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Russian Magnetos, Ignition Systems and Timing Them

By George Coy

I have been asked many times to explain the ignition systems on the **M-14P** engines and their cousins the M14B, the **M-14V26**, the **AI-14RA**, the M462 and the **Ash62IR**. The following is a discussion of the ignition systems and how to properly time them.

Definitions

The M-14P (the data plate will show the Russian character ∏ which is the Russian letter P) also known as the **Vedeneyev**, **Voronesh** or **Bacanoff** engine is the basic 360 hp. (or 400 hp.) 9 cylinder radial used on most Russian piston aircraft. That includes the Yaks (18T, 52, 54 & 55) and Sukhois (Su26, 29 &31).

The **AI-14RA** is the engine that comes on the Wilga and several other eastern aircraft. It is closely related to the engines on the Chinese Namchung aircraft.

The M462 is a Czechoslovakian variant of the **AI-14RA** that produces 315 Hp and is used on many Eastern agricultural aircraft.

The **M-14V26** is a variant of the standard 360 Hp **M-14P** that has a right angle drive on the nose case and a pair of these engines are used to drive the rotor gearbox on the Kamov 26 helicopter.

The M14B is a **360** Hp. engine with a splined shaft for the propeller. It was developed for the AN14 aircraft a light twin similar to the Aerocommanders.

The **Ash 62IR** is the 1000 hp engine used on the An-2 aircraft. It is also a 9 cylinder radial that has a magneto that looks very similar to the magnetos on the smaller engines. The **Ash 62IR** magneto does not interchange with them, as it has a different basic internal gear ratio and has a different rotor cap.

The three magnetos are the M9Φ (Russian Character Phi western letter F), the M9-35M and the M9-BSM (Big Soviet Magneto?). The M9-BSM is used only on the **Ash62IR** engine and will not work on the smaller engines. We will limit our discussions to the M9 F (Φ) and the M9-35M

Some Radial Basics

Many people do not understand the basics of the radial engine and why it has an odd number of cylinders. The odd number of cylinders is necessary because it is a four-cycle engine. Think about a four-cycle engine and the four cycles. The piston must come to the top of the cylinder two times for each cycle. Once at the top of the exhaust stroke (beginning of the intake stroke), and once at the top of the compression stroke (beginning of the power stroke). Now imagine the #1 piston at the top of the compression and ready to fire for the power stroke. As the single throw crankshaft rotates, the #2 piston will need to be coming up to the top of the exhaust stroke and ready to start the intake stroke. Continue this around the engine. Thus we fire on 1, 3, 5, 7, 9 and intake on 2, 4, 6and 8.

Soon you will come back to the number 1 again. If we had an even number of cylinders, we would never get to fire half of the cylinders and the other half would never get to do the intake/exhaust stroke. Thus an odd number of cylinders are necessary so we can skip around the engine firing all cylinders. The firing order becomes 1,3,5,7,9,2,4,6 and 8.

The M-9 Magneto

There are basic two versions of the M9 magnetos used on these engines. They both will work fine on any of the AI-14RA, M462 or M-14P series engines. They differ only in the system used to start the engine. The M9-35M has a centrifugal advance system that is used to retard the spark at engine starting speeds, and the M9 F (Φ) uses a rotor with two fingers and a cap with a separate lead for the second rotor finger. They both use what is commonly referred to a "shower of sparks", but they are in reality very different in how they work.

The M9 F (Φ) needs a separate high voltage coil that continuously produces a high voltage current. (similar to the old model T spark coils). The M9-35M has an interrupter in the "P" lead circuit during the starting that turns on and off many times a second. This produces sparks similar to the normal points opening by alternately grounding and opening the "P" lead several hundred times a second. This is similar to the now popular Slick Start system and in fact the Slick Start vibrator box is an excellent way to utilize the M9-35M magnetos. It is considerable more reliable that the Czech or Russian vibrator boxes that are used on eastern aircraft.

These differences also require different starting techniques. The M9 F (Φ) system requires that the magneto switch be in the OFF position until the engine is firing and then switched to the on or both position. This is to avoid the magnetos firing at the full advance angle and the engine starting backwards. The M9-35M system requires the magneto switch to be on during starting.

The M9 F (Φ) system starter button must also engage the high voltage coil system. This produces a spark voltage that is led from the coil to the left magneto. There is a separate lead hole in the magneto cap that allows this wire to conduct the current to the cap. It then jumps a small gap to a copper ring on the rotor. The rotor has two fingers. The leading finger is about 25^{o} ahead of the trailing finger in the direction of rotation. The starting voltage is lead to the trailing finger and then as the engine rotates to the proper lead to the spark plug for the appropriate cylinder. As this finger is about 25^{o} behind the main finger, the engine fires at just past top dead center.

The M9-35M system must be started with the magneto switch in the both position. The starter button also engages the vibrator box which does the high speed switching to produce continuous sparks while the points are open.

Timing the M9 Magnetos

Now how to time the two systems. First remember that we are dealing with a geared engine. This means that the engine timing in degrees before top dead center on the crankshaft will not be the same as the number of degrees on the propeller flange. As we can only measure the advance angle at the prop flange, we must either know the gear ratio or as luck would have it, the engine manufacturers have already made the calculations and give us the advance angle in terms of prop flange angle. Thus the M14P manual calls for the points to open 14.5^{o} to 16^{o} before top dead center. This is in terms

of propeller flange degrees. It is really about 24^{o} of crankshaft rotation before top dead center.

The tools I use are the normal dual magneto timing box available from most aircraft tool houses, and a model E25 timing indicator. This indicator is a large aluminum cup with a weighted pointer and a degree scale that can be attached to the propeller hub. These are available again from most aircraft tool houses. It is used to determine TDC and the timing point (where the points just open as the engine rotates in the normal direction). I prefer these as over the years I have found them to be the most accurate way to set the timing angle. The engine tool kits come with a timing indicator that screws into the spark plug hole on the #4 cylinder. (No.4 is the master rod and presumably less chance for error in timing). These indicators can be used to determine the TDC point and the timing point. They accomplish this by measuring the piston travel in the cylinder. I have also on occasion used a pointed instrument (read screw driver) inserted in the spark plug hole of #4 cylinder to determine the TDC point. I then taped a bent piece of safety wire to the engine cowling so that it lined up with the zero mark on the propeller flange, then using that bent wire as a guide read the timing angle from the small scale stamped on the **flange of propeller shaft**.

The idea is to get the points to just open at the timing point. As stated above, for the M-14P engine this is 14.5^{o} to 16^{o} of propeller flange rotation (about 24^{o} of crankshaft rotation) before top dead center. ($23^{o} \pm 2^{o}$ BTC on the AI-14RA and M462 **of crankshaft rotation**). The eastern engine manuals call for determining the point opening position by inserting a very thin feeler gage between the points and rotating the engine in the normal direction until the feeler gage falls out. Most of us prefer to use the electronic dual magneto timing indicator. It will be necessary to make a little adapter to allow the timing indicator leads to attach to contact in the hole where the P lead screws in. I use some old lead ends from a U.S. ignition harness. It is sometimes very difficult to get to the P lead contact when the engine is mounted in the aircraft. I have seen some people partially disassemble the mag switch and attach to that end of the P lead instead of going in the P lead hole in the magneto. Either way works as long as the electronic timing indicator can determine when the points open.

I usually back the propeller 30 to 40 degrees before the timing point then slowly advance to the timing point to remove any gear backlash. I then loosen the magneto and rotate it until the points just open. I then lock the magneto down and back the propeller up again and come forward until the timing indicator shows the points opening. Then confirm this is the proper place. I usually do this for one magneto and then time the second magneto to the first.

Before starting this timing process, I have inspected the magneto and have either confirmed the point cap is correct, or have reset the gap to the proper specifications. These are set to .010 to .014 in (.25mm to .35mm). The points are platinum. Make sure that they are clean with no hint of oil on them. Wipe them with a clean lint free rag. Do not use any solvents that may leave a film behind.

Now as you may notice, the range of adjustment of the magneto for timing is rather small. You can only rotate the magneto about 10 deg. If it becomes necessary to

rotate it further to get the point opening in the right place, you will have to remove the magneto from the engine and adjust the coupling between the magneto and the engine drive gear. This is not usually a fun process with an engine mounted to an aircraft. You should consult your engine service manual for the details on how to do this. I must say that on occasion when I have rotated the magneto as far as I can and can't quite make the points open, I have fudged the point gap a little in order to get the engine to time properly without removing the magneto and fooling with the coupling.

The M9-35M magneto has a different procedure to determine the timing point. Remember that these magnetos have a built in centrifugal advance mechanism and thus the static timing point is not the same place as the running timing point. The M9-35M magnetos have a number stamped on the face that the metal cover bolts to. When you remove the cover and the cap to do the inspection and check the point gap, note this number as it may not be the same from magneto to magneto. The timing point is determined by subtracting this advance angle stamped in the magneto divided by the magneto transmission drive ratio from the normal (running) crankshaft angle. Thus if the magneto has the number 35^{o} stamped on it, then the proper static timing point for the M14P points to open is 24^{o} - (35^{o} / 1.125) = minus **7^{o}. These are seven degrees** past top dead center of crankshaft angle. You then multiply this by the propeller gearbox ratio (.787 for the **AI-14RA & M462** or .658 for the M-14P). Thus the proper place for the points to open on an **AI-14RA** with a M9-35M magneto marked 35^{o} is between **$5.5^{o} \pm .5^{o}$** after TDC **and $4.5^{o} \pm .5^{o}$ after TDC for M-14P**. Your engine service manual usually has a small table with these values already calculated for you. Be careful not to time one magneto to the other unless they both have the same advance angle stamped on them.

IGNITION PROBLEMS

Over the years of operating and maintaining these engines, we have found the magnetos to be relatively trouble free. The main problems being arc tracking in the rotor cap, broken or worn points, broken or worn center carbon button, broken or badly worn rotor or poor timing. The main problems with these ignition systems are usually with the spark plugs or the leads from the spark magnetos to the spark plug leads. The original engines used a black rubber insulation on the ignition leads. This rubber tends to break down with time. (remember under their system they had a 5-year calendar overhaul period on these engines. All rubber goods were replaced at 5-year intervals). The original Russian spark plugs are sometimes a problem. If you ever drop one on the floor immediately throw it away as it probably has internal damage to the porcelain insulator that you will only detect when the center of the spark plug is pushed out of the barrel during flight. This causes a nice torch to squirt out of the spark plug barrel each time the cylinder fires. It does wonders for the rest of the engine accessories.

I have seen the lead breakdown problems happen only at certain rpm and power settings, while not occurring at other settings. Lead problems are further confounded by sometimes not being detectable with a high-tension lead checker. If you suspect lead problems the install some new 5MM silicone wire available here in the U.S.

Hard starting or no start problems if not fuel related are probably the shower of sparks system. It is easy to check. Turn the air system off and run out any residual air using the air start system or other aircraft air equipment. Remove a spark plug from each cylinder (so the engine does not accidentally start). Position the propeller so that the No. 4 piston is just past TDC on the power stroke position. Install a spark plug in the #4 lead end and rest it against some metal part of the engine. Depress the starter switch and look for sparks at the plug. No sparks means trouble with the shower of sparks system.

Another useful technique to determine which plug or lead is bad is to put a dab of grease on each exhaust pipe near where it comes out of the cylinder. Start the engine and immediately go to the "bad" mag and run for about 30 seconds. The Exhaust pipe that still has the grease intact is the one that is not firing. Now move the plug to from the front position to the rear position. Still have a problem then it is probably a lead. If the problem went to the other magneto then it is probably a bad plug. The left magneto (as seen from the cockpit) fires the front spark plugs and is usually marked "1" on the magneto switch. You should double check this with an ohm meter as I have seen them "messed" with before.

Good luck and happy flying.

George Coy