No more fretting about fretting

Jet engine manufacturers have devised tribological methods to reduce the failure of their products due to fretting corrosion.

by Dr. Robert M. Gresham
Contributing Editor

On page 28 Douglas Godfrey does an excellent job of differentiating between true and false brinelling of rolling element bearings. Indeed, one immediately envisions the difficulties encountered in transporting cars, trucks and military equipment overseas via ship and across the country on intercontinental trucks. For days, weeks or even months the vehicle rocks back and forth on its bearings.

Godfrey also discusses fretting wear, particularly fretting corrosion of steel. He correctly defines fretting wear as "the damage to contacting surfaces, experiencing slight relative reciprocating sliding motion of low amplitude."

Before joining STLE's professional staff in 1998 I spent many years with E/M Products Corp. where we worked with jet engine manufacturers to delay the rate of failure of jet engines, particularly smaller engines, due to this phenomenon.

Jet engines are basically big rotating turbine fans. Some of the fan blades, which are made from some pretty exotic metals, are static, and some are mounted on the rotator and rotate within the engine. Some blades are located toward the front of the engine, the compressor, which compresses air coming into the engine. Some are located toward the rear, the turbine, where the energy of combustion spins the rotator, providing thrust and energy to compress more air into the engine.

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While there are a number of different design variations, basically the blades are mounted into the stator and rotor via a tongue and groove arrangement analogous to the way furniture drawers are constructed. This design is very strong but is subject to fretting wear due to the vibration of the engine. While engine manufacturers strive to minimize engine vibration, the problem occurs with the so-called root section of the blade (the tongue of the tongue and groove) experiencing slight relative reciprocating sliding motion of low amplitude against the surfaces of the slot into which it is mounted.

Can you imagine the consequences of wear on the root section of the blade, the part that fits into the slot and the slot surfaces? As fretting wear continues, the root section gets smaller and the slot gets larger. Clearly one can see that if left long enough, the blade will eventually come loose and could severely damage the engine.

Engine manufacturers have developed a number of techniques for delaying failure due to this wear mechanism. In some cases a pin is inserted through the root section of the blade to hold it in place, which adds to expense but certainly reduces risk. In other cases, like a missile engine, the unit only runs for a few seconds and either hits its target or misses—either way, however, the engine is destroyed.

Naturally, the wear of the root sections and slot surfaces have been reduced through the use of solid-film lubricants (think high-tech slippery, paint-like coatings). Solid-film lubricants (SFL) are excellent boundary lubricants, which work well in cases like this because there is virtually no opportunity for hydrodynamic lubrication, meaning not only is there no fluid lubricant there's no way to get one into place.

SFLs can vary depending on which part of the engine they are used. In the compressor section, where temperatures are competitively low, conventional SFLs are used. In the turbine section, where temperatures can be quite high, exotic ceramic-bonded SFLs are used. As a result the job of the SFL is to lubricate the slight relative reciprocating sliding motion of low amplitude.

Because of the work of tribologists and their vendors, jet engine manufacturers are able to control the rate of failure due to this problem. It's another example of how the fundamentals of lubrication serve us all.

Best of all, when we fly we need not fret about fretting. <<

Jet engines are big rotating turbine fans (as shown here)

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