C48 Analyzing a Starter-Generator Failure on a Turbo-Prop Aircraft Engine

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The goal of this presentation is to describe a unique item of electrical equipment which performs two separate tasks in the operation of small turbo-prop and turbo-jet aircraft engines. While in flight, function lights indicated a problem had occurred with the electrical generator on one of the aircraft's engines, so the airplane made an emergency landing. Instead of waiting for a certified FAA mechanic to inspect the engine the next morning, a cursory inspection was made by the pilot, and finding nothing obviously wrong, he attempted to restart the engine and the result was disastrous.

This presentation will impact the forensic community and/or humanity by demonstrating why an operator of any equipment should always rely on the vehicle's instruments, and not try to out-smart those instruments.

There are thousands of one and two turbo-prop engined aircraft flying today. Should a pilot, having seen a generator malfunction light illuminate during flight and tried to trouble-shoot the problem, it could have roved to be disastrous to life and aircraft. Manufacturing defects have largely been engineered out of present day Starter-Generators and thus contributing to greater safety for passengers and crew while flying small jet-powered aircraft.

A chartered Piper Cheyenne aircraft was returning to Sarasota, FL, from Miami, FL, when the pilot noticed a generator red "NO-CHARGE" light illuminate. He immediately changed course and landed at Naples, FL, airport. He removed the left engine covers and visually inspected the auxiliary equipment in the left side PT6A-41 engine, and in particular, the AUXILEC Starter-Generator. The pilot determined the brushes were not worn away and that they were functioning correctly, and after taping other relays in the generator circuit he decided to restart the engine. After a second or two, and with the generator light still on, the starting mechanism completely seized.

The subject Starter-Generator, DC Aircraft, was an AUXILEC Model 8013C. Its operating specifications as a starter were 36 volt max. at 1000 amp max., and as a generator its output was 30 volt at 200 amp, with a shaft speed of 7000/12150 rpm.

From the air-intake end of the PT6A-41 engine, which faces rearward, the compressor turbine was connected to the outside of that gear box. The two shafts were linked together through bevel gears which had an approximate 3:1 gear ratio. During the engine starting procedure, the starter section of the unit is powered from the battery and it runs-up the compressor to approximately 30,000 rpm and then the engine's operation is commenced by the introduction of fuel to the combustion chamber and energizing the ignitors. A generator reverse current relay senses a reduced current requirement in the armature series field coils, and that relay switches to the output from the shunt-field armature coil in the then driven Starter-Generator.

The illumination of the generator charge light during flight was indicative of an electrical fault, which can often be traced to heat damage to insulation on electrical components, and lead to electrical shorts, or electrical/mechanical malfunction between the brushes and the commutator. After an emergency landing the pilot removed the engine covers, and with a flashlight and screw driver he proceeded to inspect the then exposed commutator end of the starter-generator where most electrical faults have historically been found. In the subject case nothing was found to be out of order, so the pilot then attempted to restart the engine. After several seconds of applying battery power to the starter, the armature abruptly stopped turning, and it was only then that the pilot realized the futility of trying to restart the engine, and so he left it to be inspected by a mechanic the following morning.

A partial tear-down found the bevel drive gears in the assessory gear box had been electrical-resistance welded together. Further, four (4) lengths of the forward facing beryllium-copper (Be-Cu) armature retaining ring were recovered from the inside of the front housing. The armature series-field coil windings and the shunt-field coil windings had been rubbed, or machined, to expose bare copper wire.

Rubbing-wear signatures were observed on one portion of the armature's circumferential surface as well as on one portion of the facing surface in the stator. Those rub marks indicated the armature had rotated in an elliptical pattern for a considerable period of in-service time. The temperature excursions due to frictional rubbing of the metal components in the armature and stator were accompanied by thermal expansion, heat treatment and oxidation/corrosion of the metal parts. At a late stage in the stator-generator service life the armature ring cracked all the way across its width, starting at one of the incipient cracks in the surface of the hydrogen-embrittled Be-Cu ring - as determined by SEM/EDS analysis.

The longest piece of the Be-Cu ring had been bent into a "J" shape with the hook-end around the shaft and the free end long enough to make contact with the bare copper ends of the armature coils. The shunt-field coil had been partly shorted to the armature shaft by the "J" piece, causing the generator light to illuminate. During normal engine operation, the starter series-field coils are disconnected from the battery, so no serious damage was done when the bare copper wire ends of the starter coils were also shorted by the metal "J" piece.

When an attempt to restart the turbine was made, the full charge of the battery was shorted across the

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metal “J” piece to the armature shaft. However, the path of least resistance to the “engine ground” was through the bevel gears in the auxiliary gear box. They became welded together, and their seizure caused considerable damage and expensive repairs to both the accessory gear box and to the compressor turbine.

The case went to trial, and the verdict was that the starter-generator failed due to a manufacturing defect, but all other repair costs were the responsibility of the pilot/owner, who should not have attempted to restart the engine.

Turbo-Prop Engine, Starter-Generator System, Beryllium-Copper Armature Ring

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