IMPROVEMENTS IN GEAR OIL TECHNOLOGY FOR BENEFIT OF STEEL INDUSTRY

Samrat Das
Technical Services - IOCL
Gears are classified in **three main groups** depending on the:

- position of the shafts relative to each other,
- type of flank contact.

- Primarily rolling contact gears
- Combined rolling and sliding gears
- Primarily sliding contact gears

The higher the sliding percentage, the higher the wear load on the tooth flanks, the higher the requirements a lubricant has to meet.
## Tribological aspect

<table>
<thead>
<tr>
<th>Types</th>
<th>Gears</th>
<th>Position of the shafts</th>
<th>Tooth flank contact</th>
<th>Gear components</th>
<th>Type of movement</th>
<th>Sliding percentage [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolling contact</td>
<td>Spur gears</td>
<td>parallel</td>
<td>line</td>
<td>cylinders</td>
<td>rolling and sliding</td>
<td>10 to 30</td>
</tr>
<tr>
<td>Rolling contact</td>
<td>Bevel gears</td>
<td>intersecting</td>
<td>line</td>
<td>cones</td>
<td>rolling and sliding</td>
<td>20 to 40</td>
</tr>
<tr>
<td>Rolling / sliding contact</td>
<td>Crossed helical gears</td>
<td>crossing</td>
<td>point</td>
<td>cylinders</td>
<td>increased sliding</td>
<td>60 to 70</td>
</tr>
<tr>
<td>Rolling / sliding contact</td>
<td>Hypoid gears</td>
<td>crossing</td>
<td>line</td>
<td>cones</td>
<td>increased sliding</td>
<td>60 to 70</td>
</tr>
<tr>
<td>Sliding contact</td>
<td>Worm gears</td>
<td>crossing</td>
<td>line</td>
<td>cylindrical and globoid element</td>
<td>mainly sliding</td>
<td>70 to 100</td>
</tr>
</tbody>
</table>
EHD is characterized by two phenomena:

1) The **surface of the materials in contact** momentarily deform elastically under pressure, thereby spreading the load over a greater area.

2) The **viscosity of the lubricant** momentarily increases dramatically at high pressure, thereby increasing the load-carrying ability in the contact zone.

- **Correct ISO-VG grade** to ensure thick enough EHD film.
- **Correct additive system** to protect against extreme pressure, temperature, wear, scuffing, micro pitting, etc.

The selection and application of the lubricant must be made to meet the requirements of the application.
The trend toward **smaller oil reservoirs** means with less time to:
- dissipate heat,
- release foam,
- settle out contaminants and
- demulsify water
Major factors influencing change in gear oil technology

- New Materials and Surface Finish
- Higher Loads on gear teeth and bearings
- Better micropitting resistance
- Increased Power density

The world is changing: recent developments in industrial gearboxes

- Power Output
- Operating Temperature
- Quantity of Lubricant
- Oil Service Life
- Oil Change Frequency

- Gearbox Size
New Properties Required for High Performance Industrial Gear Oils

Important Properties

Basic Requirements - DIN 51517 (CLP) Part 3 / US Steel 224 / AGMA 9005:
- Water Separation – ASTM D 1401 & D 2711
- Rust protection – ASTM D 665 (A / B)
- Foam Control – ASTM D 892
- Oxidation & Deposit control – ASTM D 2893
- FZG test (A/8.3/90) – DIN 51354 (conventional)
- FAG FE 8 wear test – DIN 51819 P3

Flender / OEMs Requirements:
- Anti-micro-pitting

Primary Other Requirements
- Superior control in Foam – Flender Foam test
- FZG test (A/16.6/90) – DIN 51354 (high speed)
- Good Filterability – HDVAC Filtration test
- Compatibility with seals & paint
Weld load IP 239 : 250 Kg

Wear Scar Dia (WSD) ASTM D 4172 @ 40 Kg : 0.4 mm

FAG FE 8 (DIN 51819 Part 3) Bearing Roller & Cage wear test - Pass

FZG Rig test (DIN 51354) - scuffing
Conventional (A/8.3/90)
High Speed (A/16.6/90)

FZG FVA 54 / IV (micro-pitting) : 96 + 480 = 576 hours (24 d)
Progressive loading stage (96 hours),
Endurance test (80 h x 6 stages = 480 hours),

Roller wear =< 30 mg;
Cage wear =< 200 mg

Progressive loading stage (96 hours),
Endurance test (80 h x 6 stages = 480 hours),

Assessment of Tribological Performance
Gear Lubricant – Mineral Oil Based
High Performance Industrial Gear Oils
Servomesh XP 150 / 220 / 320 / 460 / 680

- Meets
  - DIN 51517 Part 3 (CLP), AGMA 9005-E02, AIST 224 (formerly USS 224), ISO 12915-1
  - Flender gear oil requirements

- Salient Features
  - Resistance against micropitting fatigue – extended gear & bearing life
  - Higher load bearing ability than market products
  - Compatibility with ferrous & non-ferrous metals – longer life of machine parts
  - Resistance to oxidation at higher temperatures - extended life & drain intervals
  - Filterability in wet conditions – no filter choking

- Applications: Highly loaded case hardened gears,
  experiencing micropitting problems,
  running at slightly higher oil bath temperature,
  having foaming problems

- Performance: Proven in many Indian Steel & Cement Plants
To

DGM [Institutional Lube Sales]
Indian Oil Corporation Ltd.
Bhubaneswar

03.02.2018

Kind Attention: Kuidhop Pradhan, A.M. (ELS), Angul Sales Area

Subject: Performance Letter on servo Lubricants used in Mill stand Lubrication systems of Bar-Mill

Dear Sir

We are pleased to inform that we have been using various lubricants supplied by you in our lubrication system in SMS MEER Bar-Mill. Details of lubricants along with its application are mentioned herewith.

<table>
<thead>
<tr>
<th>SL NO</th>
<th>GRADE</th>
<th>EQUIPMENT</th>
<th>APPLICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SERVO MESH XP 320</td>
<td>ROUGHING MILL STAND GEAR BOXES</td>
<td>FORCE LUBRICATION SYSTEM</td>
</tr>
<tr>
<td></td>
<td>SERVO MESH XP 220</td>
<td>FINISHING MILL STAND GEAR BOXES</td>
<td>FORCE LUBRICATION SYSTEM</td>
</tr>
</tbody>
</table>

The performance of these grades is satisfactory.

Sincerely Yours,

Ruma Charitra Subudhi
Dy. Manager, Mechanical
Bar-Mill
Date: 10.01.2018

M/s Indian Oil Corporation Ltd
#8, Infantry Road
Cenomment
Ballari
Karnataka-583104

Kind att: Mr AV Suresh Babu
(GM (ILS) - Karnataka)

Dear Sir,

Sub: Performance of Servo Mesh XP 460 (Gear Oil) - reg

We would like to inform you that Servo Mesh XP 460 oil supplied by Indian Oil Corporation Ltd is being used in lubrication of all heavy duty gear boxes of Roughing mills, finishing Mills, SSP and down coiler in our 5.0MTPS Hot Strip Mill-2 (Primateal Technologies make). The oil is supplied in barrels. Oil Sampling, testing & analysis is done by IOCL on quarterly basis.

This lubricating oil is being used since Oct'2016 without any problem and the performance of the oil has been satisfactory.

Thanking you

Yours truly,

For M/s JSW Steel Ltd, Vijaynagar works

PVNP Rama Rao
GM- Hot Strip Mill 2
To
State Institutional Sales Manager
Bihar State Office
Indian Oil Corporation

Ref: TBSL/MECH/IOCL/2017-1
Date: 17-02-2017

Endorsement letter of Servo Mesh XP 320

Dear Sir,

We are pleased to inform you that we have been using your anti-micropitting gear oil Servo Mesh XP 320 at “Pay Off Reel-1 & 2, Entry Accumulator & Tension Reel Gear boxes of Metal [Zn-Al] coating line” application of 12 months now and the performance of the product is found to be satisfactory.

Indian Oil has also extended after sales technical support to us.

This is for your kind information & necessary action please.

Sincerely Yours

NAVAL KISHOR PRASAD
HEAD- Mechanical Maintenance
Tata BlueScope Steel Limited
Coated Steel Project, At: Bara, P.O. Agrico, Jamshedpur - 831009
Jharkhand State India. Mobile: +919031009657

[Signature]
To,
Shri S.K. Srivastava
SISM, Rajasthan State Office
M/s Indian Oil Corporation Ltd.

(Kind attention:- Mr. Jai Kumar Dhaka – DM(TS) Udaipur)

Date: 25.02.2016

Subject: Performance of “SERVO MESH XP 320” in our gear box

We have conducted a successful trial of SERVO MESH XP 320 in the main gear box of Cement Mill 4 in our cement plant at Pindwara, Dist Sirohi (Rajasthan). This is a M/s Citic Heavy Engineering China make gear box (rating – 4000 KW, rpm – 744/16 rpm), with oil sump capacity of 3000 ltrs.

Earlier we were facing foaming in gear oil for this gear box.

Subsequently we have replaced the previous gear oil with IOCL’s high performance gear oil - SERVO MESH XP 320. This oil is in use from last May’15 onwards and I am pleased to share that there has been no issue of foaming with this gear oil and also overall the performance of this oil is extremely good.

We thank you for support extended during the course of the trial including testing of oil samples at regular intervals of time and furnishing of other relevant data.

With Regards,

[Signature]
N.L. Suthar

GM (Mech),

Binani Cement Ltd.
Meets
- DIN 51517 Part 3 (CLP), AGMA 9005-E02, AIST 224 (USS), ISO 12915-1 &
- Flender requirements

Salient Features:
- Superb protection from micropitting fatigue wear & scuffing – Pass Micropitting test (FVA 54-I/IV)
- FZG scuffing load stage (A/16.6/90) : >12
- FAG FE 8 wear test : Pass (DIN 51819 - Part 3)
- Compatibility with Loctite, other seal materials - (Static & Dynamic) : Pass
- Flender foam test : Pass

Recommended for Helical, Bevel and Planetary gear boxes

Approved by M/s Siemens AG (formerly Flender), Germany
Gear Lubricant – Fully Synthetic
### Table Shows: Change in Viscosity with Temperature

(Viscosity Index 90 to 95)

<table>
<thead>
<tr>
<th>Temp, degree Centigrade</th>
<th>150 cst Oil</th>
<th>220 cst Oil</th>
<th>320 cst Oil</th>
<th>460 cst Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>545.70</td>
<td>854.37</td>
<td>1383.70</td>
<td>2129.8</td>
</tr>
<tr>
<td>40</td>
<td>147.11</td>
<td><strong>218.1</strong></td>
<td><strong>325.1</strong></td>
<td><strong>468.0</strong></td>
</tr>
<tr>
<td>60</td>
<td>54.84</td>
<td>77.62</td>
<td>108.5</td>
<td>148.1</td>
</tr>
<tr>
<td>80</td>
<td>25.65</td>
<td>34.93</td>
<td>46.5</td>
<td>60.8</td>
</tr>
<tr>
<td>100</td>
<td>14.10</td>
<td>18.60</td>
<td>23.8</td>
<td>30.1</td>
</tr>
</tbody>
</table>

**THUS HIGH VISCOSITY INDEX OIL IS DESIRABLE** .... As it provides thicker oil film at operating temperatures
Why do synthetic gear oils offer improved performance and high efficiency?

**Colder temperatures**
- Lower churning losses
- Lower friction
  → Improved mechanical efficiency

**Warmer temperatures**
- Less leakage
- Lower compressibility
  → Higher volumetric efficiency
- Increased film thickness
  → Improved equipment protection
Performance Advantages

- Reduced energy consumption

- Extended drain intervals by improving
  - Oxidation resistance and thermal stability
  - Reduced volatility

- Longer equipment life and lower downtime
  - Improved film thickness, better inherent lubricity, reduced wear and pitting
  - Lubricate under extreme conditions
  - Good solvency and low varnish leading to lower filter clog

- Low operating costs and improved performance
**Grades: VG 220 to 680**
- Meets DIN 51517 Part 3 (CLP), AGMA 9005-E02, AIST 224 (USS), ISO 12915-1 & Flender requirements

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**Recommended** for Helical, Bevel and Planetary gear boxes

Approved by M/s Siemens AG (formerly Flender), Germany
Meets:
- DIN 51517 Part 3 (CLP), AGMA 9005-E02, AIST 224 (formerly USS 224)

Salient Features
- Extreme pressure & load carrying capability - reduced gear wear
- Resistance to oxidation - extended lubricant life
- Protection against rust & corrosion (sea water) – protection of equipment
- Antifoam & water separation – problem free operation
- Reduced maintenance, down time & overall lubrication cost

Applications
- Spur, helical, bevel, worm gear: conveyor, gear drive, pump, turning gear, heavily loaded plain & rolling contact bearing, slow and medium speed gear system

Very High Viscosity index, reduced frictional losses & enhance efficiency
Oxidation Stability Comparison
[ASTM D 943 (TOST) & ASTM D 2893 (GOOT)]

- Oil is exposed to elevated temp., ingress of air, metals during its service & oil oxidation process initiated
- Generation of acids & insoluble sludge during oxidation may cause severe damage to system

<table>
<thead>
<tr>
<th>ASTM D 2893 (K.V. increase, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Servosyn?ear 220 Plus</td>
</tr>
<tr>
<td>Servosyn?mesh Gold 220</td>
</tr>
<tr>
<td>Servomesh Gold 220</td>
</tr>
<tr>
<td>Servomesh XP 220</td>
</tr>
<tr>
<td>Servomesh SP 220</td>
</tr>
<tr>
<td>ISO 12915-1</td>
</tr>
<tr>
<td>AGMA 9005 E02</td>
</tr>
<tr>
<td>US Steel 224</td>
</tr>
<tr>
<td>DIN 51517 (P 3)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Description</th>
<th>D 2893</th>
<th>D 943</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test sample</td>
<td>300 ml</td>
<td>300 ml + 60 ml distilled water</td>
</tr>
<tr>
<td>Duration, hrs.</td>
<td>312 ± 1.0</td>
<td>Time to reach 2 TAN</td>
</tr>
<tr>
<td>Flow rate, L/hr.</td>
<td>10 ± 0.5</td>
<td>3.0 ± 0.5</td>
</tr>
<tr>
<td>Gas</td>
<td>Air</td>
<td>Oxygen</td>
</tr>
<tr>
<td>Temp., ⁰C</td>
<td>121 ± 1.0</td>
<td>95 ± 1.0</td>
</tr>
<tr>
<td>Catalysts</td>
<td>--</td>
<td>Cu &amp; Steel (3 Meter each)</td>
</tr>
<tr>
<td>Assessment criteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% change in kin viscosity</td>
<td>6.0 Max Report</td>
<td>--</td>
</tr>
<tr>
<td>Precipitation no.</td>
<td>--</td>
<td></td>
</tr>
<tr>
<td>Time to reach 2 TAN, mg KOH/g</td>
<td>--</td>
<td>Time in hours</td>
</tr>
</tbody>
</table>

Laboratory scale assessment for oxidation stability – life of oil in the system
SEMI - SYNTHETICS GEAR LUBRICANTS

“NUFLUX technology”
Position of NUFLUX™ within industrial gear oils

Mineral IGOs

NUFLUX™

Synthetic IGOs

- Focus on high tier applications where high VI, low temperature performance, film thickness and wear protection play a major role

**NUFLUX™ is best suited for:**

- Price-sensitive high-tier applications where synthetics are too expensive
- Applications where mineral-based IGOs cannot achieve the desired performance
- Independent blenders who don’t have the resources to go through the challenging development and approval process for IGOs
- Independent blenders with limited access to high-viscosity PAOs
FZG Efficiency of NUFLUX Compared to PAO and Mineral Oil

• At 30°C, NUFLUX showed the lowest torque losses across all load stages.
• Losses on average
  • 11% lower than those of the mineral oil
  • 6% lower than those of the PAO formulation
• At 60°C, PAO formulation and NUFLUX outperform mineral oil at higher loads. Losses of NUFLUX and PAO on average
  • 6% lower than those of mineral oil

Test was run acc. PV 1456; Correlation to FVA 345 was shown in 345 lb
Higher Drain Interval Confirmations

Increase in Kv

- Significantly lower increase in viscosity (~60% lower) vs. SP 320

Wear Metals

- Significantly lower Fe & Si pickup (~50% lower) vs. SP320

Confirms the Enhancement of Drain Interval and Correlates well with Laboratory Oxidation & Tribological Test Results
Meets

- DIN 51517 Part 3 (CLP), AGMA 9005-E02, AIST 224 (USS), ISO 12915-1 & Flender requirements

Salient Features:

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Recommended for Helical, Bevel and Planetary gear boxes

Approved by M/s Siemens AG (formerly Flender), Germany

Approved by Hansen, Germany
Comparison: Mineral — PAO — NUFLUX

- Total fluid cost
- Efficiency
- Additive compatibility
- Durability
- Wear protection

- Mineral
- PAO
- NUFLUX™
NUFLUX™ offers the possibility to:

- replace PAO with a more economic alternative at similar performance
- Upgrading mineral oils toward longer service life and better efficiency
Tailor made gear oils suitable for high temperature, pressure & load / heavy duty cycles for INDIAN STEEL Industry

Mineral Base:
- **Servomesh SP**: Conventional S-P chemistry
- **Servomesh XP**: Anti-micropitting (AMP) with improved thermal / oxidation stability and AW/EP performance
- **Servomesh Gold**: AMP properties with excellent thermal / oxidation stability & Flender approved

Semi-synthetic Base:
- **Servosynmesh Gold**: Anti-micropitting (AMP) with superior thermal / oxidation stability and AW/EP performance; Flender approved

Synthetic Base:
- **Servosyngear oils**: PAO based synthetic gear oils
- **Servosyngear HVI oils**: PAG based synthetic gear oils
- **Servosyngear Plus**: PAO based synthetic gear oils Flender approved
Thank you