Root causes of lubricant degradation and how to prevent it from harming your machines

Ms. Sanya Mathura, MLE
Sanya Mathura
Managing Director, Strategic Reliability Solutions Ltd.

- ICML MLE certified (first in the Caribbean)
- Several years experience in the Lubrication and Reliability sector
- Master of Science, Engineering Asset Management
- Bachelor of Science, Electrical & Computer Engineering
Strategic Reliability Solutions Ltd.

Our Mission
To provide strategic reliability solutions to professionals within the Petrochemical, Manufacturing and Energy sector globally.

Our Vision
To become the forerunner in the development and implementation of a Reliability culture within the global Petrochemical, Manufacturing and Energy sector.
Agenda

01 Definition of Lubricant Degradation
02 Methods of Identifying Degradation
03 Lab Tests for Various Mechanisms
04 Dealing with Degradation
POLL QUESTION No. 1

Which sector do you work in?
(Click only one answer)

- Engineering
- Oil & gas
- Manufacturing
- Other
Definition of Lubricant Degradation
What are the functions of a lubricant?

- Reduce friction
- Minimize wear
- Distribute heat
- Remove contaminants
- Improve efficiency
What does lubricant degradation mean for your equipment?

- Occurs throughout the service life of the lubricant
- Baseline for change occurs when further deterioration leads to a level where it can no longer protect the system

Lubricant Degradation

- Downtime
- Decrease in product quality
- Reduction in output
- Increased budget
Lubricant degradation modes

These can also be classified by environmental triggers

Modes of Degradation:
- Oxidation
- Contamination
- Thermal Degradation
- Additive Depletion
- Microdieseling
- Electrostatic Spark Discharge
Methods of Identifying Degradation
1. What is oxidation?

Addition of oxygen to the base oil to form:

- Aldehydes
- Ketones
- Hydroperoxides
- Carboxylic Aids
1. Initiation
- Production of free radicals via the lubricant and catalyst

2. Propagation
- Production of more free radicals

3. Termination
- Continuation of the oxidation process after the antioxidants have been depleted or the antioxidant stops the process

Main causes of oxidation: oxygen and temperature
Results of oxidation

Deposits and characteristics in your machines

- Varnish
- Base oil breakdown
- Additive depletion
- Sludge
- Increase in viscosity
- Loss in antifoaming properties
2. What is thermal degradation?

Thermal cracking occurs when the temperature exceeds the thermal stability point of the lubricant.

Temperatures must exceed 200°C

- Shearing of molecules
- Decrease in viscosity
- Polymerization
Process of thermal degradation

Shearing of molecules allow small molecules to become cleaved off.

**Volatize**
- Does not leave any deposit

**Condense**
- Dehydrogenation (in the absence of air).
- Coke is formed as the final deposit
- Other deposits occur between the start to final deposit
Oxidation vs. thermal degradation

**Oxidation**
- Requires oxygen
- Increase in viscosity
- Produces sludge and varnish

**Thermal degradation**
- Requires temperatures over 200°C
- Decrease in viscosity
- Produces lacquer and carbonaceous deposits
3. What is microdieseling?

- Also known as compressive heating
- A form of pressure induced thermal degradation

Transition of entrained air from low pressure to high pressure zone

Produces localized temperatures in excess of 1,000°C

Bubble interface become carbonized

Oil darkens rapidly and produces carbon deposits due to oxidation
Results of microdieseling

Conditions for microdieseling include:
- Low flashpoint with low implosion pressure or
- Low flashpoint with high implosion pressure

Ignition products of incomplete combustion form: soot, tars, and sludge

Adiabatic compressive thermal heating degradation produces varnish from carbon insolubles, including coke, tars, resins
4. What is electrostatic spark discharge?

Static electricity occurs at a molecular level when dry oil passes through tight clearances.

- **Spark production**: Static electricity builds up to the point where it produces a spark.
- **Increase in temp**: Spark can then induce temperatures higher than 10,000°C.
Stages of electrostatic spark discharge

1. Static electricity builds up to produce a spark
   - Temperatures are in excess of 10,000°C
   - Lubricant begins to degrade significantly

2. Free radicals are formed
   - These contribute to polymerization of the lubricant

3. Uncontrolled polymerization
   - Produces varnish and sludge which can remain in solution or be deposited
   - Can also result in elevated fluid degradation and presence of insoluble materials
Thermal degradation vs. microdieseling vs. ESD

 Thermal degradation

- Temperature: <200°C
- Effects:
  - Decrease in viscosity
  - Produces Coke as final deposit

Microdieseling

- Temperature: <1,000°C
- Effects:
  - Produces deposits of Soot, Tars, and Sludge (High Implosion)

Electrostatic spark discharge

- Temperature: <10,000°C
- Effects:
  - Produces Varnish and Sludge (remain in solution or deposit)
  - Result in elevated fluid degradation and presence of insoluble materials
5. What is additive depletion?

Additives are sacrificial to protect the base oil. The nature of the deposit is dependent on:

- Type of additive
- Reaction of the additive with other components in the oil
Type of deposit (additive depletion)

**Organic**
- Rust and oxidation additive drop out
- Usually react to form primary antioxidant species

**Inorganic**
- Additives that dropped out did not react with anything
- Usually ZDDP (to reduce wear)
6. What is contamination?

Any foreign material entering the lubricant and being used as catalysts

Can be classified by:

- Air
- Water
- Metals
Types of degradation (contamination)

Contaminants can induce various types of degradation such as:

- Oxidation
- Microdieseling
- Thermal degradation
Lab Tests for Various Mechanisms
POLL QUESTION No. 2

Which practice is most common in how you deal with lubricant degradation? (Click only one answer)

- Change the oil immediately and hope for the best
- Change the oil supplier
- Identify the root cause of the issue
- Bring in external parties to assist
- Something else
Lab tests for oxidation

Even though viscosity is not mentioned here, it should be used although it cannot verify if oxidation has occurred.

Typically, an increase in viscosity is present during oxidation.

- **Acid number**
  - Increase of 0.3 mgKOH/g
- **Colour**
  - Rapid Changes
- **FTIR**
  - Presence of insolubles
- **MPC**
  - 25-35 Abnormal
  - >35 Critical
- **RULER & RPVOT**
  - <25% new oil value
Lab tests for thermal degradation

- Viscosity: Decrease of 5%
- Colour: Rapid changes
- FTIR: Presence of carbonaceous deposits
Lab tests for microdieseling

Visual inspection of components

Is cavitation present?

FTIR and QSA

Presence of these by-products:

- Soot, tars, sludge (high implosion)
- Carbon Insolubles such as coke, tars, or resins (low implosion)
Lab tests for electrostatic spark discharge

- **Filter inspection**
  - Presence of burnt and clogged membrane

- **FTIR & QSA**
  - Presence of varnish, sludge, or insoluble materials

- **RULER**
  - Depletion of antioxidants (<25%)

- **DGA**
  - Presence of acetylene, ethylene, and methane
Lab tests for additive depletion

- **FTIR & QSA**: Presence or absence of additives
- **Colour**: Use lab guidelines (for different additives)
- **QSA**: Presence of insoluble materials
- **RULER & RPVOT**: Presence or absence of antioxidant additive (<25%)
Lab tests for contamination

- Colour
  - Use lab guidelines

- Presence of water / fuel / coolant
  - Presence of any foreign material
Dealing with Degradation
Dealing with degradation

1. Understand equipment
2. Determine applicable tests
3. Interpret the results
4. Implement measures
1. Understanding the equipment

Decide criticality before assigning lab tests.

- Is it CRITICAL?
- Is it SEMI CRITICAL?
- Is it NON CRITICAL?
2. Determine applicable tests

- Viscosity trend changes and monitor changes of +/-5%.
  - ASTM D445

- Presence of water / fuel
  - Contaminants such as water or fuel can degrade the lubricant and promote other degradation mechanisms.
  - ASTM D664 / ASTM D2896

- Increases in TAN of 0.3mgKOH/g or decreases of 50% of TBN value can indicate the presence of acids as by-products of degradation mechanisms.

- Presence or absence of any of these items can indicate that degradation is occurring in the lubricant.
  - Concentration of additives, metals, or contaminants

- Contaminants such as water or fuel can degrade the lubricant and promote other degradation mechanisms.
3. Interpreting the results

Conditions
- Increase in viscosity
- Spike in acid number
- Dark colour
- No water present

Mode present?
- Oxidation?
- Contamination?

Verify
- Elemental
- RPVOT
- RULER
- MPC
3. Interpreting the results

**Conditions**
- Decrease in Viscosity
- Dark colour
- No fuel present

**Mode present?**
- Thermal Degradation?
- Microdieseling?
- Electrostatic Spark Discharge?

**Verify**
- Inspect components (Burnt membrane: ESD, Cavitation: Microdieseling)
- QSA
- RULER
- DGA
4. Implementing measures

Chemical filtration
- Oxidation

Residence time
- Reduce temperatures (Thermal Degradation)
- Allow air to escape (Microdieselng)

Adjusting clearances
- Reduce temperatures

Kidney loop filtration
- Remove contaminants (contamination)
- ESD

Antistatic filters
- ESD
QUESTIONS?

Thank you!
Sanya Mathura
Managing Director | Senior Consultant
Strategic Reliability Solutions Ltd.

Strategic Reliability Solutions Ltd
Strategic Reliability
Strategic Reliability Solutions
Next webinar: How today's advanced electric motor testing technologies expose motor failure

BEST PRACTICE WEBINAR
Wednesday, Feb. 3, 11 a.m. ET

How today's advanced electric motor testing technologies expose motor failure

The increasingly sophisticated motor testing technologies used today quickly identify anomalies and mechanisms leading to motor failure. In this presentation, Don Donofrio, veteran instructor and consultant for The Snell Group, an internationally recognized expert in electric motor testing training and research, demonstrates the methods used for de-energized and energized motor testing. These methods are powered by completely different technologies, which he will talk through.

Donofrio also will cover static winding, circuit, and insulation assessment methods, and will discuss power quality, current signature, in-rush, and electrical signature analysis. He will leverage several case studies to illustrate the effectiveness of these advanced motor testing capabilities.
To learn more about **Accelix and our Webinar Series**

**SURVEY**
Please provide feedback on this webinar by responding to our survey. Do you want a Certificate of Attendance?

**WEBINAR SERIES**
Visit this page to learn more about our Webinar Series: [https://www.accelix.com/community/best-practice-webinars/](https://www.accelix.com/community/best-practice-webinars/)

**DEMO**
Visit Accelix.com for a free demo of our Connected Reliability Framework.