Electronic Ignition Concern

I recently received a phone call from Bill Scott of Precision Engine, (502) 684-1083, concerning the possible danger of running a combination of a magneto and an electronic ignition unit, with spark advance, on your aircraft engine. Bill reported the concern was also voiced by Harry Fenton, (815) 965-4700, technical representative for Slick mags and renowned expert on mags.

Understanding of the problem may be enhanced after review of the related physics.

Air is an insulator. The more dense the air, the greater the insulative property. In WW II, magnetos had to be pressurized to operate at high cruise altitudes where the air is "thin". In a non-pressurized mag internal air pressure is nearly the same as that outside the airplane. The low density air offers little resistance to the flow of current inside the mag. When the air pressure in the mag drops enough, the mag's current will arc to ground within the mag.

Electrical current follows the path of least resistance. In this high altitude case there was less resistance to discharge internally to ground within the mag than to go through the ignition wires and then have to cross the air gap in the spark plug.

Spark discharge within the mag does several bad things which include: engine misfire, formation of conductive carbon trace within the mag, and possible cross fire.

Misfire causes excess vibration as well as mechanical and operator stress. Lower power, poor cooling, higher fuel consumption generally also occur.

An internal spark discharge leaves a small trace of electrically conductive carbon inside the mag. This will usually happens in the high voltage (secondary) portion of the mag as there is more electrical pressure to "jump" the internal air gaps. Bill Scott has reported seeing the low voltage (primary) side of the circuit become involved too. An ignition system became grounded through the primary side of an ignition switch. Once the arcing path has started the carbon trace provides a low resistance path for the current to follow and future internal grounding is easier.

Cross fire can result when the high voltage spark, coming out of the secondary side of the mag, goes to the wrong spark plug. Normally secondary current travels through a rotating arm or rotor (like the hand on a clock) to be distributed to terminals (like the numbers on the clock face). The terminals are connected to spark plug wires which end at the spark plugs. If abnormally high resistance is found in this secondary distribution path, the current will find a less resistive path to ground. Frequently this will be to jump to a different spark plug terminal within the distributor section of the mag. (Imagine the clock hand is over the "3" but resistance is so high that the spark jumps to either the "2" or the "4".) The effect is that the "other" spark plug will fire at the wrong time. If the "other" plug fires as it's piston is starting to move up on compression detonation may occur which can severely damage the engine.

Recommended ignition maintenance on the mag, high tension ignition wires, and correct spark plug gap normally keeps secondary resistance low enough to prevent such internal arcing.

Many people believe these problems do not occur with electronic ignition systems because of the absence of internal air gaps. There may not be an air gap in your electronic ignition but the ignition module itself has an insulative case around it. If ignition wires have high resistance or spark plugs have excessive gap the electronic ignition current can "bore" a hole through its insulative case and ground itself providing no ignition to the engine. Many drivers of modern electronic ignition cars have found themselves stranded along the road because of this.

Secondary resistance can also be increased to permit internal mag arcing by another means. If air density in the combustion chamber increases, the insulative effect of the air in the spark plug gap will increase. Air density can be increased by turbo or supercharging, by using high compression pistons, or by trying to fire a spark plug after the other plug in the cylinder has fired.

The retarded firing scenario seems to apply to us that are operating one mag and one electronic ignition. The mag fires at a fixed value when operated above the impulse coupling RPM. A typical value is 25° before top dead center (BTDC). The electronic ignition has spark advance capability which allows greater engine efficiency, especially at high altitude and lower power operation. The spark plug is fired earlier, perhaps 35° BTDC, (advanced 10° more than the mag) in the compression stroke thus allowing more time for the fuel air mixture to be completely burned before the exhaust stroke occurs.

The result is higher CHT and lower EGT because less heat and power are prematurely expelled through the exhaust system. More power is available to turn the prop. That is good as we can then go faster, climb faster or use less fuel at the same airspeed.

The bad implication with all this is that the mag's spark plug is fired, perhaps 10°, after the electronic ignition's spark plug. The mag's spark plug is trying to fire in a combustion chamber where the internal pressure has been increased enormously by the 10° advance firing of the electronic ignition.

The internal pressure of the cylinder raises the mag spark plug air gap resistance so high that the plug may not fire. The mag's high voltage will discharge itself to ground by an alternate path, probably within the mag's highly stressed insulation or will crossfire to another cylinder. **The crossfire - detonation relationship may place you in danger of destroying the engine.**

Questions and implications at this stage of investigation are many. How likely is this to happen? How can one prevent it? How many degrees of uneven spark advance can one run before the mag's plug will fail to fire?

I do not have the expertise to answer the likelihood question. I suspect it varies widely dependent upon the mag and secondary system's condition as well as the advance curve of the electronic ignition unit and type of pressure sensors used.

It appears there are three different ways to prevent the event. 1. Operate your ignition system with two mags set at the same advance. You will lose the many advantages of electronic ignition but may have greater peace of mind. 2. Operate your ignition system with two electronic ignition units set at the same advance. You will have the advantages of electronic ignition but will have lost your independent power source for ignition. That is a huge unacceptable loss! 3. Use both the mag and electronic ignition for take off and landing but turn the mag off in flight. Very close attention should be given to keeping the battery in a good state of charge as the mag may have been under higher than normal stress with previous combined mag and electronic ignition operation and be more prone to failure. If your electronic ignition or power source should fail you will be completely dependent upon the previously weakened mag.

Thoughts on Mag and Electronic Ignition Combination

Klaus Savier (CA) - I have no concerns when the LSE Light Speed Engineering system is used in conjunction with a magneto or I would have never recommended this setup to anyone. I also feel that 4 years of testing in this configuration (1986-1989), with a magneto was adequate. No unusual problems showed. During this time, about 900 hours, I had one magneto coil failure which is about average. AOPA statistics show that magnetos fail every 500 hours. I believe it was a first when I installed a second fully electronic system on an aircraft engine on December 30, 1989.

I have stated in my forums that most magneto coil failures are the result of excessive spark plug gaps. This increased gap requires a higher voltage which overheats an otherwise excellent coil. It also stresses the distributor. This points to a solution for those running a magneto/electronic ignition combination that are concerned about shorter magneto life. Reduce your spark plug gap to .012" on the plugs fired by the magneto. This change will definitely make it easy for the spark to jump the gap. **Under no condition do I recommend turning the remaining mag off with an LSE system.** I have heard of other systems which gave increased power when the mag was turned off. This is a sign of incorrect advance however which should be corrected.

I remember a statement by Mike Melvill, a couple of years ago after he had installed the LSE CDI (capacitor discharge ignition) system. He noticed that his frequent mag failures did not occur anymore after the change.

In the past 10 years of selling the system I can remember only of one or two customers who installed a second electronic ignition system as a result of a magneto failure in a bastard installation. All others switched to the second electronic ignition system because they liked what they got with the first one.

The technical issues related to the perceived problem are huge and anything I would write on the subject would overflow your newsletter before I could transfer enough information to make a valid point.

Those who wish to do some serious reading on the subject should own the two volumes by Charles Fayette Taylor: The Internal Combustion Engine in Theory and Practice Published by MIT Press (1966-1968). ISBN 0-262-70027-1. Harry Ricardo also wrote on the subject in his famous book on combustion engines. I would love to buy a copy if anyone has one! I only have copies of sections since it is no longer available.

The issues deserving close examination include: flame front propagation velocity in combustion chambers without squish, flame front propagation versus pressure build up, normal combustion pressure rise versus crank angle as a function of compression ratio, octane of the fuel and jacket temperature, and flame direction of the two fronts.

We should also look at the political side of the perceived problem. Unison is a uniquely vertical company. They make everything in house, from castings to coils. They exist because of their expertise in producing, marketing and repairing magnetos.

Their "Electronic Ignition" is only two magnetos with variable timing. The essential magneto technology is retained with all of its production efficiency as well as mechanical and electrical problems.

It seems logical they would be concerned when they read in Sport Aviation how a vastly better system will replace their magnetos. A good way to slow the rapid growth in popularity of the electronic ignition would be to circulate unfounded rumors of possible engine failure or at least premature mag failure.