COKING PROPENSITY

AeroShell

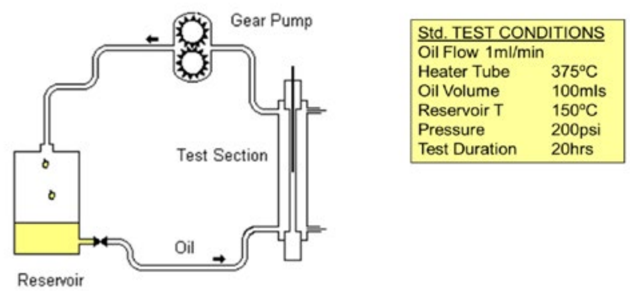
The pace of engine development over the last 70 years has required engines to run hotter and last longer. This is where the engine oils play such an important role. Today's oil does not only lubricate the bearings and gears but also acts as a coolant to remove excess heat from the system. This can put an immense stress on the lubricant, which can result in oxidative or thermal degradation of the oil and, ultimately, coke formation.

In the early 1930s, the first jet engines ran on mineral turbine oils. It soon became clear, however, that the high temperatures generated in these new turbine engines caused the mineral oils to degrade and form coke deposits, so the search was on for replacements. During the late 1950s, this led to the development of the first synthetic turbine oils, which were 3 centi-stoke oils. As with the mineral oils, these 3 centi-stoke synthetic oils also started to reach the limits of their performance. The 1960s saw the development of a new generation of synthetic oils which had a natural viscosity of 5 centi-stoke at 100°C together with excellent thermal stability. The development of these 'second generation' oils was driven by the needs of the US Navy which published Mil-L-23699 as the controlling specification. This was quickly adopted by the engine manufacturers for their new generation civil turbofan engines.

Since the early 1980s considerable advances have taken place in engine performance in terms of improved fuel consumption, higher operating temperatures and higher pressures. These together with changing maintenance practices resulted in increased severity in lubricant operating conditions. Such changes put stress on the engine oil and as a result the original 'second generation' oils became less suitable for use in modern aircraft engines. This ultimately led to the need to develop an oil with high thermal stability (HTS). HTS oil, which has better thermal stability, is now generally known as a 'third generation' oil.
Gas turbine design is still advancing with major advances being witnessed in the use of exotic high temperature alloys and materials. This is being driven by operators requiring improved specific fuel consumption and reduced operating costs. Now in use, hotter running, high-efficiency engines, with greater shaft speeds are expected to stay on the wing well in excess of 25,000 hours. The heat produced by these engines has to go somewhere and so today's oils tend to act more as a coolant than a lubricant. Moreover, they are expected to operate through normal top-up servicing, without a requirement for an oil change in service. Excessive heat can cause oxidative or thermal degradation of the oil, which can result in coke deposition in bearing chambers, oil feed pipes, vent pipes and scavenge pipes.

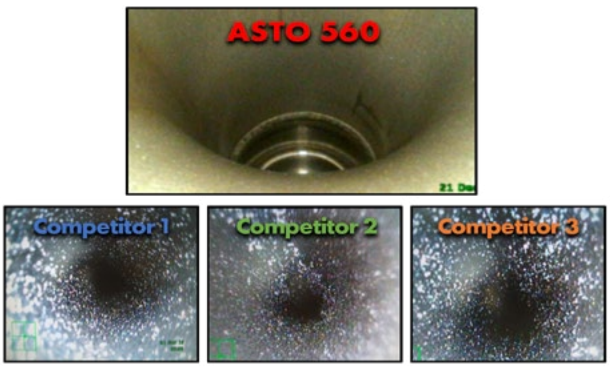
SAE AS 5780A specification was issued in the late 2000s for qualifying turbine engine oils for commercial aviation, to meet the demands of the latest generation of high-performance turbine engines. Oil suppliers have had to keep pace with engine developments by formulating new oils to meet the ever-increasing demands of the gas turbine engine. The cost of development of new oils is high due to lengthy development and approval processes conducted with the engine manufacturers. However, this is necessary to ensure the safe running and integrity of engines. The high development cost of these oils has seen a reduction in the number of manufacturers of these products from around 20 in the heyday of the 1970s to only a handful now.

The evolution of turbine engine oil that blends base oil with additives to give an effective oil package that helps in preventing coking and being elastomer friendly are already present in the market. Similar to synthetic base oil replacing mineral base oil 60 to 70 years ago, the advances in engine development in the last two decades could mean that early generation of standard engine oil is reaching the end of their effective life.

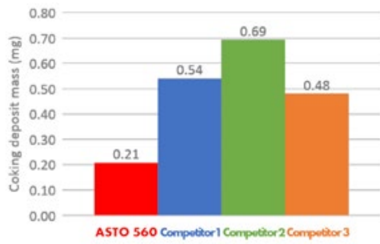


In a Hot Liquid Process Simulator (HLPS) test rig (shown above), it simulates the oil feed tube environment in an aircraft engine and is a required SAE AS5780 test. The test evaluates the coking propensity of an oil, and the deposits is assessed by the weight of the coke formed.

Comparison of an oil feed tube of ASTO 560 user vs standard oil user



Shell tested ASTO 560 against 3 standard oils. And the results show a clear advantage of HTS oil vs standard oil.



Hot Liquid Process Simulator Test