Mohammadreza Ghafari

Motor Oil Production Overview

Motor oil production involves several stages, from refining base oils to adding additives, and finally packaging. The quality and performance of motor oil are largely determined by the choice of base oils and additives used.

Base Oils (Group I, II, III, IV, and V)

- **Group I: Mineral oils with basic refinement, suitable for standard applications.**
- **Group II: Highly refined mineral oils with better oxidation resistance and higher performance, suitable for high-performance applications.**
- **Group III: Synthetic oils (using mineral oil) with even higher refinement, commonly known as synthetic blend or fully synthetic oils. SN500 is an example of Group II.**
- **Group IV: Fully synthetic oils made from polyalphaolefins (PAOs), offering excellent thermal stability and performance in extreme conditions.**
- **Group V: Oils with unique additives or synthetic bases, such as esters, used for specific needs.**

Additives in Motor Oil (API SP)

- **Additives are crucial in achieving performance standards like API SP (current highest performance level for gasoline engines).**
- **Typical additives include:**
    - **Detergents to clean and prevent deposits.**
    - **Dispersants to maintain oil cleanliness.**
    - **Antioxidants to prevent oil breakdown under heat.**
    - **Anti-wear agents to protect engine components.**
    - **Viscosity index improvers to maintain oil thickness across temperature ranges.**
    - **Friction modifiers for smoother operation.**

Base Oil Selection: SN150 vs SN500

- **SN150: A lower-quality, less refined base oil used for standard engine applications with basic performance requirements.**
- **SN500: A highly refined base oil from Group II, offering better thermal stability, oxidation resistance, and overall performance, suitable for high-performance engines.**

SN Base Oils

- **SN stands for Saturation and Neutralization, referring to the level of refinement and the oil's resistance to oxidation and breakdown.**
    - **SN150 has lower refinement and is suitable for general applications.**
    - **SN500 is better refined and provides superior resistance to heat and oxidation, making it ideal for high-performance oils.**

Choosing the Right Base Oil (SN500 for API SP)

- **SN500 is an ideal choice for producing high-performance oils, such as those meeting API SP standards, due to its superior oxidation resistance and stability at high temperatures.**

Suppliers of Base Oils in Iran

- **Major suppliers of base oils in Iran include:**
    - **Sepahan Oil: One of the largest producers of base oils in the country.**
    - **Iranol: A well-established company that produces a wide range of oils, including SN oils.**
    - **Petripars: Another major player in the production of base oils.**

These companies provide oils like SN500, suitable for high-performance motor oils.

Importing Base Oil to Japan

- **Base oils, including SN500, can be imported from Iran to Japan through intermediaries in the UAE.**
- **The process typically involves:**
    1. **Contacting suppliers for pricing and terms.**
    2. **Navigating import regulations and customs in both countries.**
    3. **Importing the base oils and blending them with additives in your own factory in Japan.**

Key Steps for Starting Motor Oil Production

1. **Select the right base oil (SN500 for high-performance oils).**
2. **Source additives that match API SP standards.**
3. **Set up blending and packaging in your factory.**
4. **Establish import/export logistics for base oils and additives.**

Here is the detailed translation of the provided text into English, formatted as a Word document. You can copy the content below and paste it into a Word file:

How is Engine Oil Produced from Start to Finish?

The production of engine oil is a complex process that involves refining crude oil, adding chemical additives, and packaging the final product. Below are the general steps of this process:

1. Extraction and Refining of Crude Oil

Engine oil is produced from crude oil. The initial steps include:

- Extraction of crude oil from oil wells.
- Refining crude oil in refineries, which involves distillation in a distillation tower. During this stage, crude oil is separated into various components, including oil cuts suitable for engine oil production.

2. Refining of Base Oil

Base oil is the primary component of engine oil and is obtained from refining crude oil. The refining of base oil includes the following processes:

- **Hydrocracking**: To remove undesirable compounds such as sulfur and nitrogen.
- **Dewaxing**: To improve performance at low temperatures.
- **Filtration and Purification**: To enhance stability and clarity of the oil.

3. Adding Additives

To improve the performance of the oil, chemical additives are added, including:

- **Antioxidants**: To prevent oil breakdown at high temperatures.
- **Anti-wear Agents**: To protect engine components.

- **Anti-foam Agents**: To prevent air bubble formation.
- **Detergents and Dispersants**: To keep the engine clean.

4. Blending and Mixing

In this stage, the base oil and additives are mixed in appropriate proportions to produce the final engine oil with the desired viscosity and specifications.

5. Packaging and Distribution

The finished engine oil is packaged in suitable containers (plastic bottles, gallons, barrels) and distributed to the market.

6. Quality Control and Standards

Before being released to the market, engine oil undergoes quality tests to ensure compliance with standards such as SAE, API, and ACEA.

Are There Different Types of Engine Oils?

Yes, there are different types of engine oils, such as mineral, synthetic, and semi-synthetic oils. Below is a detailed explanation of how these oils are produced:

1. Base Oil (Base Oil) – The Raw Material for All Oils

All lubricating oils use base oil as the primary raw material, which is divided into two main categories:

a) Mineral Base Oil

This oil is derived from crude oil and is divided into three main groups:

- **Group I**: Simple refining, high aromatic content, suitable for general lubrication.
- **Group II**: More advanced refining, lower sulfur content, better thermal stability.
- **Group III**: Highly refined, very pure, with performance close to synthetic oils.

b) Synthetic Base Oil

This oil is produced through chemical synthesis and includes the following types:

- **Polyalphaolefin (PAO)**: High thermal stability and viscosity, suitable for advanced engines.
- **Esters**: Superior lubricating properties, often used in aviation and racing cars.
- **Polyglycol (PAG)**: Suitable for high temperatures and specific hydraulic systems.

c) Semi-Synthetic Base Oil

A blend of mineral and synthetic oils, offering a balance between cost and performance.

2. Production of Different Oils with Specific Additives

After selecting the appropriate base oil, various oils are produced by adding specific chemical additives. Below is the production process for some important oils:

a) Engine Oil

- **Steps**:
    1. Selection of the appropriate base oil (mineral, synthetic, or semi-synthetic).
    2. Addition of additives such as antioxidants, detergents, anti-wear agents, and anti-foam agents.
    3. Mixing at controlled temperatures.
    4. Quality testing and packaging.
- **Types**:
    - **Mineral Oil**: Made from crude oil, suitable for older engines.
    - **Semi-Synthetic Oil**: A blend of mineral and synthetic oils, offering a balance between cost and performance.
    - **Synthetic Oil**: High performance in extreme temperatures, longer lifespan, and better fuel efficiency.

b) Gear Oil

- **Steps**:
    1. Use of Group II or III base oil for better stability.
    2. Addition of additives such as extreme pressure (EP) agents and anti-corrosion agents.
    3. Quality testing and packaging.
- **Types**:
    - **Regular Gear Oil (GL-4)**: Suitable for standard gearboxes.
    - **High-Performance Gear Oil (GL-5)**: Contains EP additives for hypoid gears.

c) Hydraulic Oil

- **Steps**:
    1. Selection of high-viscosity index base oil.
    2. Addition of anti-wear agents, antioxidants, and friction modifiers.
    3. Filtration to remove suspended particles.
    4. Testing for compatibility with hydraulic pumps.
    5. Packaging.

- **Types**:
    - **Mineral Hydraulic Oil**: The most common type, based on crude oil.
    - **Synthetic Hydraulic Oil**: For high temperatures and harsh conditions.
    - **Biodegradable Hydraulic Oil**: Suitable for environmentally sensitive areas.

d) Compressor Oil

- **Steps**:
    1. Use of highly pure base oil (usually synthetic).
    2. Addition of strong antioxidants, anti-foam agents, and viscosity stabilizers.
    3. Packaging and testing under operational conditions.
- **Types**:
    - **Mineral Oil**: For standard air compressors.
    - **Synthetic Oil (PAO or Ester)**: For high temperatures and pressures.

e) Turbine Oil

- **Steps**:
    1. Selection of high-viscosity index base oil.
    2. Addition of strong antioxidants, friction modifiers, and anti-corrosion agents.
    3. Rigorous testing, including oxidation stability tests.
    4. Packaging.
- **Types**:
    - **Steam Turbine Oil**: For power plants.
    - **Gas Turbine Oil**: Resistant to very high temperatures.

What Are Synthetic Oils?

Synthetic oils are produced through chemical processes and have more uniform molecular structures compared to mineral oils, which are derived from crude oil. These oils are used in automotive, aviation, heavy industries, and even medical applications.

1. Production of Synthetic Oils

a) Synthesis of Synthetic Base Oil

Synthetic oils are produced through chemical processes, including:

- **Selection of Raw Materials**:
    - Natural gas (the most important raw material).
    - Pure hydrocarbons such as ethylene and propylene.
    - Alcohols and organic acids.
- **Polymerization or Synthetic Reactions**:
    - Small molecules (such as ethylene) are converted into larger molecules under controlled pressure and temperature.
    - The result is oil with a uniform molecular structure.
- **Purification**:
    - Removal of undesirable compounds such as sulfur and nitrogen.
    - Reduction of contaminants to enhance thermal and chemical stability.
- **Structural Modification**:
    - Adjusting properties such as viscosity, boiling point, and freezing point by precisely controlling the molecular structure.

b) Adding Additives

After producing the synthetic base oil, various chemical additives are added to provide the required properties for specific applications:

- **Antioxidants**: To prevent oil degradation at high temperatures.
- **Anti-wear Agents**: To increase the lifespan of moving parts.
- **Friction Modifiers**: To improve efficiency and reduce fuel consumption.
- **Anti-foam Agents**: To prevent air bubble formation.

2. Types of Synthetic Oils and Their Production Methods

Synthetic oils are divided into several main groups, each produced using specific methods:

a) Polyalphaolefin (PAO)

- **Properties**:
    - Very high thermal stability.
    - Resistance to oxidation.
    - Suitable for very low and very high temperatures.
    - Longer lifespan compared to mineral oils.
- **Production Method**:

- Ethylene is used as the raw material.
- A controlled polymerization reaction creates long, uniform molecules.
- The result is a highly pure and stable oil suitable for turbocharged engines, racing cars, and heavy equipment.

b) Esters

- **Properties**:
  - Excellent lubricating properties.
  - High chemical stability.
  - Lower moisture absorption.
  - Used in aircraft engines and high-performance cars.
- **Production Method**:
  - Esters are synthesized by combining alcohols and organic acids.
  - These molecules have polar properties, allowing the oil to adhere to metal surfaces and provide better protection against wear and friction.

c) Polyalkylene Glycol (PAG)

- **Properties**:
  - Resistant to sludge and deposit formation.
  - Suitable for very high temperatures.
  - Used in hydraulic oils, turbines, and compressors.
- **Production Method**:
  - PAG molecules are produced by combining ethylene oxide and propylene oxide.
  - These oils are typically used in specific hydraulic systems and gearboxes due to their excellent lubricating properties.

d) Gas-to-Liquid (GTL) Base Oils

- **Properties**:
  - Stable viscosity at different temperatures.
  - Produced from natural gas (free of undesirable crude oil compounds).
  - Longer lifespan and reduced fuel consumption.
- **Production Method**:
  - Pure hydrocarbons are extracted from natural gas.

- These compounds are converted into highly pure synthetic oils through the Fischer-Tropsch process.
- These oils are a good replacement for mineral oils in modern vehicles.

3. Comparison of Synthetic and Mineral Oils

Feature	Mineral Oil	Synthetic Oil
Thermal Stability	Moderate	High
Lifespan	Shorter	Longer
Oxidation Resistance	Lower	Higher
Performance at Low Temps	Poorer	Excellent
Price	Cheaper	More Expensive
Fuel Consumption	Higher	Lower
Sludge and Deposit Formation	More Likely	Less Likely

4. Advantages of Using Synthetic Oils

- **Increased Engine Lifespan**: Reduced wear and friction.
- **Reduced Fuel Consumption**: Due to lower viscosity and reduced internal resistance.
- **Stability in Harsh Conditions**: Suitable for very high and very low temperatures.
- **No Sludge Formation**: Keeps the engine and moving parts clean.
- **Better Heat Transfer**: Helps cool the engine and mechanical components.
- **Longer Lifespan**: Requires less frequent oil changes.

5. Applications of Synthetic Oils

- **Modern Car Engines and Turbocharged Engines** (e.g., PAO and ester oils).
- **Aviation and Aerospace Industries** (e.g., ester oils).
- **Automatic and CVT Transmissions** (e.g., PAG and PAO).
- **Marine and Power Plant Industries** (e.g., GTL and PAG oils).
- **Turbines and Compressors** (e.g., PAG and ester oils).

6. Should You Always Use Synthetic Oil?

- **For New and Advanced Engines**: Synthetic oil is recommended.
- **For Older Vehicles or Equipment Designed for Mineral Oil**: Synthetic oil is not necessary.

- **For Specific Engines** (e.g., heavy-duty diesel engines): A semi-synthetic blend may be more cost-effective.

Is API SP the Same as Synthetic Oils?

No, synthetic oils and the API SP standard are two separate concepts, but they can be related. Let me explain in detail:

1. Difference Between "Synthetic Oil" and "API SP Standard"

- **Synthetic Oil**:
    - Refers to the type of base oil produced through chemical synthesis.
    - Has better properties such as high thermal stability, reduced friction, and longer lifespan.
    - Includes various types such as PAO, esters, PAG, and GTL.
- **API SP Standard**:
    - A standard defined by the American Petroleum Institute (API) for gasoline engine oils.
    - API SP is the highest current standard (after API SN and API SM) and is designed for modern, turbocharged, and start-stop engines.
    - Any oil labeled API SP can be mineral, semi-synthetic, or synthetic, but not all API SP oils are synthetic.

2. Are Synthetic Oils Always API SP?

- **No!** A synthetic oil may have a lower standard such as API SN or API SL.
- **Conversely**, some semi-synthetic or even mineral oils may meet the API SP standard.

3. What Are the Key Features of API SP?

- **Main Features of API SP Compared to API SN**:
    - Reduced engine deposits and sludge.
    - Improved protection for timing chains in modern engines.
    - Increased resistance to oxidation and oil breakdown.
    - Better protection against thermal shock in turbocharged engines.
    - Compatibility with emission control systems and catalysts.

4. How to Identify if a Synthetic Oil is API SP?

- Check the oil label. If "API SP" is mentioned, it means the oil has met all API SP standards, regardless of whether it is mineral, semi-synthetic, or synthetic.

- If the label says "Full Synthetic" and also mentions API SP, it means the oil is both synthetic and meets the API SP standard.

5. Summary

- Synthetic oils refer to the production method, while API SP is a quality standard.
- A synthetic oil can be API SP, but this is not mandatory.
- To determine the type of oil, pay attention to both the "base type" (mineral/synthetic) and the "API standard."

Can Mineral Oils Be Produced to Meet API SP Standards?

Yes, you are absolutely correct! Mineral oils (derived from crude oil) can be enhanced with appropriate additives to meet API SP standards. This means that an API SP oil is not necessarily synthetic and can be produced from mineral base oil.

How Can a Mineral Oil Meet API SP Standards?

1. Selection of Suitable Mineral Base Oil

- Mineral oils are produced during the refining of crude oil and are divided into several groups based on refining level and quality:
    - **Group I**: Least refined, higher aromatic and sulfur content.
    - **Group II**: Better refined, lower sulfur content, and more stable.
    - **Group III**: Highly refined mineral oils, close to synthetic oils.
- To meet API SP, at least Group II or III base oils should be used.

2. Adding Additives to Meet API SP Standards

Since mineral oils alone cannot meet all the requirements of modern engines, advanced additives must be added. These additives include:

- **Antioxidants**: To prevent oil breakdown at high temperatures.
- **Anti-wear Agents**: To protect engine components.
- **Detergents**: To reduce sludge and deposits.
- **Viscosity Modifiers**: For better performance at different temperatures.
- **Friction Modifiers**: To reduce fuel consumption and improve engine performance.
- **Anti-foam Agents**: To prevent foam formation in the oil.
- **Anti-corrosion Agents**: To prevent rust and corrosion of engine parts.

By combining these additives, even a mineral oil can achieve API SP standards.

3. Comparison of Mineral API SP and Synthetic API SP Oils

Feature	Mineral API SP	Synthetic API SP
Thermal Stability	Moderate	High
Lifespan	Shorter	Longer
Oxidation Resistance	Good	Excellent
Performance at Low Temps	Poorer	Very Good
Sludge and Deposit Formation	More Likely	Less Likely
Price	Cheaper	More Expensive

4. Are Mineral API SP Oils Suitable for All Vehicles?

- For older vehicles (pre-2010) and engines with lower pressure, a mineral API SP oil can be a suitable choice.
- For turbocharged engines, start-stop systems, and newer vehicles, synthetic API SP oils are recommended.

Final Summary

- API SP is a standard, not a type of oil.
- Mineral oils can be API SP if the right additives are added.
- Synthetic API SP oils perform better under harsh conditions, but mineral API SP oils can be sufficient for some engines.

What Additives Are Needed to Meet API SP Standards?

To produce an API SP oil from base oil (mineral, semi-synthetic, or synthetic), a package of additives must be added. These additives are essential for improving the oil's properties and meeting API SP standards.

1. List of Required Additives for API SP

Additive Type	Function	Approximate Percentage (%)
Antioxidants	Prevent oil degradation at high temperatures	1-2%
Anti-Wear Additives	Reduce wear on engine components (e.g., timing chains)	0.5-2%
Detergents	Prevent deposits and keep the engine clean	2-4%

Additive Type	Function	Approximate Percentage (%)
Dispersants	Keep contaminants suspended and prevent sludge formation	4-6%
Viscosity Index Improvers (VII)	Stabilize viscosity at high and low temperatures	2-6%
Friction Modifiers	Reduce friction for better fuel efficiency	0.1-1%
Anti-Foam Agents	Prevent foam formation in the oil	Less than 0.1%
Corrosion Inhibitors	Protect metal parts from rust and corrosion	0.5-1%
Catalyst Compatibility Additives	Reduce damage to catalytic converters	1-2%

2. Detailed Explanation of API SP Additives

a) Antioxidants

- These additives prevent oil breakdown at high temperatures and extend its lifespan.
- Common examples: ZDDP (Zinc Dialkyldithiophosphate), phenols, amines.

b) Anti-Wear Additives

- Protect sensitive components like timing chains and valves from wear.
- Common examples: ZDDP, organic phosphates, borates.
- In API SP oils, ZDDP levels are reduced to avoid damaging catalytic converters.

c) Detergents

- Remove deposits and prevent sludge formation.
- Common examples: calcium and magnesium sulfonates, phenates, salicylates.

d) Dispersants

- Keep contaminants suspended to prevent settling in the engine.
- Common examples: substituted succinimides.

e) Viscosity Index Improvers (VII)

- Maintain oil performance at different temperatures and prevent thinning in heat.
- Common examples: polymethylmethacrylate (PMMA), olefin copolymers (OCP).

f) Friction Modifiers

- Reduce fuel consumption and improve engine performance.
- Common examples: molybdenum disulfide (MoS_2), organic esters.

g) Anti-Foam Agents

- Prevent foam formation in the oil and maintain oil film stability.
- Common examples: silicones, polydimethylsiloxane (PDMS).

h) Corrosion Inhibitors

- Prevent rust and corrosion of engine parts.
- Common examples: organic amines, phosphate esters.

i) Catalyst Compatibility Additives

- Reduce the harmful effects of oil on catalytic converters and diesel particulate filters (DPF).
- Common examples: low SAPS (Sulfated Ash, Phosphorus, Sulfur) compounds, organic phosph