Tech topic

Coking

Did you know?

Severe coking can cause aircraft turn-back, lost revenue-generating hours, in-flight shutdowns and impeded engine performance.

Introduction

Coke is the solid residue created when oil undergoes severe oxidative and thermal breakdown at extreme engine temperatures. The higher the temperature, the harder, blacker and more brittle the coke/deposit residue. Coking performance of oils varies based on formulation and the engine environmental conditions.

Coking classification

Thin film	Mist/vapor	Puddles	Dynamic
▪ Forms from high surface-to-volume ratio of oil film; short coking residence time ▪ Deposits develop in layers with engine cycles ▪ Surface appearance typically shiny, smooth, can have "spikes" when formed in high centrifugal force areas ▪ Can shed or curl back to leave clean surfaces	▪ Forms due to inadequate wall washing/cooling effects ▪ Coking residence time variable with air/oil ratios ▪ Surface appearance usually matte with many irregularities ▪ Can shed fragments in many different sizes	▪ Forms from high surface-to-volume ratio of oil layers; long coking residence time ▪ Deposits form in thick chunks ▪ Surface varies from shiny to matte with lava-like appearance ▪ Can shed in lumps or large particles to leave clean surface	▪ Forms inside oil distribution pipework often in areas where size and direction change (e.g., behind obstructions or bends in pipes) ▪ Surface appearance varies, can include growth in columns facing direction of oil flow ▪ Can shed in variable sized lumps ▪ Can continue to form after engine shutdown in conducted or convected heat

Some oils that perform exceedingly well under one set of conditions can perform poorly under another.

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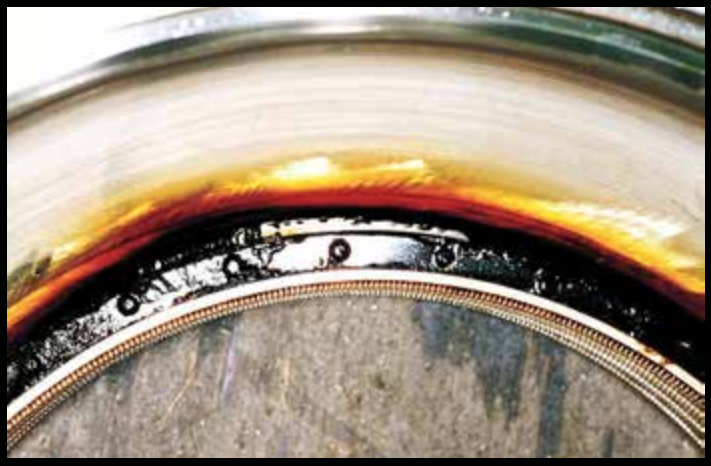
Influencers

- Coking occurs because the temperature and the oil residue time are higher than the oil stability limitations.
- Coke formation increases dramatically as local metal contact temperatures exceed 300°C.
- Operational factors can influence coke formation, such as hot shutdowns, which promote coke build up.
- Obstructions to flow or directional changes cause reduction in flow rate and increases in oil residence time.
- High post-shutdown temperatures due to conducted or convected heat increase deposition in low-drainage areas.
- Low-clearance scavenge ports increase the likelihood of blockage due to shedding.
- Prolonged aircraft inactivity enables moisture absorption of coke deposits, which typically shed after startup.
- Unprotected reactive metals in the oil system, such as lead, cadmium or magnesium, can increase deposits (reaction between oil and metals).
- Low-alloy iron and copper can stimulate coke formation by catalysis.
- Positive washing of system surfaces by high liquid oil flow reduces residence time.
- Increased airflow in high-temperature metal contact zones reduces the amount of coke deposits formed by promoting oil volatilization.
- Thermal insulation of supply, scavenge or vent lines in the gas path can significantly reduce deposits.

Deposits

While deposits are not desirable, if they form, staying where they form is preferred.

- Coke shedding can cause blockage of filters and engine oil system passageways.
  - Shedding can occur by absorption of moisture during prolonged shutdown periods and engine thermal cycles.
- Cracking, crazing and lifting of deposits from formation surfaces causes more oil to be trapped, increasing coke formation.



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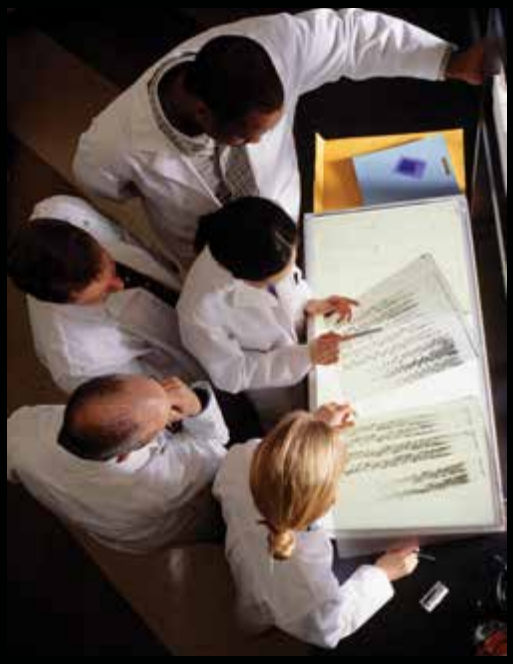

Laboratory/rig testing

Deposition testing is routinely conducted under conditions designed to mimic and accelerate formation of coke. Deposit control testing is rigorous and causes severe degradation to the oil. Measurement of viscosity and acidity change has little relevance to the bulk deterioration of oil in a typical circulatory engine system.

- Some coking tests have demonstrated powerful predictive capability and are essential during oil formulation and development phases.
- Coking tests are a vital part of oil approval testing.
- Tests are specifically designed to mimic formation of coke in engines; during the tests, oil is subjected to similar conditions that are known to generate coke/deposits.

ExxonMobil Research & Engineering (EMRE) subjects engine oils to a battery of tests including:

Test	Description
Thin Film Oxidation	▪ Proprietary ExxonMobil Research & Engineering test ▪ Predictive indicator of an oil's propensity to generate thin film deposits ▪ Internal test, results supported by actual performance in turbine bearings and seal compartments ▪ Oil deposition assessed using visual rating scale
Vapor Phase Coking	▪ Industry standard/required test ▪ Evaluates formation of deposits generated when oil mist/vapor is subjected to heat ▪ Oil misted into heated metal tube; deposits assessed by weight and visual appearance ▪ Test designed to simulate deposit formation in hot sections of engine vent lines
ALCOR High Temperature	▪ Industry and US Military standard/required test ▪ Evaluates deposit formation when oil meets hot surfaces ▪ Oil flowed over heated stainless steel tube; deposits assessed by weight and type ▪ Test designed to simulate flow of oil through hot oil line sections of engine and evaluates the propensity of oil to form deposits in lines
ERDCO Bearing	▪ Industry and US Military standard/required test ▪ Evaluates bulk oil stability and deposition in bearing compartments ▪ Oil deposition assessed using visual rating scale ▪ Test designed to simulate propensity of oil to form deposits in turbine bearing areas
Hot Liquid Process Simulator	▪ Required AS5780 specification and ExxonMobil batch qualification test ▪ Evaluates oil's propensity to form deposits in a fully flooded region of the engine ▪ Deposits assessed by weight ▪ Test designed to simulate oil flowing through pressurized lines

For more information

Please contact your ExxonMobil aviation sales representative.