

Back-up PM Generator for Aircraft Rotary Engine

Objective:

To install a PM stator rotor assembly between a Mazda 13B engine flywheel/dampner plate and a RWS PSRU, to provide sufficient emergency backup power to supply required power for an e-buss consisting of flight critical items such as; engine controller, ignition coils, fuel injectors, fuel pumps, electric water pump. Generator will have no mechanical connection to the e-shaft (belts, gears, chains etc.), but rotor will be fixed to dampner plate, while stator is fixed to PSRU mounting plate.

Background:

A modern alternative engine is very dependant on electrical power for continued operation, due to it's use of what amounts to a basic computer as an engine controller along with electronic ignition, fuel injectors, etc. An alternator failure leaves a limited amount of time to get on the ground before battery power runs out. This can be extended by the use of an essential buss whereas only the items absolutly critical to sustaining flight are on this buss which can be isolated from the rest of the electrical system and fed directly from the battery, bypassing solenoids. For further back-up, some carry a spare battery, however this also has a finite life as well. Depending on when the failure occurred it may or may not be exhausted before the fuel. Did I mention heavy? A second alternator is more desirable, as it can take over the load and flight can continue to original destination as planned, where repairs can be done. Unfortunately it can be difficult to find space to mount a second alternator. Another concern is that occasionally an alternator failure is the result of a broken belt. Does the spare alternator share a serpentine belt? Then it's gone too. If not, often a belt failure can take out other belts too. Most installations have a mechanical pump, so loosing this belt creates much more severe problems. My installation uses an electric water pump, so I don't have this concern, but I do have even more requirement for power. Mounting the back-up alternator at the opposite end of the engine eliminates these concerns, however if it is belt driven, then it would require prop/PSRU removal to change the belt – not ideal. So the Stator/Rotor idea was born. It addresses all concerns and puts out more than enough to supply an essential buss. It's just so darned hard to squeeze it all in there. This is how I did it.

Credits:

Ernest Christly deserves the credit for this idea and determining that a Harley Davidson stator assembly was close to suitable for this application. Unfortunatley his installation is different enough that I couldn't wait for him to do all the experimenting for me. This idea may actually be the brainchild of someone else entirely as I remember it being kicked around several times over the years, before Ernest began to run with it. So if it was originally your idea, my apologies for not giving credit, and I thank you.

Thanks to Kelly Troyer for the proof reading.

And of course, thanks to FlyRotary for the invaluable resource of information sharing.

Parts:

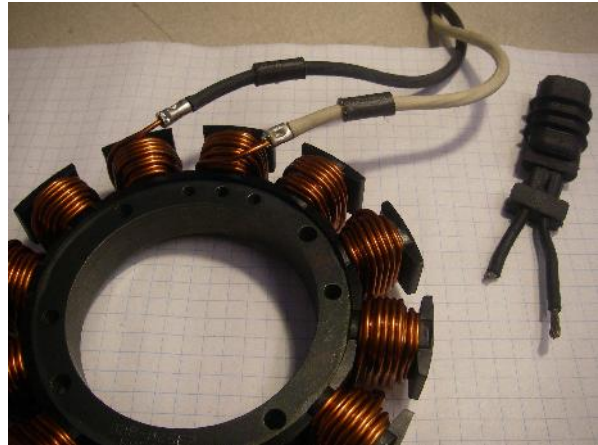
- Engine – 1986 Mazda 13B
- PSRU - RWS RD-1B
- Stator – Harley Davidson 29970-88DHD
- Rotor – Harley Davidson 29957-81BHD
- Voltage Regulator – yet to be purchased
- I recommend buying the stator/rotor/regulator from Compufire. Part #55540 \$249.95
- 1/8lb. Rivets- AN426AD-6-10
- 2 SS Rivets 3/16"x1/2"
- 2 Aluminum Rivets with steel shank 3/16"x1/2"
- 12 Bolts AN4-45
- 12 Nuts MS21044N4
- Oil Seal – Timken 471224
- 4 Stator mounting bolts 1/4"x1-3/8"
- Small brass tube clips or equivalent to clamp wires

Tools:

- Lathe
- Milling machine
- Hydraulic press
- Countersink
- Micrometer
- Wrenches, etc.
- Aluminum oxide or diamond grinding wheel
- Pneumatic blind rivet puller
- Counter Bore 5/8" with interchangeable 1/4" pilot

Procedure:

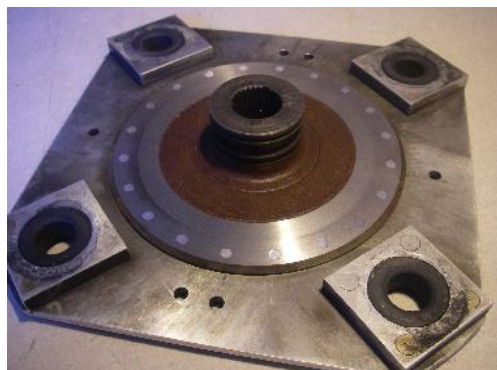
1. Remove the stock connector plug from the stator and replace with 12AWG wires long enough to reach your firewall or desired regulator mounting location. To do this you must carefully unwind the windings enough to work on them. Carefully sand ~1/2" of the insulating enamel off the wire ends. Use an uninsulated crimp to join your new wires and then solder this joint. Test the continuity of your joint carefully using an ohmmeter while wiggling the wires. This is important as it is possible to not remove enough enamel to get a proper joint.



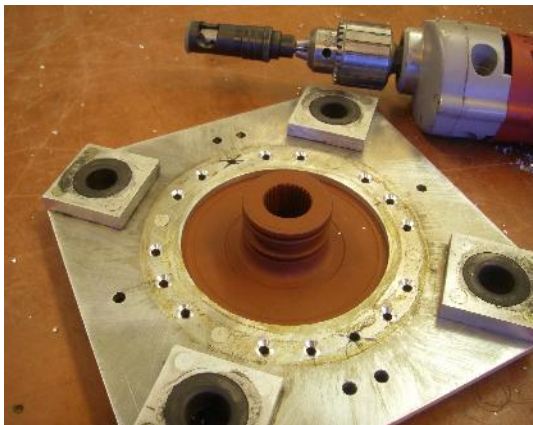
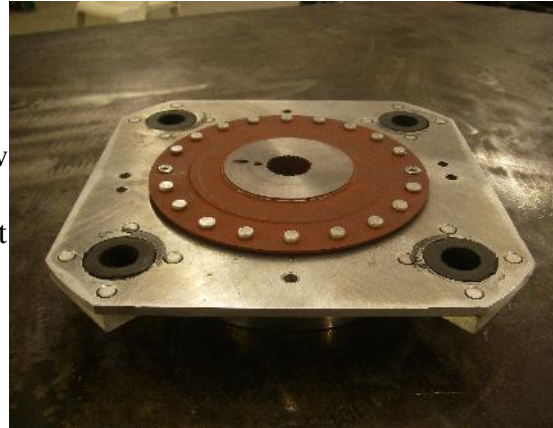
Finish this joint with the insulating sleeve removed from stock connector plug, then re-wind the wires tightly and finally replace the plastic wire guard.



2. In order to gain clearance space for the rotor, the steel hub needs to be moved to the opposite side of the dampner plate. The steel hub needs to have a small ridge machined off and all rivets removed for disassembly. I did this at once by simply machining off the rivet heads during the same operation as removing the low ridge. Then the rivets are easily punched out. My assembly had an indexing punch mark in both peices already. If yours doesn't, you should do this before disassembly.



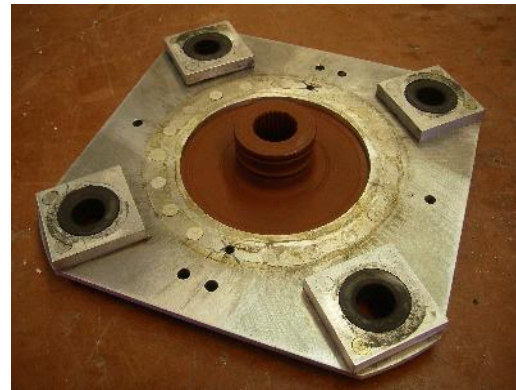
- Machine 0.25" off the backside of the steel hub. This is required for clearance from the large flywheel nut. This picture shows it was done later as I needed to wait until I could partially reassemble to determine how much would need to be removed, but it can be more easily done now. Don't worry about the oil passages that will be exposed during this machining process, they are irrelevant to our use.



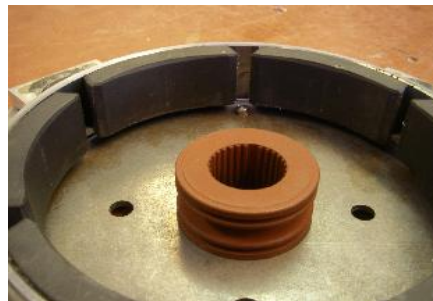
- Countersink the rivet holes in the forward facing side of the dampner plate, leaving 4 holes 90 degrees to each other uncountersunk. These will be used for mounting the rotor.

In this pic you can see that I only left out 2 holes 180 degrees apart. I changed this later to add 2 more for securing the rotor.

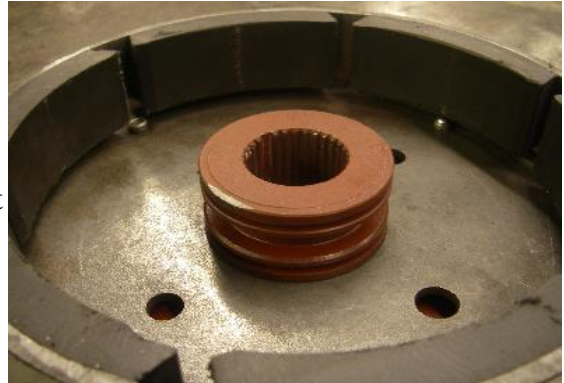
- Install the steel hub on the backside of the dampner plate (opposite to it's original location), but still in the same orientation. Use a hydraulic press to squeeze the AN426AD rivets, ensuring that the rivets are flush with the plate.



- The rotor needs to have 3/32" machined off the backside, as well as enlarging the center hole to tightly fit onto the dampner plate assembly. Do not rivet it in place yet (as seen in the pic).



7. Despite all efforts to make room for the rotor, I still needed to remove material from the edge of the rotor. This is where I discovered how HARD magnets are. A ceramic cutting tool simply broke. Carbide tools broke too. Didn't have a diamond cutting tool but it should work. I finally found that an Aluminum oxide grinding wheel (for sharpening carbide tools) worked nicely. I used it to remove 1/16" from the edge. A diamond grinding wheel should also work. Don't allow the magnet to get hot as too much heat will destroy the magnetism. Final width of the rotor should be 1-3/8"



8. Now the rotor can be riveted to the dampner assembly. The above picture shows how 2 of the rivets line up the breaks in the magnets, while the other 2 are located under magnets. None of the other magnet breaks line up with any of the remaining rivet holes. This allows a 3/16"x1/2" SS rivet to be used to fasten the rotor in 2 places. Simply fit the rotor onto the dampner assembly to center it and turn until the break between magnets is lined up with the empty holes then match drill. Remove to deburr, then hold together with clecos. The remaining 2 holes must be drilled using a stop on the bit. While the magnet is extremely hard it is also brittle, so no sense risking shattering the magnet when you drill through the stator. Remove and deburr again. Use the SS rivets for the 2 holes that line up with the magnet breaks fastening the rotor to the dampner assembly. The remaining 2 holes require a quality aluminum rivet with a steel shank. The reason for this is that a 1/2" rivet will not have the head seated when the rivet bottoms out against the magnet. A 3/8" rivet produced an insufuccient shop head. When a SS rivet is pulled before the head is seated it will expand before the head can seat regardless of hard the rivet is pushed while pulling with a pneumatic gun, but due to the different way that the aluminum rivets squeeze, they will seat the head nicely as the gun pulls them in. I'd preferr to have had a SS rivet here or squeezed AN470 rivets, but neither are possible as far as I can see. If anybody else can come up with a better solution, I'd love to hear it.

9. A locator block must be made to ensure the stator centered properly. The oil seal must be removed for this. The locator block fits into the oil seal recess and in the center of the stator. As it is near impossible to remove the oil seal without damaging it, discard it and replace with a new one.

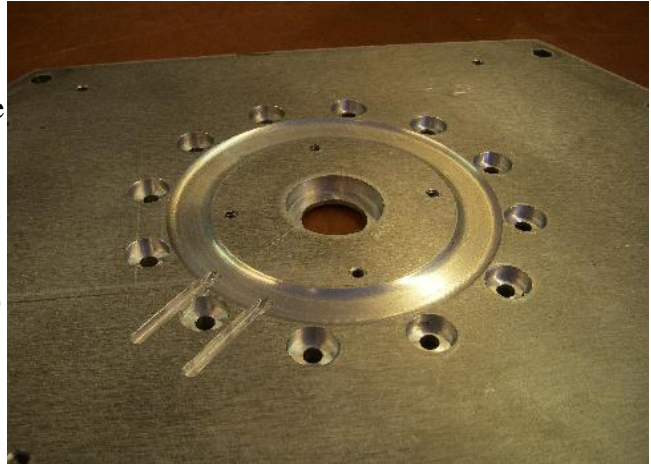


10. A 5/16" thick spacer ring is required to hold the stator off the face of the PSRU mounting plate. I machined this out of aluminum. The bolts shown in this pic were perfect, but I don't have a part number for them, however they have a 1" shoulder and 3/8" thread depth. Do not mount it quite yet, as the PSRU plate requires some further machine work.



11. The stator windings require a little additional clearance to ensure that they do not come in contact with the mount plate. I machined a 1/16" deep groove 5/8" wide to provide the clearance.
12. There needs to be 2 small channels 3/16"Dx3/16"Wx2"L for the wires to pass under the edge of the rotor.

13. The PSRU bolt holes need to be counter-bored as they line up exactly with the rotor edge. A standard counter-bore is sized for Allen-head bolts which would be ideal, but I couldn't find a source for these. So I had to order a counter-bore with an interchangeable pilot. The pilot is 1/4" to fit the existing bolt holes, but the bore size is 5/8" to allow a 7/16" socket to be used. Bore these holes just deep enough to allow the bolt head to sit flush with the plate (3/16"), without using washers. Using the washer here would require boring a little deeper, which I didn't want to do. I replaced all the existing AN4-47 bolts with AN4-45 bolts to allow for the shorter length required due to the counter-bore and omission of 1 washer. A washer is still used on the nut end. I also replaced all the old nuts.

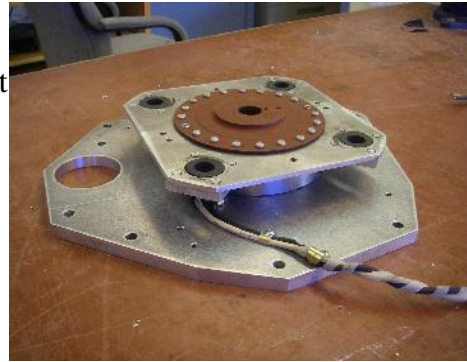


14. Now the stator can be mounted using the locator block that you'll make for this purpose. Locate the block in the center, with the wire leads in the small channels and drill through the stator mount holes to mark the hole positions. Remove the stator and finish drilling and tapping these holes to 3/8" deep using a bottoming tap. Do not drill through as the other side of this plate is the oil filled side of the PSRU. If you do, then I'm sure it won't be a real big deal as long as the stator mounting bolts are sealed with Lock-Tite. Best to just avoid this. Mount the stator in position with the spacer ring and use Lock-tite on the mounting bolts.



15. Mix a small amount of JB weld or equivalent and force it down around the wires in the wire grooves. These wires must not be allowed to come loose as they could come into contact with the spinning rotor edge. I used small brass tube clips to securely fasten the wires to the mount plate, held down by #10 screw tapped 1/4" deep. This is also important as the bolts that fasten the dampner plate to the flywheel must also not be allowed to contact these wires for obvious reasons.
16. You can install the new oil seal at this time.

17. Carefully fit the stator and rotor together. Caution must be used as the magnet is strong and can result in pinched fingers or chipping of the magnet surface. When the stator and rotor are assembled, they should result in the rotor floating due to its attraction to the stator which should leave a 1/16" gap between the rotor edge and the PSRU mount plate.



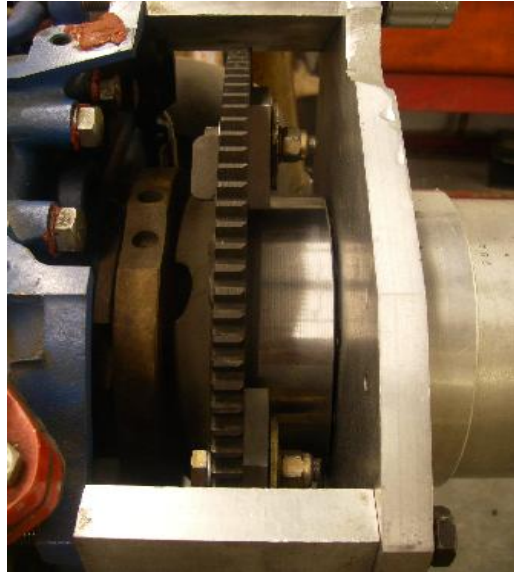
18. Assemble the stator/ mount plate to the PSRU.



19. Assemble the rotor/ dampner plate to the flywheel. There are large washers on both sides of the rubber dampner mounts that are 1/8" thick. You may be thinking that you can gain some space here by removing them from the backside in order to avoid having to remove material from the magnet. Don't remove them as they are required to completely constrain the rubber dampner.



20. Assemble the PSRU to the engine using the spacer blocks. When all mount bolts are torqued, there should be ~1/16" clearance. Rotate the flywheel by hand to ensure there is no contact sounds between the stator and rotor.



21. Ensure that there is adequate clearance between the flywheel mount bolts and stator wires.



22. Voltage regulator connection to electrical system;
To be determined.

Conclusion;

I feel that it is a successful fit and should work, however this will not be proven until later when I do an engine run. I will update this info when available.