything from the top plate
- Apply 12V power to the jack socket
- Turn the speed control knob about 45° clockwise to turn on the fan to a low speed. The LED should illuminate, and the fan should start spinning. The fan may take a few seconds before it moves – this is normal. If none of this happens, turn off the stirrer, disconnect the power supply and check things out.
- If the LED and the fan appear to work properly, slowly increase the speed until the maximum is achieved. Leave for several minutes. If your stirrer hasn't caught fire or blown itself apart, it's ready to use.

STIR-BARS

Stir-bars are also known as fleas (presumably because they can be made to jump around easily). They can come in a variety of sizes and shapes (and costs). Contrary to expectation, it's easier to stir a large volume of liquid with a small stir-bar than with a large stir-bar. The big ones just can't keep up with the motor when it runs at high speeds and will quickly leap to the side of the vessel.

For 6 gallons of liquid inside a HDPE bucket, I found that a 30mm stir-bar was the easier to use and gave the best performance. I've found that a 30mm stir-bar works best in most vessels and will give the greatest stirring effect. The exception would be for a small volume (e.g. 50mL) in a small vessel where a much smaller stir-bar would be better.

The best solution would be to buy a set of stir-bars with a range of sizes and you can try them out on your equipment.

Stir-bars are very easy to lose and so the storage feature inbuilt into the stirrer is very useful.

Note that PTFE can withstand high temperatures and so a good way to sanitize a stir-bar would be to boil it in water for several minutes.

USING THE STIRRER

Using a magnetic stirrer needs a bit of skill and patience. Dumping the stir-bar in a vessel and turning on the motor is not going to work reliably.

Easy Setup

The following is the procedure I use to set up a typical stirring session. It's important to start at a slow speed, otherwise the stir-bar won't be able to lock on to fast spinning magnets.

- Place the stirrer in the location you want to use it.
- Turn the speed control to off.
- Connect the 12V power supply.
- Place the vessel containing the liquid to be stirred on the stirrer top plate.
- Carefully centralize the vessel on the top plate.
- Drop the sanitized stir-bar down the center of the vessel. It will lock on to the magnets.
- Seal the vessel (purge with carbon dioxide if the beer is already fermented to prevent oxidation).
- Turn the speed control about 45° clockwise to set a slow starting speed. You may not hear the stir-bar rotating so look at the liquid to see signs of movement.
- Increase the speed to get the degree of stirring required. Setting the speed too high can make the stir-bar fly off the magnets.
- Continue stirring until it's finished (you decide when that is). Consider using a mains outlet timer if you want to automate the stirring period.

Getting the Stir-bar back on the Magnets

Sometimes, no matter how careful you are, the stir-bar will fly off the magnets and sit at the edge of the of the base of the vessel.

You will have to carefully lift the vessel a few mm and slide it around above the top plate. The magnets should recapture the stir-bar. Return the vessel to the top plate and centralize it. You should be good to go.

Getting a Stir-bar out of a Vessel

When I bought my neodymium magnets for the fan, I accidentally bought 4. I use one of these to fish out stir-bars from carboys and buckets. Just hold the magnet near the side of base of the vessel, the stir-bar will latch on to it immediately. Slide the magnet up the outside surface of the vessel and up to the lip. The stir-bar will follow it and it can be easily pulled out.

Making a Yeast Starter

Despite being big, this stirrer can still be used with smaller vessels such as those used to make yeast starters. For instance, put the yeast in 500mL of 10% malt solution in a 1000mL Erlenmeyer flask with a cotton wool or foam plug – this lets air into the liquid while it stirs. Let it stir for 2 or 3 days at ~20°C. Evidence of fermentation should be apparent. Use this to make a bigger starter if needed, otherwise stick it in your beer.

Dissolving Solids

There are two ways I use the stirrer to dissolve solid material such as powders into beer.

In the first instance, when I'm preparing to bottle a beer, cider or mead, I need to add some priming sugar or some conditioners such as potassium metabisulfite or potassium sorbate. Just adding these things to the liquid waiting to be bottled means that the powders either end up floating or sinking to the bottom and not getting mixed at all. It's better to pre-dissolve this stuff in water and add it as a solution. Although this is better than adding powder, it may still take several days for the additions to become thoroughly mixed. By using the stirrer, I can add powders directly to the liquid and they will be fully mixed and ready to bottle in just a few minutes.

In the second instance, I want to add powders such as sugars or dried malt extract during fermentation – sort of a staggered nutrition, I suppose. One of the big problems in doing this without stirring is that the concentration of carbon dioxide in the fermenting beer can be very high. When powder is added, there's nucleation and a big explosion or bubbles leading to the loss of most of the beer. By rapidly stirring the beer prior to adding the powder, the beer is effectively degassed and no explosion occurs as the powder is added. The powder still needs to be added cautiously as it may clump and stick to the stir-bar. A

Slowly adding about 500g each hour seems to work.

Mixing Viscous Liquids

Many of my recipes involve the addition of liquid malt extract, honey, candi syrup etc. during fermentation I find that this help greatly when making really strong beers. It's not a good idea to put a large amount of sugar into the initial fermentation – the yeast won't like it!

If you add thick heavy liquids like this to fermenting beer, they will just sink to the bottom of the vessel and sit there laughing at you. It could take months for this stuff to naturally mix in. Using the magnetic stirrer will quickly mix in such liquids. Care still needs to be taken – if the heavy liquid is added too quickly, it will sink to the bottom of the vessel and the stir-bar will stick in it and stop stirring. I find if I slowly add 500g of the thick liquid every 3 hours, this seems to prevent the stir-bar from sticking.

If the stir-bar does stick, you going to need a long spoon or something similar to manually stir up and mix the thick liquid into the rest of the liquid and free up the stir-bar.

Mixing Fruit

In short, using a magnetic stirrer to mix fruit into a beer is a really bad idea. I tried it once with blackberries in a mead and it was a total disaster. The rapidly spinning stir-bar pulverized the fruit into a very thin puree. At the end of fermentation, I had a 50% level of trub in my mead. It's best to keep pieces of fruit intact so that you can drain the beer out from the gaps between them.

Aeration

The big benefit of a magnetic stirrer is that it can stir things up in a sealed container. In other words, air can be excluded during stirring. This is a big deal in homebrewing - beer and air are not good bedfellows and need to be kept apart. However, if air is present, the stirrer can be used to aerate a wort for instance. Although effective, this is probably not the best way of aeration as it could introduce unwanted microorganisms into the wort.

Degassing

During fermentation, carbon dioxide is generated in great quantity. Some of this will dissolve in the fermenting beer and can easily supersaturate to elevated concentrations. I believe that some yeasts can undergo carbon dioxide poisoning - for instance in the case of some Saison yeasts that have a tendency to stall. A brisk stir is a very effective way of reducing the level of dissolved gases. I've experienced better fermentation of a Saison beer with continued stirring.

Keeping Yeast Suspended

With regular fermentation, the trub and spent yeast will settle to the bottle of the fermenter where they will start to compact and rot. Stirring will keep the yeast and other material suspended and in contact with the sugars and nutrients in the fermenting beer. I believe that this helps to keep the yeast healthy,

reduces off-flavors and speeds up the fermentation - especially at the end of a fermentation. It also helps by reducing the concentration of carbon dioxide as mentioned above. I use this technique routinely for very strong beers.

WARNING

The biggest danger are the magnets! Don't let anything made from steel get anywhere near them. If you put a steel tray on top of the stirrer you may never be able to remove it again and it may pull pieces off the fan and completely wreck the stirrer. This stirrer is not a toy and, although you can do funny things with a stirrer like this (see the video on the website), don't let children anywhere near it!

FINAL THOUGHTS

So, there you have it!

If you do build one of these devices, I hope it works well for you. I've been using mine for over 5 years without any problems.

Good luck!