Recharging Flywheel Magnets: Is There Any Benefit?

Recharging Flywheel Mangets_R1.doc Rev. 1.0 W. Mohat April 30, 2018

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As most AOMCI members know, ignition system on antique outboards are usually “magneto” systems, as opposed to battery, points and coil types of systems. This means that the power to generate the ignition spark comes from a magnet and pickup coil, instead of from a battery. (The spinning magnet and pickup coil form an electric generator, eliminating the need for a battery.) And, most AOMCI members probably also know that the faster you spin a generator, the more power you get out of it.

However, what most people are <u>not</u> aware of is that all permanent magnets slowly lose their charge over time. And, the weaker a magnet gets, the less power you get out of your "generator". Eventually, the magneto in your outboard will get to the point where it cannot generate spark at lower speeds (in Revolutions Per Minute, or RPM) anymore. This means that you will have to spin the motor faster to get the spark to work, and it limits how low of an idle speed the motor can achieve. This translates into harder starting, and rough, higher idle speeds.

The question is, just how fast do magnets lose their charge in outboard motors? After all, if it takes 1000 years for a magnet to lose its charge, this is sort of a pointless discussion! But, if they can lose their charge significantly in less than 100 years, then our 90 year old antique outboards might have significant problems with weak magnets.

Now, this question of “how fast do magneto magnets lose their charge", and "does re-magnetizing your flywheel magnets have any benefit" is one of the most hotly debated topics on the AOMCI forums. If you ask 10 members for their thoughts, you will get at least 12 different opinions! Some will say that they had their magnets recharged, and it made no difference at all to the operation behavior of their outboard. Others will claim that their motor didn’t run at all, but after they had the magnets recharged, the motor now runs perfectly with a smooth, low idle speed. Who is right? Well, perhaps they both are.

One thing we noticed is that none of the people on the Forums had taken any actual measurements of their engines performance. Nobody had actually measured the strength of their magnets, or of the idle RPM before or after the magnets were recharged. Without any measurements taken by actual test equipment, the opinions of these folks on the Forums were just subjective opinions, with no hard data to back them up. So, we at the Western Reserve Chapter of the AOMCI decided to do a formal scientific study, to bring some actual knowledge to this debate.

The first question we needed to answer was, just how fast do magnets in outboards lose their charge? A quick review of the literature on Permanent Magnets raised far more questions than it produced in the way of answers. More to the point, the types of magnets that we have in our antique outboards are nothing at all like the modern "rare earth" Samarium Cobalt and Neodymium magnets that are popular today.

Characteristics of Permanent Magnets in Outboard Motors

Magnet Type	Composition Example	PEAK Surface Magnetic Strength (in Gauss)	Rate of Demagnetization
Ferrite	KS Steel - 1910 MK Steel - 1930	3,500 Gauss PEAK (350 practical)	Depend strongly on environment: can be up to 1% per year
Alnico	Al-Ni-Co - 1935	10,000 Gauss PEAK (1000 practical)	About 1% in 5 years
Samarium Cobalt	SmCo5 - 1965	11,000 Gauss PEAK	About 1% in 10 years
Neodymium	Nd2Fe14B - 1985	13,000 Gauss PEAK	Less than 1% in 10 years

Fig. XX

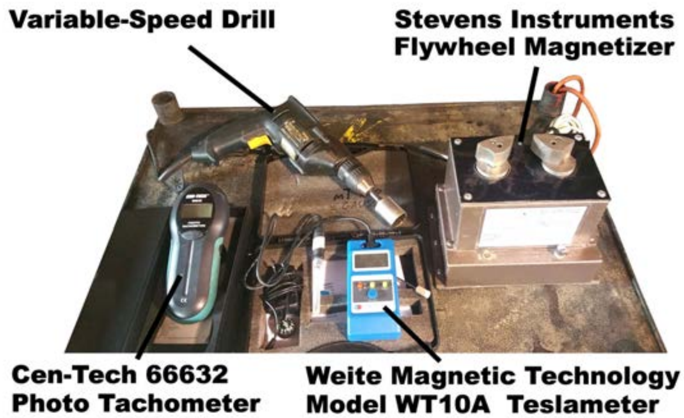
All of the articles we read stated that there were many things that could cause a magnet to lose it's charge, including heat, shock and vibration, stray magnetic fields, radiation, the chemical composition of the magnetic material itself, and (significantly) the shape of the magnet in question. Great….this proved to be of little help at all!

So, we decided to do a formal lab test on a number of outboards, and figure this out for ourselves. We decided to test a collection of outboards using the following test procedure:

1) We would remove the spark plug (so it would make the motor easy to spin!). Then, we would spin the motor slowly, and measure the RPM at which the magneto could generate a consistent, even spark.
2) We would then remove the flywheel, and the magneto magnets.
3) The strength of the magnets would be measured in Gauss.
4) The magnets would then be "recharged" on a commercial outboard flywheel magnetizer.
5) The magnets would then be measure (in Gauss) to see if there was any significant increase in field strength.
6) The outboard magnets and flywheel would then be re-installed on the motor.
7) We would then spin the motor slowly again, and measure the RPM at which the magneto could generate a stable, consistent spark, and note if there were any significant improvements.

To perform these tests, we used the following test equipment:

Test Equipment Used



Not many people have actually seen one of these Stevens Instruments magnetizers, as they have not been produced (for that matter, by ANY company) for over 30 years. Modern magnets just don't lose their charge like the old steel and Alnico magnets used in the antique outboards we are dealing with! But, some older outboards **did** have problems with magnets losing their charge, and back 50 years ago, marine repair shops usually **did** have a magnetizer as part of their standard repair equipment. Good luck finding a marine repair shop that still has one today! (For that matter, good luck trying to find a marine repair shop that will even look at an antique outboard, no matter what you might be willing to pay! This is why the AOMCI exists!)

The Stevens unit was by far the most popular magnetizer of it's day, and there are a few AOMCI members that still own one of these old units. The key to this magnetizer was it's rather unique "pole pieces", that were built to be able to directly couple to almost any type of flywheel magnet. See the pictures below for details:

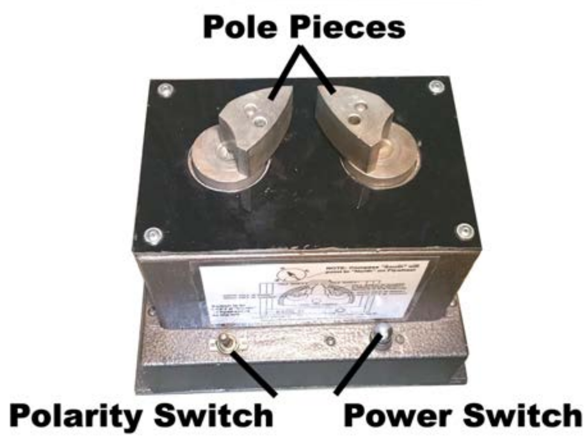
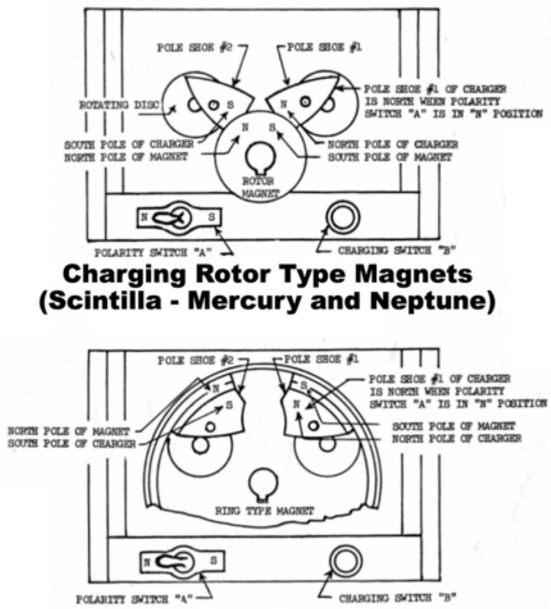


Figure XX: Stevens Magnetizer



Charging Rotor Type Magnets
(Scintilla - Mercury and Neptune)

Charging Ring Type Magnets

Fig. XX Using the Stevens Magnetizer

And so, armed with our test equipment and magnetizer, we set up a test stand and started collecting data. Over several months, we collected data on 20 different motors.

Water Witch Under Test

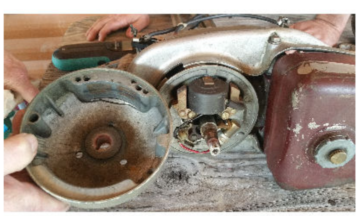
Flywheel Being Magnetized

We quickly discovered that there were more flywheel / magnet / spark coil configurations than we could imagine. Almost no two motors were the same in their construction! **And, as we were soon to discover, the physical arrangement of the magnets is a large predictor of how well they will survive over time.**

1964 British Seagull

1946 Sea King

1926 Caille "5-Speed"



1956 Neptune AA1A

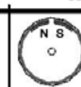
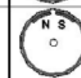
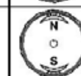
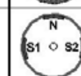
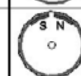
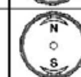
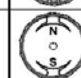
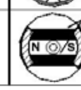
1935 Johnson 300

1933 Caille Model 179

Figure XX - Wide Range of Flywheel Styles

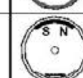
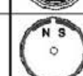
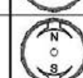
Test Data for Flywheel Magnet Analysis

NOTE: 1mT (milliTesla) = 10 Gauss. The very old steel magnets are around 400 gauss, where newer Alnico magnets are around 1,000 to 7000 Gauss.
In comparison, MRI scans (magnetic resonance) fields are typically 2 to 3 Teslas, (20,000 to 30,000 gauss), or 2000 to 3000x the Earth's field (0.25 to 0.65 Gauss).

Test No.	Outboard Tested Year / Model	Initial Condition: Gauss (Left)	Initial Condition: Gauss (Middle)	Initial Condition: Gauss (Right)	Initial Condition: Starting R.P.M.	Final Condition: Gauss (Left)	Final Condition: Gauss (Middle)	Final Condition: Gauss (Right)	Final Condition: Starting R.P.M.	NOTES
1	1925 Johnson A25 Single, 2.5 H.P.	Center: N 370 Edge:	Center: Edge:	Center: S500 Edge:	128	Center: N620 Edge:	Center: Edge:	Center: S660 Edge:	120	 VERY HEAVY 2-pole magnet structure. Almost no change in magnet strength, or in engine performance. (Steel magnets?)
* 2	1941 Water Witch Single, 3/4 H.P.	Center: N 1100 Edge: N 5300	Center: Edge:	Center: S 1100 Edge: S 4800	240	Center: N 1700 Edge: N 7500	Center: Edge:	Center: S 1950 Edge: S 5500	127	 Moderate 2-pole magnet structure. Significant increase in strength, and drop in RPM to get spark. (Alnico?)
* 3	1945 Speedy Twin (Evinrude) Twin cylinder opposed, 22 H.P.	Center: N 760 Edge: N 3300	Center: Edge:	Center: S 970 Edge: S 5400	325	Center: N 980 Edge: N 6100	Center: Edge:	Center: S 1200 Edge: S 6800	235	 MASSIVELY heavy 2-pole structure. Med. change in mag. strength and RPM. Alnico? Why the massive magnets?
4	1964 British Seagull Single Cylinder, 3 H.P.	Center: S 1100 Edge: S 2870	Center: N 1690 Edge: N 5100	Center: S 1040 Edge: S 990	445	Center: S 1160 Edge: S 2300	Center: N 1930 Edge: N 6200	Center: S 1270 Edge: S 1190	445	 Very peculiar, 3-pole magnet structure. Almost no change in mag. strength, and NO change in RPM to get spark.
5	1925 Johnson K45 Twin cylinder opposed, 9.8 H.P.	Center: S 165 Edge: S 390	Center: Edge:	Center: N 127 Edge: N 365	< 60	Center: S 212 Edge: S 595	Center: Edge:	Center: N 180 Edge: N 490	< 40	 VERY HEAVY 2-pole magnet structure. About a 25% increase in mag. strength. Hard to measure RPM under 60! (Steel magnets?)
6	1935 Johnson Model 300 Opposed Twin 3.7 H.P	Center: S 128 Edge: S 330	Center: Edge:	Center: N 102 Edge: N 310	140	Center: S 160 Edge: S 400	Center: Edge:	Center: N 130 Edge: N 420	100	 MASSIVELY heavy 2-pole structure. Med. change in mag. strength and RPM. Why the massive magnets?
7	(1926) Evinrude Model "N" "Sportwin", twin cylinder, about 2 H.P.	Center: S 120 Edge: S 320	Center: Edge:	Center: N 90 Edge: N 320	X	Center: S 140 Edge: S 425	Center: Edge:	Center: N 160 Edge: N 410	X	 Very heavy 2-pole structure. MASSIVE, passive pole pieces. (Jerry Kay motor)
* 8	Caille Model 179 1933 Single Cylinder, about 2 H.P.	Center: N 50 Edge: N 110	Center: Edge:	Center: S 20 Edge: S 43	X	Center: N 77 Edge: N 160	Center: Edge:	Center: S 42 Edge: S 93	X	 (2) Steel bar magnets, SMALL (2) raw steel pole pieces; this doesn't hold mag. charge very well. Jerry Kay said: "hard to start", but now is "fixed".

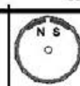
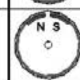
MagnetoFunctions3.dwg

Test Data for Flywheel Magnet Analysis

Test No.	Outboard Tested Year / Model	Initial Condition: Gauss (Left)	Initial Condition: Gauss (Middle)	Initial Condition: Gauss (Right)	Initial Condition: Starting R.P.M.	Final Condition: Gauss (Left)	Final Condition: Gauss (Middle)	Final Condition: Gauss (Right)	Final Condition: Starting R.P.M.	NOTES
9	1941 Evinrude Speedy Four, 33 H.P.	Center: S110 Edge: S530	Center: Edge:	Center: N90 Edge: N490	150	Center: S140 Edge: S670	Center: Edge:	Center: N120 Edge: N490	110	 Massive, single steel magnet. Low flux. Very large 2-pole structure. Polarity of magnets was OPPOSITE of what we normally see.
10	1951-52 Johnson QD-13 Twin, 10 H.P	Center: S310 Edge: S650	Center: Edge:	Center: N490 Edge: N850	190	Center: S320 Edge: S650	Center: Edge:	Center: N520 Edge: N910	160	 True modern-style magneto, with 3-pole armature and 2-pole magnet structure. Apprear to be ALNICO magnets; only 10% improvement. SMALL magnet!
11	1924 Johnson Model "A" 2H.P. horizontally-opposed twin.	Center: S144 Edge: S534	Center: Edge:	Center: N101 Edge: N423	160	Center: S166 Edge: S669	Center: Edge:	Center: N140 Edge: N482	145	 VERY HEAVY 2-pole magnet structure. Almost no change in magnet strength, or in engine performance. LOW FLUX steel magnets.
12	1929 Evinrude Model "N" 2.5 H.P. horizontally-opposed "Sportwin"	Center: N320 Edge: S340	Center: N85 Edge: S102	Center: N376 Edge: S400	275	Center: N384 Edge: S383	Center: N104 Edge: S125	Center: N433 Edge: S451	216	 Very heavy 2-pole structure. Massive magnet ring, passive pole structure. STEEL, med.
* 13	1946 SeaKing "Midget" 1.1 H.P. Single	Center: N454 Edge: N680	Center: Edge:	Center: S477 Edge: S1356	210	Center: N585 Edge: N1635	Center: Edge:	Center: S615 Edge: S1615	133	 Tiny, "Scintilla-style" center magnet (Alnico? Why the "fade"?) Significant improvement.
* 14	1947 SeaKing "Midget" 1.1 H.P. Single	Center: N531 Edge: N1250	Center: Edge:	Center: S549 Edge: S1455	214	Center: N607 Edge: N1660	Center: Edge:	Center: S635 Edge: S1875	134	 Tiny, "Scintilla-style" center magnet (Alnico? Why the "fade"?) Significant improvement.
15	1956 Neptune Model AA1A 1.7 H.P "Mighty Mite"	Center: S387 Edge: S1049	Center: Edge:	Center: N378 Edge: N1405	220	Center: S423 Edge: S1140	Center: Edge:	Center: N409 Edge: N1565	143	 True modern-style magneto, with 3-pole armature and 2-pole magnet structure. Apprear to be ALNICO magnets; only 10% improvement. Tiny everything!!
* 16	1930 Johnson K50 Rotary-valve TWIN, 8 H.P.	Center: N142 Edge: N499	Center: Edge:	Center: S170 Edge: S490	330	Center: N176 Edge: N632	Center: Edge:	Center: S212 Edge: S615	152	 VERY HEAVY 2-pole magnet structure. Medium change in magnet strength, significantly better engine performance. Fairly weak steel magnet, good fix!

MagnetoFunctions3.dwg

Test Data for Flywheel Magnet Analysis

Test No.	Outboard Tested Year / Model	Initial Condition: Gauss (Left)	Initial Condition: Gauss (Middle)	Initial Condition: Gauss (Right)	Initial Condition: Starting R.P.M.	Final Condition: Gauss (Left)	Final Condition: Gauss (Middle)	Final Condition: Gauss (Right)	Final Condition: Starting R.P.M.	NOTES
• 17	1938 Neptune Model 9A2X. 9 H.P twin, horizontally opposed.	Center: S155 Edge: S627	Center: Edge:	Center: N139 Edge: N720	300	Center: S241 Edge: S901	Center: Edge:	Center: N174 Edge: N900	85	 VERY HEAVY 2-pole magnet structure. Medium change in magnet strength, Significantly better engine performance. MUCH smaller coil than competitors....
• 18	1925 Johnson A25 opposed cylinder twin 2.25 H.P.	Center: N141 Edge: N445	Center: Edge:	Center: S174 Edge: S505	175	Center: N204 Edge: N664	Center: Edge:	Center: S227 Edge: S733	112	 VERY HEAVY 2-pole magnet structure. Medium change in magnet strength, Significantly better engine performance. MASSIVE single secondary for 2 plugs.
19	1947 Mercury KD4 Alternate-firing twin 6.6 H.P.	Center 1: S292	Center 2: S223	Center 3: S290	Center 4: N733 / 123	Center 1: S294	Center 2: S230	Center 3: S301	Center 4: N764 / 120	 Small, Scintilla-style INTERNAL magnet. 4-pole (3 South, 1 North !) Alnico. Not much improvement in mag. strength or RPM.
• 20	1926 Caille "5-Speed" Opposed Twin Cylinder, 2 3/4 H.P.	Center: S111 Edge: S406	Center: Edge:	Center: N79 Edge: N440	225	Center: S147 Edge: S523	Center: Edge:	Center: N98 Edge: N603	131	 Massive steel magnet, with HUGE armature / coil structure, that included a "keeper" in the magnet gap. Significant improvement overall.
21		Center: Edge:	Center: Edge:	Center: Edge:		Center: Edge:	Center: Edge:	Center: Edge:		
22		Center: Edge:	Center: Edge:	Center: Edge:		Center: Edge:	Center: Edge:	Center: Edge:		
23		Center: Edge:	Center: Edge:	Center: Edge:		Center: Edge:	Center: Edge:	Center: Edge:		
24		Center: Edge:	Center: Edge:	Center: Edge:		Center: Edge:	Center: Edge:	Center: Edge:		

MagnetoFunctions3.dwg

Analysis of Test Results

1) First of all, we discovered that EVERY OUTBOARD did show <u>some</u> improvement in magnetic field strength, typically about 25% to 50%. This increase in magnet strength, however, did NOT directly correspond to an increase in low-RPM ignition performance. The relationship between magnet strength and low-RPM performance was NOT a simple 1 to 1 relationship. The types and sizes of the magnets and coils had a strong impact on the performance of the "recharged" magneto system. While every outboard showed some improvement, the low RPM speed on some (for example) might have only dropped from 120 to 100 RPM…..far too low of a improvement to perceive without test equipment. On other outboards, even if the magnetic improvement was slight, the RPM needed for a hot spark might drop from 300 to less than 100 RPM. It was impossible to predict how much improvement in spark strength and lowering of RPM you would get, just based on the improvement in the magnet strength.
2) On the REALLY OLD outboards (pre 1930)…..we discovered that most of them were WILDLY OVERBUILT. The size of the magnets in the flywheels, and the size of the pickup coils and armatures, were FAR LARGER than was necessary to product a very nasty spark, even at fairly low RPM speeds. Take a look at the size of the magnets, pole pieces, and coils in this 1926 Caille "5-Speed", for example. These parts are at least 3 times larger than they needed to be, to produce a reliable spark at very low RPMs. For this reason, many of the 1920s vintage outboards did NOT show much improvement, because even with significant loss

of magnetic field strength, they still had far more size than was necessary to produce a good low RPM spark. We suspect this is why many people had their magnets recharged, and did not see any improvement in performance that they could perceive with their 5 senses.

3) We had one 1925 Johnson K45 that could knock a person on their backside, at under 45 RPM, just turning the flywheel by hand. (Ask me how I know this, and why Gary Orloff is still laughing about it!) But, not every 1920s outboard held up this well. Look at the 1933 Caille Model 179, in the picture below. Note how it has two separate bar magnets (not the large huge "U" magnet like what was in the Caille 5-Speed.) This magnet had significant loss in strength and RPM performance over time. We theorize that the "U" magnets, with their end pole pieces so close together, sort of act like their own "keeper". The Model 179, in contrast, acts like raw bar magnets with no "keeper", and this might account for the losses.

4) Once you get to the mid 1930s, two big changes seem to have occurred at almost the same time:

1. The manufacturers switched to the “3-pole” armatures, and MUCH SMALLER magnets and pickup coils. Clearly, this was done to save costs. However, now that the magneto components were JUST BARELY LARGE ENOUGH TO DO THE JOB, any loss in magnet strength produced a SIGNIFICANT LOSS in low-RPM performance.
2. By the later 1930s, most manufacturers switched from STEEL to ALNICO magnets. This greatly reduced the size of the magnets needed to get a hot spark at low RPM. However, the Alnico magnets were too new for the manufacturers to have any experience with them, so some were oversized, and some were undersized.

As a result of these two evolutionary changes at the same time, the mid 1930s to early 1940s motors seemed to be the most vulnerable to loss of magnet strength, AND to loss in low RPM performance because of it. It was this group of motors that seemed to have the most improvement when their magnets were recharged.

5) After 1950, however, most manufacturers seemed to get everything sorted out. They managed to take advantage of the more powerful Alnico magnets, and also figured out the optimal size for their pickup armatures and coils. As a result, outboards after 1950 seemed to NOT have significant problems with loss of magnet strength producing performance problems. (However, again, EVERY outboard did show SOME improvement, on the order of 10 to 20%, in spark performance.) This might not produce a noticeable improvement in “ease of starting” and “low RPM performance”…..but there was always SOME improvement. Lab test equipment doesn’t lie!

6) The “rotor style” tiny internal magnets, like the Scintilla units used on some Neptune and Mercury models, seemed to all have Alnico magnets. However, where these smaller rotors in TWIN cylinder engines all seemed to work fine, and didn’t seem to fade much over time, the small rotors in SINGLE cylinder engines seemed to degrade rather quickly. It seems the magnet structures in the SINGLE cylinder engine rotors are about ½ the size of the magnets used in the TWIN cylinder engines. For some reason, this doubling of size greatly reduced the “loss of magnetism over time” effect on small rotor magnets. This was a complete surprise to us. (For example, the SeaKing singles were not NEARLY as robust as the Mercury KD4 twins, even though the systems look very similar. Odd!)

6) Almost all of the older magnets that looked like a solid bar were made of steel, and had field strengths on the order of 100 to 300 Gauss. Almost all of the newer magnets looked like they were made of a stack of thin plates (like laminated transformer cores)…..and these were all Alnico magnets, with field strengths on

the order of 500 to 7000 Gauss. But, ALL of the magnets faded a bit, and ALL showed some improvement after recharging (even if it was slight.)

Summary, and Final Observations:

I hate to weasel out of any strong recommendations, but our test results seemed to prove the old adage that "Your mileage may vary…..!" As stated earlier, each and every outboard did show some improvement in magnet strength after being re-magnetized, but this didn't necessarily translate to noticeable improvement in the low-RPM idle speed. On some outboards, the improvement could only be perceived with lab-grade test equipment. However, on other outboards with similar magnet structures and improvement in magnetic field strength, you might see a dramatic improvement in the low-RPM idle speed.

As Gary Orloff points out, though….just because your SPARK works at very low RPM, doesn't mean your engine will be able to run that slowly! If your carbs are not cleaned and adjusted properly, (or if any of 100 other problems exist), a hot spark won't get you any better low-RPM performance. As the old adage says, "a chain is only as strong as the weakest link". Assuming you have everything else in your outboard all cleaned, aligned, and adjusted properly, but you still can't get it to start easily or idle at a low speed, then recharging your magnets might be just the fix you need.

Only about 30% of the outboards we tested showed a dramatic improvement in ignition performance. Another 20% showed SOME improvement, but not very noticeable without test equipment. And, about 50% showed such slight improvement, that you could say that recharging the magnets was a waste of time. Problem is, you just don't know whether or not recharging the magnets on any specific outboard will give you significant gains or not!

Fortunately, recharging the magnets is a very simple thing to do. And, (at least at the AOMCI Western Reserve Chapter), it won't cost you anything. So, our recommendation is, if you already have your motor disassembled for repairs, you might as well recharge the flywheel magnets while you are there. It certainly couldn't hurt, and you might well be very pleasantly surprised at the results!

One last note: I'd like to invite all other AOMCI members to send me information about magnetizers that you know about. If someone in your local chapter, or if any local marine repair center that you know about has a magnetizer, please let me know, and send me complete contact information for these sources. **Also, please let me know if they will remagnetize a flywheel for free, or if they expect to charge some fee for it.** I'd like to produce a list of the magnetizers that our club members know about, and make this list available to the club membership at large. This is what this club is all about!

Oh, and what I said about the Western Reserve chapter NOT charging a fee for recharging your flywheel magnets…..that only applies if you bring us a small number of flywheels to work on. But, if you send us a truckload of flywheels and expect us to fix them all and return them for free, then I suspect we're going to have to have a discussion about it!

1947 Mercury KD4, with Scintilla style rotor.