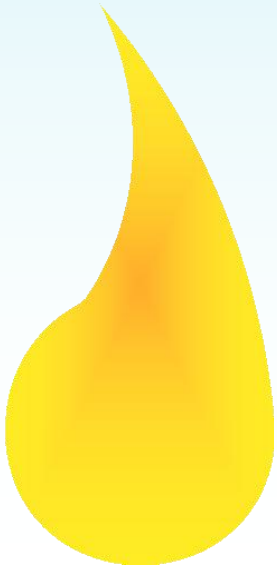


Lubricants and lubrication

By: Mudit M. Saxena

Meaning of lubrication

- Friction – is created when there is relative motion between two surfaces
- Resistance to motion is defined as friction.
- Lubrication is use of a material between surfaces to reduce friction.
- Any material used for this purpose is called a lubricant

Methods of lubrication

- Two main methods
  - Hydrodynamic lubrication
  - Boundary lubrication

- Hydrodynamic lubrication
  - Also called complete or full flow
  - Occurs when two surfaces are completed separated by a fluid film

Methods of lubrication cont..

- Boundary lubrication
  - Occurs when Hydrodynamic lubrication fails.
  - By adsorption or chemical reaction

Types of Lubricant – Physical

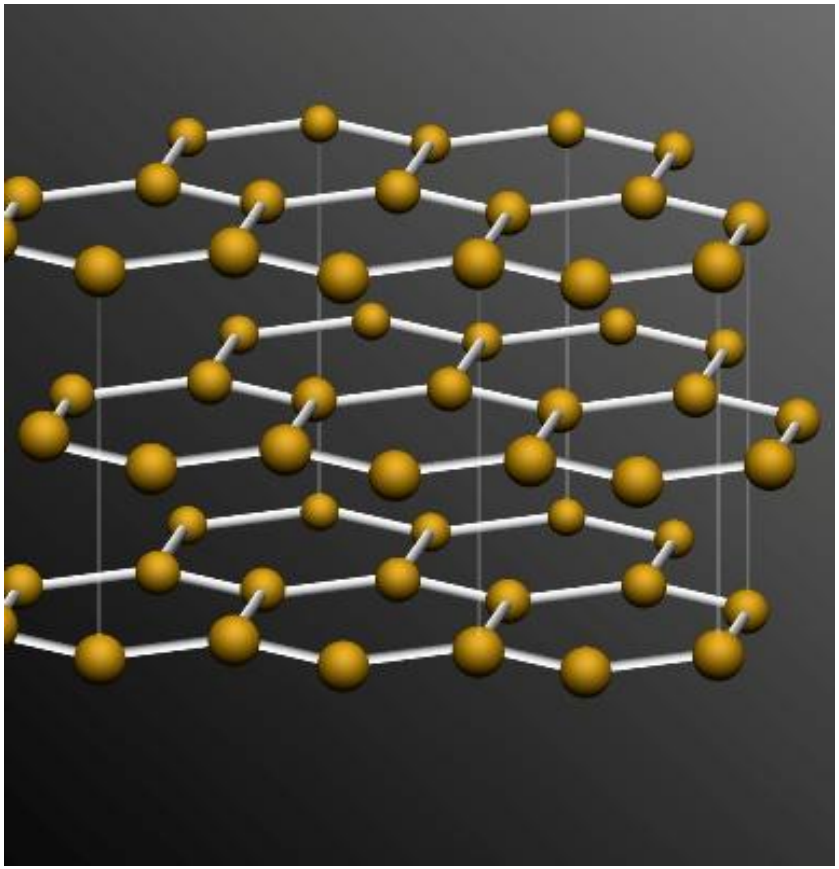
- Liquid
- Solid
- Semi solid
- Gases

Types of Lubricant – Physical

- Liquid
  - Typical lubricants are liquid/fluids
  - Mineral oil or synthetic oils
- Solid
  - Graphite, MoS_2(Molybdenum disulphide), PTFE(Polytetrafluoroethylene–Teflon)
- Semi solid
  - Greases
- Gases
  - Atomised 2 stroke oils

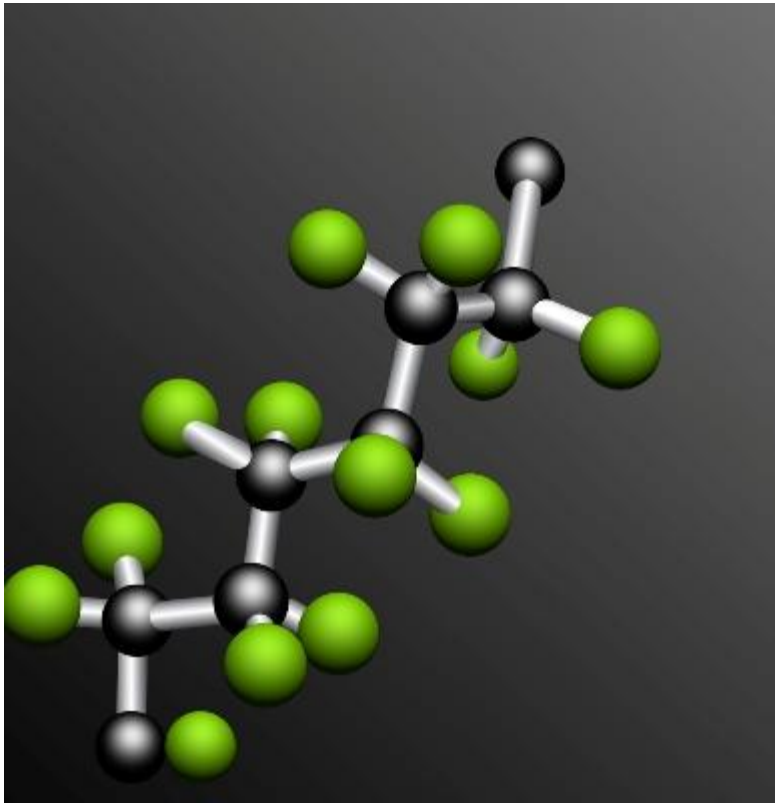
Solid Lubricants

Graphite with a layered lattice structure and weak bonding between layers delivers superior lubricity as long as the presence of moisture.



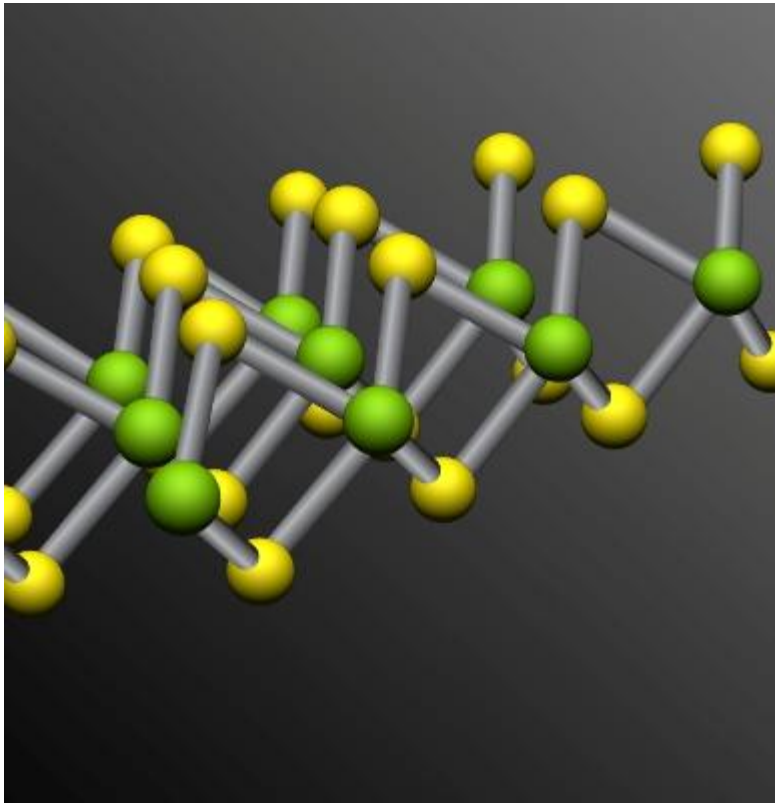
Solid Lubricants

Polytetrafluoroethylene (PTFE) comprises carbon and fluorine atoms and is recognized as one of the most slippery manmade materials due to its low surface tension.



Solid Lubricants

Molybdenum disulfide with a lamellar structure can be sheared easily in the motion direction. It is possible to match particle size and film thickness to match surface roughness.



Typical lubricants – Application

- Engine oils
- Gear Oils
- Turbine Oils
- Hydraulic Oils
- Metal working oils
  - Cutting oils
  - Forming Oils
- Rust preventives

Typical lubricants – Application

- Heat Transfer Oils
- Heat Treatment Oils
  - Quenching Oils
  - Tempering Oils
- Refrigeration Oils
- Rubber Process Oils
- Ink process Oils

Lubricant – Components

- Base Oils
  - Mineral by–products of crude oil refining process.
  - Base oils are polymerized or synthesized further and called synthetic
- Additives
  - Natural
  - Synthetic

Function of a lubricant

- Lubricate – Reduce friction
- Cooling – Heat transfer
- Cleaning – Detergency
- Noise pollution – dampening
- Sealing – prevent leakage
- Protection – prevent wear

Lubricate – reduce friction

- The effects of friction
  - Metal to metal contact
  - Leads to wear and tear
  - Generates heat
  - Results in Power loss
- Lubricant reduces friction by forming a film
  - Reduces ill effect of friction

Cooling

- When fuel is burnt in an engine
  - 33% is useful power
  - 33% removed by cooling water
  - 33% by lube oil and radiation
- Lube oil removes heat from all areas and brings it to the engine sump.
- Improper cooling can lead to over heating, lead to wear, distortion and failure.

Cleaning

- Cleans carbon and varnish deposits
- Flushes the entire system removing
  - Soot
  - Deposits
  - Acids
  - Wear products
  - Moisture
- Removes external contaminants dust, moisture (external)

Noise reduction

- Reduce noise
  - By preventing metal to metal contact
- Dampens noise
  - As between camshaft and tappet

Sealing

- Oil film
  - Between piston ring and liner
  - Helps in creating a gas tight seal

Protection

- Protection against acids and moisture
- Very important to increase life of component and equipment

Properties of lubricants

- Kinematic viscosity
- Viscosity index
- Pour Point
- Flash Point
- Total Base Number (TBN)

Properties of lubricants

- Kinematic viscosity
  - Measure of internal resistance to flow
  - “Thickness” of fluid (in laymen terms)
  - Decreases with increase in temperature
  - Important in lubricant selection
  - Increase in used oil indicates oxidation
  - Specified at 40°C and 100°C
  - Measured in Centi Stokes (CSt)

Kinematic Viscosity – Recommendations

- Low Viscosity oils used
  - High speeds
  - Low pressure
  - Low temperature
- High Viscosity oils used
  - Low speeds
  - High pressure
  - High temperature

Properties of lubricants

- Viscosity index
  - Measure of fluids change of viscosity with temperature.
  - Empirical number
  - Higher the VI lower will be the change of viscosity with temperature
  - Indicator of temperature range of operations

Properties of lubricants

- Pour Point
  - Lowest temperature at which the fluid will flow
  - Indicates lowest operating temperature
  - Measured in ˚C

Properties of lubricants

- Flash Point
  - Lowest temperature at which the vapor above the liquid will ignite under flame
  - Indicated safe maximum temperature of operation.
  - Indicator of volatility
  - Test method – COC and PMCC
  - Measured in ˚C

Properties of lubricants

- Total Base Number (TBN)
  - Measured the acid neutralizing reserve in oil.
  - Important for deciding discard of oil
  - Decreases due to
    - Oxidation of oil
    - Water contamination
    - Fuel contamination
  - Measured in Mg KOH/gm of oil

What are additives

Lubricant additives

classified on their functional capability

- Enhance existing property
- Suppress undesirable property
- Impart new property

What are additives – What they do in Engine Oils

Protect metal surfaces

- (rings, bearings, gears, etc.)

Extend the range of lubricant applicability

Extend lubricant life

Surface Protective additives

Anti wear and EP Agent

Corrosion & Rust inhibitor

Detergent

Dispersant

Friction modifier

Surface Protective additives – Automotive Lubricants

Additive type	**Anti wear & EP Agent**
Purpose	Reduce friction & wear. Prevent scoring & seizure
Typical compounds	ZDDP, Organic Phosphates, acid phosphates, organic sulfur and chlorine compounds etc.
Function	Chemical reaction with metal surface and forms a film. Prevents metal–to–metal contact

Surface Protective additives – Automotive Lubricants

Additive type	**Corrosion and Rust Inhibitor**
Purpose	Prevent corrosion and rusting of the metallic parts in contact with lubricant
Typical compounds	ZDDP, Metal phenolates, Basic Metal sulphonates, fatty acid & Amines.
Function	Preferential adsorbtion of polar constituent on metal surface. Provide protective film Neutralize corrosive acids

Surface Protective additives – Automotive Lubricants

Additive type	**Detergents**
Purpose	Keep surface free of deposits
Typical compounds	Metallo organic compounds of Sodium, Calcium and Magnesium phenolates Phosphonates and sulphonates
Function	Chemical reaction with sludge and varnish percursors to neutralize them and keep them soluble

Surface Protective additives – Automotive Lubricants

Additive type	**Dispersant**
Purpose	Keep insoluble contaminants dispersed in the lubricant
Typical compounds	Alkylsuccinimides, alkylsuccinic esters and mannich reaction products
Function	Contaminants are bonded by polar attraction to dispersant molecules. Prevented from agglomerating Kept in suspension due to solubility of dispersant

Surface Protective additives – Automotive Lubricants

Additive type	**Friction modifier**
Purpose	Alters coefficient of friction
Typical compounds	Organic fatty acids and amides. Lard Oil, high molecular weight organic phosphorus. Phosphoric acid esters
Function	Preferential adsorbtion of surface active materials

Performance additives – Automotive Lubricants

Additive type	**Pour Point Depressant**
Purpose	Enable lubricant to flow at low temperature
Typical compounds	Alkylated naphthalene Phenolic polymers, Ploymethacrylates Maleate/fumerate copolymer esters
Function	Modify wax crystal formation to reduce interlocking

Performance additives – Automotive Lubricants

Additive type	**Seal swell Agent**
Purpose	Swell elastomeric seals, gaskets
Typical compounds	Organic phosphates Aromatic hydro carbons
Function	Chemical reaction with with elastomer to cause slight swell.

Performance additives – Automotive Lubricants

Additive type	**Viscosity modifier**
Purpose	Reduce the rate of viscosity change with temperature
Typical compounds	Polymers and copolymers of olefins, methacrylates, dienes Alkylated styrenes.
Function	Polymers expand with increasing temperatures This counteract oil thinning

Performance additives – Automotive Lubricants

Additive type	**Antifoamant**
Purpose	Prevent lubricant from forming a persistent foam
Typical compounds	Silicone polymers Organic copolymers
Function	Reduce Surface tension to speed collapse of foam

Performance additives – Automotive Lubricants

Additive type	**Antioxidant**
Purpose	Retard oxidative decomposition
Typical compounds	ZDDP, Hindered phenols, Aromatic Amines, sulfurized phenols
Function	Decompose peroxides Terminates free–radical reactions

Performance additives – Automotive Lubricants

Additive type	**Metal deactivator**
Purpose	Reduce catalytic effect of metals on oxidation rate
Typical compounds	Organic complexes containing nitrogen or sulfur
	Amines, sulphides and Phosphates
Function	Forms inactive film on metal surfaces by complexing with metallic ions

Applications of Lubricants:

Applications of Liquid Lubricants:

- Horizontal bearings are lubricated by submerging them in the oil tight lubrication bath.
- Splash lubrication is used where the rotating component goes into oil and splashes it.
- Forced lubrication is carried out with the help of oil pump

Applications of Lubricants:

Semi Solid Lubricant

Grease is packed

Lubricant – Specifications

- Crankcase oils – SAE numbers
- Crankcase oils – Performance levels
- Crankcase oils – OEM Specifications
- Viscosity classification
- Grease specification

Major specifying organizations

- SAE – Society of Automotive Engineers (USA)
- API – American Petroleum Institute
- US Military Specs – US – MIL – 2104 –
- CCMC – European Specification
- ISO – International Standard Organization – ISO 3348
- NLGI – National Lubricating Grease Institute

Thank you