Viscosity Index Improvers (VIs) are used to alter the natural viscosity characteristics of base oils: these are oil-soluble polymers with high molecular weights and a complex molecular structure. By adding these, the flow behaviour of the oil is improved at low temperatures. At high temperatures, by contrast, these increase the real ‘natural’ viscosity of the oil.
How do polymer improvers differ from one another?

• In molecular structure: copolymers, block copolymers, regular copolymers

• Copolymers are different types of polymers and chains of molecules (macromolecules) that consist of two or more different structural links. Regular and irregular copolymers can be distinguished. The various structural links in irregular copolymers are distributed randomly along the chain. In regular copolymers, the various structural links are arranged in an ordered manner. Block copolymers consisting of several polymer blocks can be separately identified.

• In molecular form: linear or star-shaped

• In molecular mass

• Through additional properties – depressor properties – Pour Point Depressant (PPD).
Behaviour of traditional linear-structure polymers

**Moderate Shear**
- Orientation of coil under shear forces

**Zero Shear**
- Queiescent polymer coil in oil solution

**High Shear**
- Rupture of coil and subsequent orientation under shear forces

**REVERSIBLE**
- Temporary Viscosity Loss

**NON-REVERSIBLE**
- Permanent Viscosity Loss
Resistance to mechanical shear

Resistance of polymers to mechanical degradation under shear stress depends on the molecular weight (molecule size), structure and physical properties of the polymer additive.

**Formula for calculating viscosity loss:**

\[
\text{Shear Stability Index (SSI)} = \left( \frac{\text{Viscosity Loss}}{\text{Polymeric Viscosity Thickening Before Shear}} \right) \times 100
\]

- **Polymeric Viscosity Thickening Before Shear**
- **Base Oil Viscosity**
- **Viscosity Loss**
- **Polymeric Viscosity Thickening After Shear**
- **Base Oil Viscosity**
- **Fresh**
- **After Oil Viscosity**
- **After 30 Cycles**
Test-rig testing and testing under realistic operating conditions

Rig for engine testing

Testing under realistic operating conditions

Disadvantages of these methods:
Time and costs
ASTM D 6278 unit for measuring shear stability

The Kurt Orbahn (KO) test

The main element of the test rig is a diesel injector through which oil is pumped from a Bosch TNWD high-pressure fuel pump at a pressure of 175 bar. When passing through a small opening, mechanically unstable molecules are ripped and the oil becomes thinner. Excellent modeling of polymer degradation in average and highly contaminated oils.

<table>
<thead>
<tr>
<th>SPECIFICATION</th>
<th>UNIT</th>
<th>VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injector nozzle</td>
<td>-</td>
<td>Bosch DN 8 S2</td>
</tr>
<tr>
<td>Nozzle holder</td>
<td>-</td>
<td>Bosch KD 43 SA 53/15</td>
</tr>
<tr>
<td>Diesel injection pump</td>
<td>-</td>
<td>Bosch PE 2A 90C 300/3S 2266</td>
</tr>
<tr>
<td>Electric motor</td>
<td>Kw/ RPM</td>
<td>1.1/925±26</td>
</tr>
<tr>
<td>Dead volume</td>
<td>ml</td>
<td>20±5</td>
</tr>
<tr>
<td>Injector breaking pressure</td>
<td>bar</td>
<td>175</td>
</tr>
<tr>
<td>Flow rate</td>
<td>ml per minute</td>
<td>170±5</td>
</tr>
<tr>
<td>Oil temperature</td>
<td>°C</td>
<td>Ambient (20 to 25) to 30 to 35</td>
</tr>
<tr>
<td>Power*</td>
<td>V/Hz/Ph/HP</td>
<td>415/50/3/1.5</td>
</tr>
</tbody>
</table>

*Other voltages on request.
Standard tolerance for light vehicles is after 30 cycles, and after 90 cycles for commercial vehicles, with the oil remaining within SAE J300 viscosity limits before testing.

Distance in indicated kilometres when comparing with a BMW 4,4 V8 twin-turbo S63B44T0 engine in mixed mode: highway – racetrack.
The main unit of the test rig is a tungsten carbide rotor and stator motor. The radial clearance remains constant at about 1 μm. This makes it possible to achieve very high shear rates from $10^6$ s$^{-1}$ to $10^7$ s$^{-1}$. 
Result from using viscosity index improvers

**ADVANTAGES**

- Viscosity index increases to the required limits
- Viscosity index increases in a cost-efficient manner
- Ease of storage in its solid form
- Polymers are abundant and easily available
- Improved performance at low temperatures
- Better protection at high temperatures
- By using one or two grades of low-viscosity base oil and by altering the concentration of the improver it is possible to obtain a wide range of marketable products

**DISADVANTAGES**

- Fail under mechanical stress
- Significant alteration to viscosity during operation through polymer degradation
- Increased engine contamination
- Poor low-temperature properties
- Poor oil-film stability at high temperatures
- Formation of paint deposits and films
- As it ages, it can clog the fine passages in an engine and affect the lubrication and cooling process
RAVENOL — the number one for German motor sport

Motor sport means extreme strain at high revs and temperatures.

The lubricants used must provide the best levels of protection, retaining these properties under long and high loads. The 24 Hours of Le Mans – more than 5000 km. The 24 Hours Nürburgring – more than 3000 km.

We looked for solutions to the problems.
Disadvantages of polyalphaolefins (PAO)

PAOs have a low polarity, expressed through a high aniline number, as a result of which:

• Additives and other substances dissolve poorly within them
• Poor adherence to lubricated surfaces with trickle

➢ The aniline number is the minimum temperature at which a certain amount of aniline dissolves completely and homogeneously in a base oil.
Ultra Strong Viscosity Oil (USVO) technology using synthetic high-viscosity base oils

The modern chemical industry produces a large range of synthetic base components with a high natural viscosity index and very high polarity.

- Excellent low-temperature viscosities (CCS), with high viscosity at 100°C
- These form a sufficiently thick protective film that remains stable under high mechanical loads
- Very low freezing point
- Excellent High-temperature high-shear (HTHS) viscosity at high engine operating temperatures
HPBC – high-polarity base component

The ratio of Group 5 base oils and HPBC for various oils varies
USVO technology using highly stable star-shaped polymers

• It is not always possible to guarantee SAE standards for all viscosities on the basis of base components, e.g., 5W-50 oils
• Technology without polymer improvers is expensive and not always applicable from an economic standpoint
• It requires a large warehouse stock of various high-viscosity components

Application of star-shaped polymers
The advantages of star-shaped polymers over standard OCP

• Higher shear resistance thanks to their star-shaped structure and strong molecular bonds
• A physically smaller amount of star-shaped polymer is required when compared to standard OCP
• Stable viscosity during operation
• The fewer polymers, the fewer drawbacks associated with their use:
  ➢ Engine contamination
  ➢ Formation of paint deposits and films
  ➢ Lower reduction in viscosity during polymer degradation
Comparison of USVO with standard engine oils

10 = Superior Performance
7 = Pass
5 = Fail
Advantages of PAO-based lubricants:

- very low NOACK volatility (reduced burn-off loss = cost reduction, no need to top up, or smaller top-ups)
- improved oxidation protection (extended product life)
- higher thermal conductivity = better engine cooling
- better pumpability in cold conditions = faster lubrication of parts = better engine protection during cold starts

Properties of synthetic oils:
wide range of operating temperatures,
Increased stability at high temperatures,
Improved performance in the low temperature range.
Combinations of our technologies

USVO®
Ultra Strong Viscosity Oil

Oils with high operating characteristics compared to oils from traditional technologies
Comparison of USVO with standard engine oils

CCS = low-temperature viscosity

PP = temperature of fluidity loss

MRV = low-temperature pumping viscosity

SSI = resistance to mechanical shear
In order to compensate for the disadvantages of the VI improver, we have developed a fundamentally new solution – a new technology for our oils:

**New USVO technology**

This technology allows us to eliminate the disadvantages of the polymer VI improver while retaining its advantages.
CONCLUSION

- Better engine protection
- Improved performance
- Optimal engine cleanliness
- Extended oil change intervals
RAVENOL VMP SAE 5W-30

RAVENOL VMP SAE 5W-30 is a PAO (Polyalphaolefin) based, fully synthetic low friction motor oil with especially USVO® and proven CleanSyn® technology for passenger car petrol and diesel engines with and without turbo-charging and direct injection. Minimises friction, wear and fuel consumption with excellent cold start characteristics. Suitable for extended oil change intervals where recommended by manufacturer.

RAVENOL VMP SAE 5W-30 is based on additives with reduced ash content for use in modern passenger car with diesel and gasoline engines with excellent cold start characteristics, low oil consumption and reduced pollutant emissions. This oil will increase the DPF and TWC life. Developed for fuel economy and energy conserving in EURO IV and EURO V Standard engines with normal and extended oil change intervals (until 50,000 km or 2 years possible).

RAVENOL VMP SAE 5W-30 achieved by its formulation with special base oils a high viscosity index. The excellent cold start behaviour ensures a optimal lubrication safety in the cold running phase.

Due to a significant fuel economy RAVENOL VMP SAE 5W-30 contributes by reduction of emissions to conservation the environment. Minimal wear extends the lifespan of the engine.
Information on packaging