Nano Structure Urea Grease: Performance and Application

Akihiro SHISHIKURA and Hideki NAKATA

IDEMITSU KOSAN CO., LTD., JAPAN

5/22/2018 at Minneapolis, U.S.A.

Contents

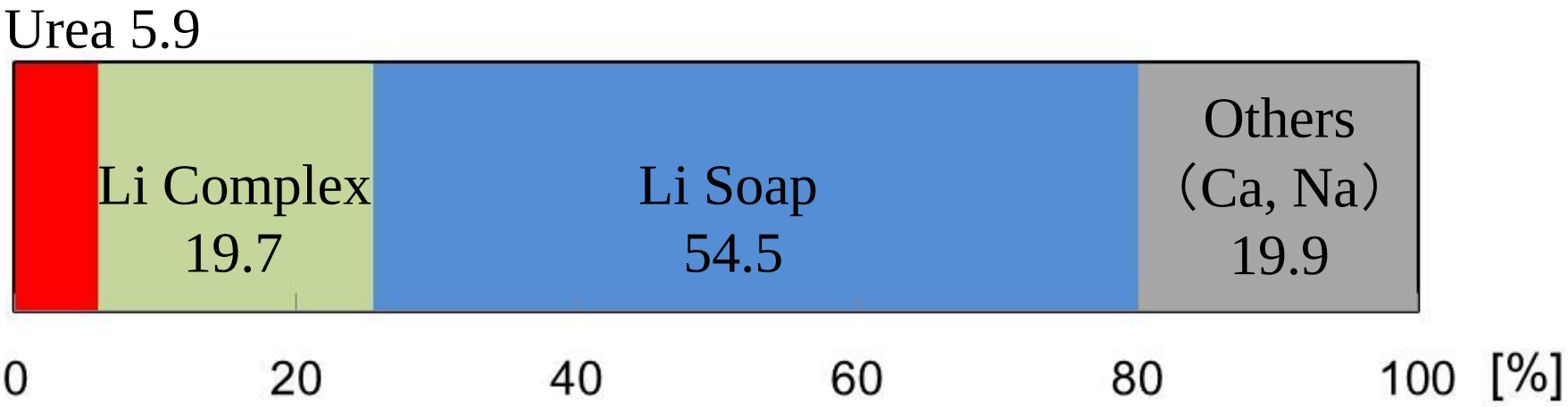
1. *Introduction*
2. *Nano Structure Urea Grease*
    - *1) Structure*
    - *2) Performance*
3. *Application for Robot's Speed Reducer*
4. *Conclusion*

1. Introduction

1. Introduction

◇ Grease Production in 2016：1.15 MT/Y

◇ High Performance Grease
= Li Complex Grease and Urea Grease



1. Introduction

Characteristics of Greases (by thickener)

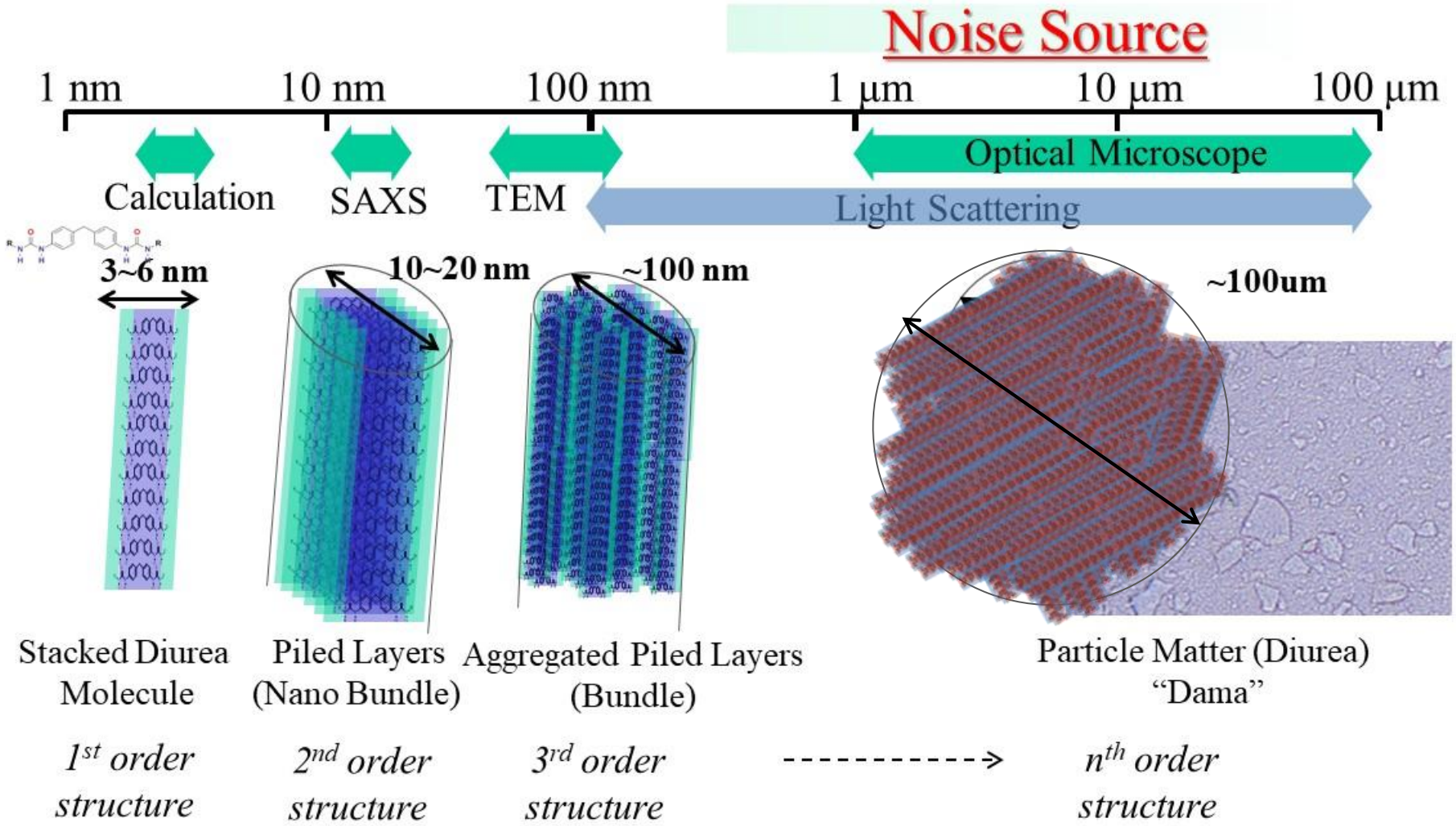
Characteristics	Li Soap	Li Complex	Urea
Heat-Resistance Oxidation	×	△	○
Lubricity	△	○	○
Noise	○	△	×→○
Price	○	△	×→○

Miniaturize grease structure
by using a novel production process

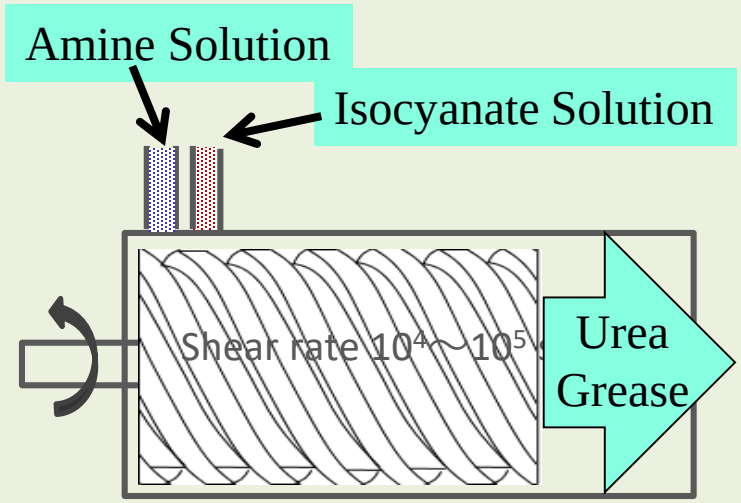
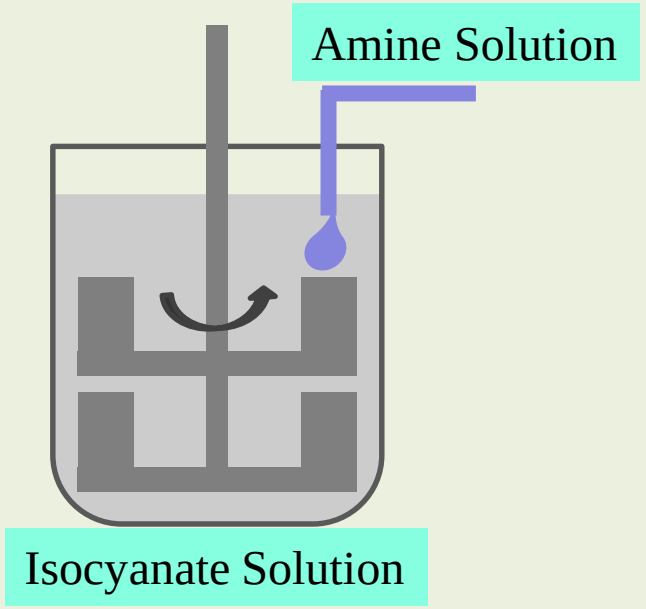
2. Nano Structure Urea Grease (INS-UG)

1) Structure

2. INS-UG 1) Structure

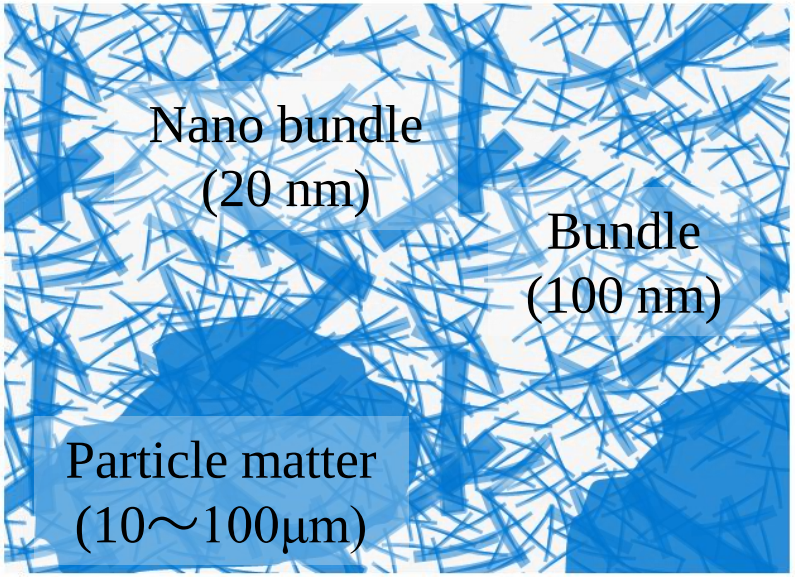


2. INS-UG 1) Structure

Process	New (Continuous)	Conventional (Batch)
Reaction		
	Miniaturize thickener in ultra-high shear field	Fiberize the thickener in stirring mixing field
Finishing	Line Mixing	Batch Mixing
Milling	No Need	Necessary

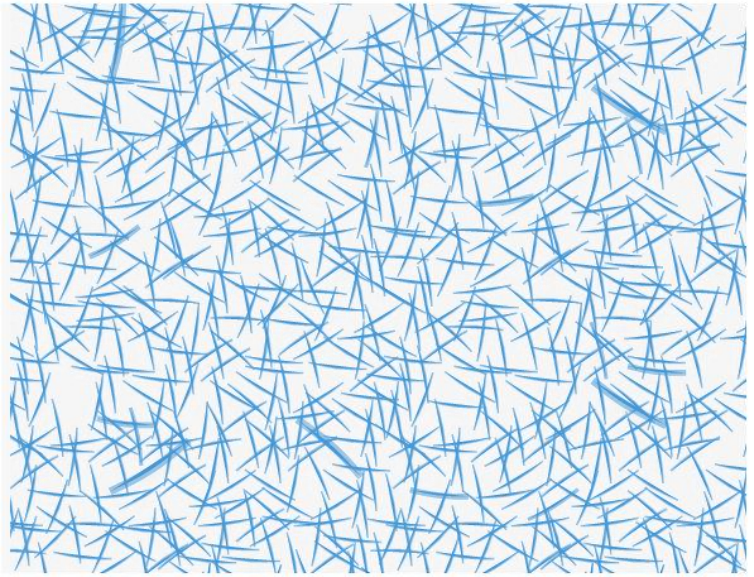
2. INS-UG 1) Structure

Conventional Process



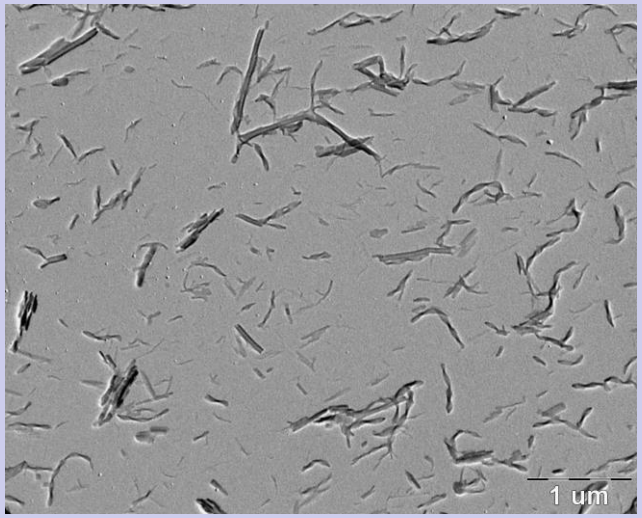
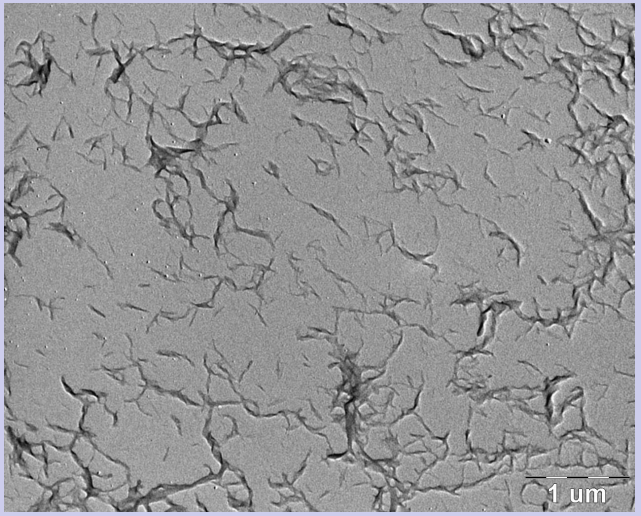
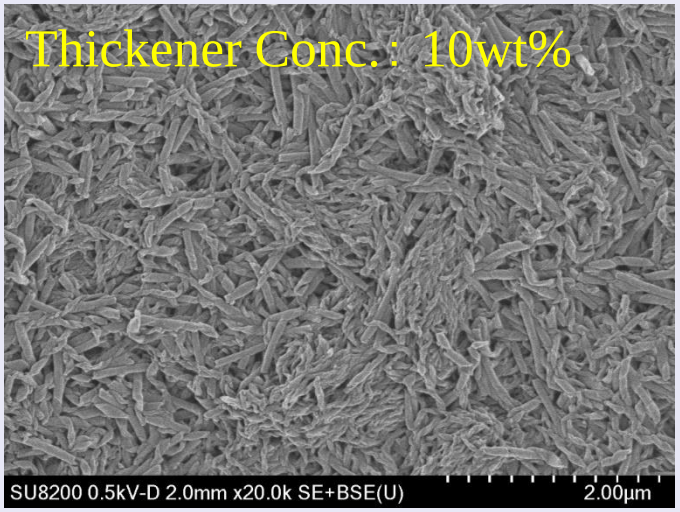
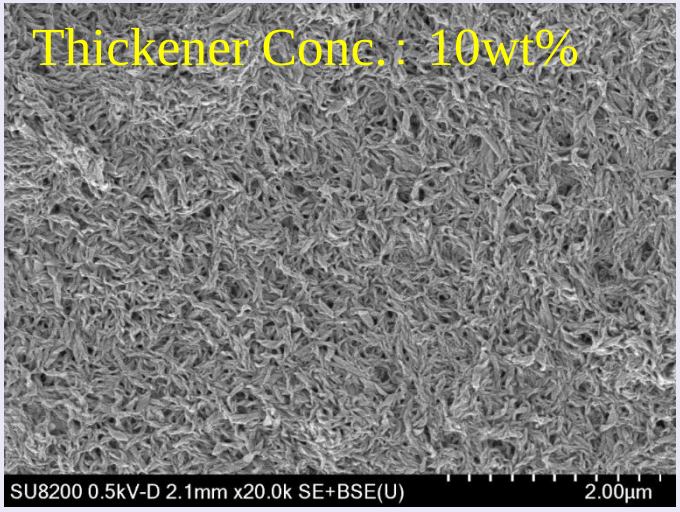
Heterogeneous Morphology

New Process (INS-UG)



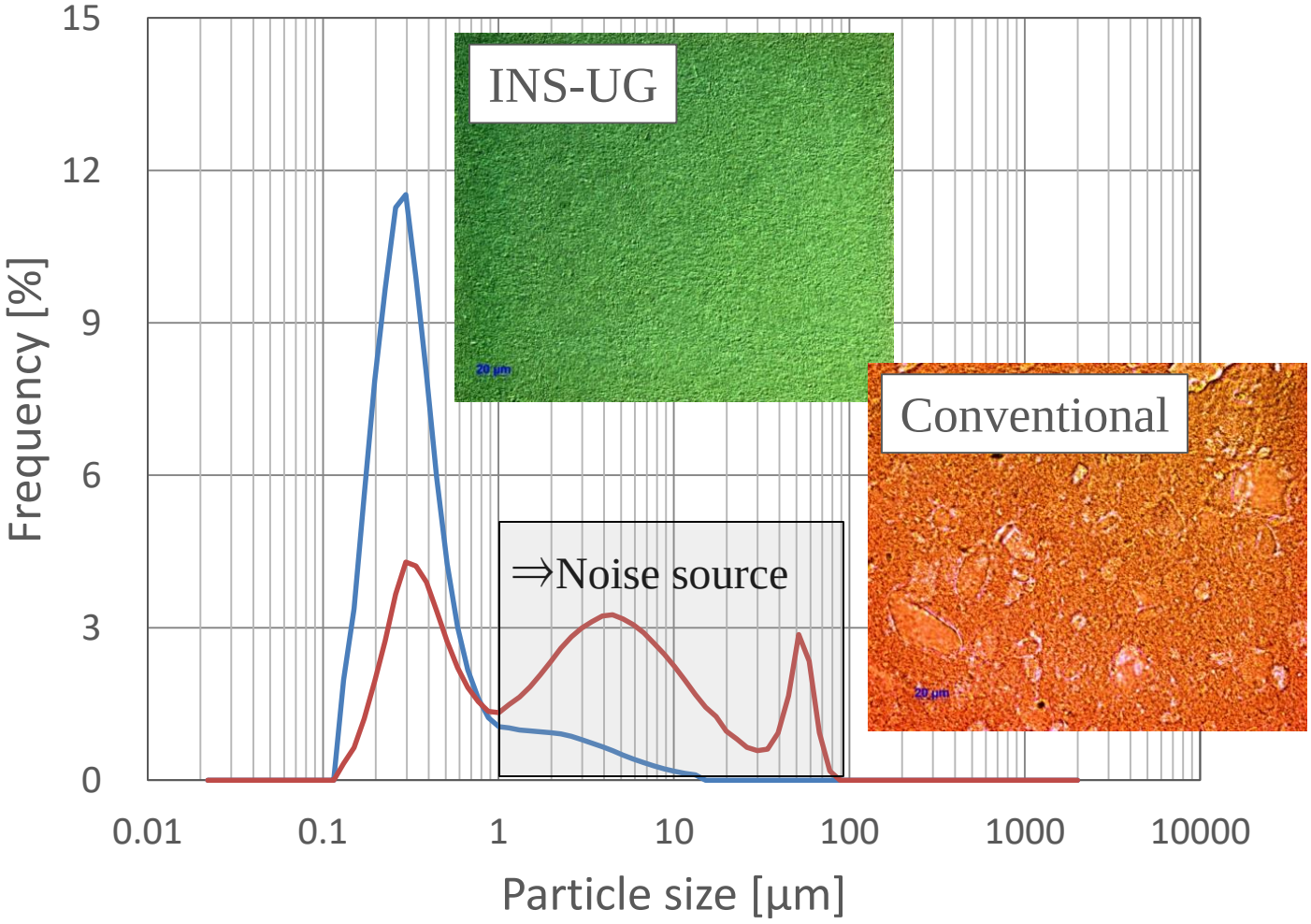
Fine “Nano-bundles” are dispersed homogeneously.

2. INS-UG 1) Structure

Method	Conventional	New Process (INS-UG)
TEM (x20000)		
SEM (x20000)		

2. INS-UG 1) Structure

Particle Size Distribution (Light Scattering Analysis)

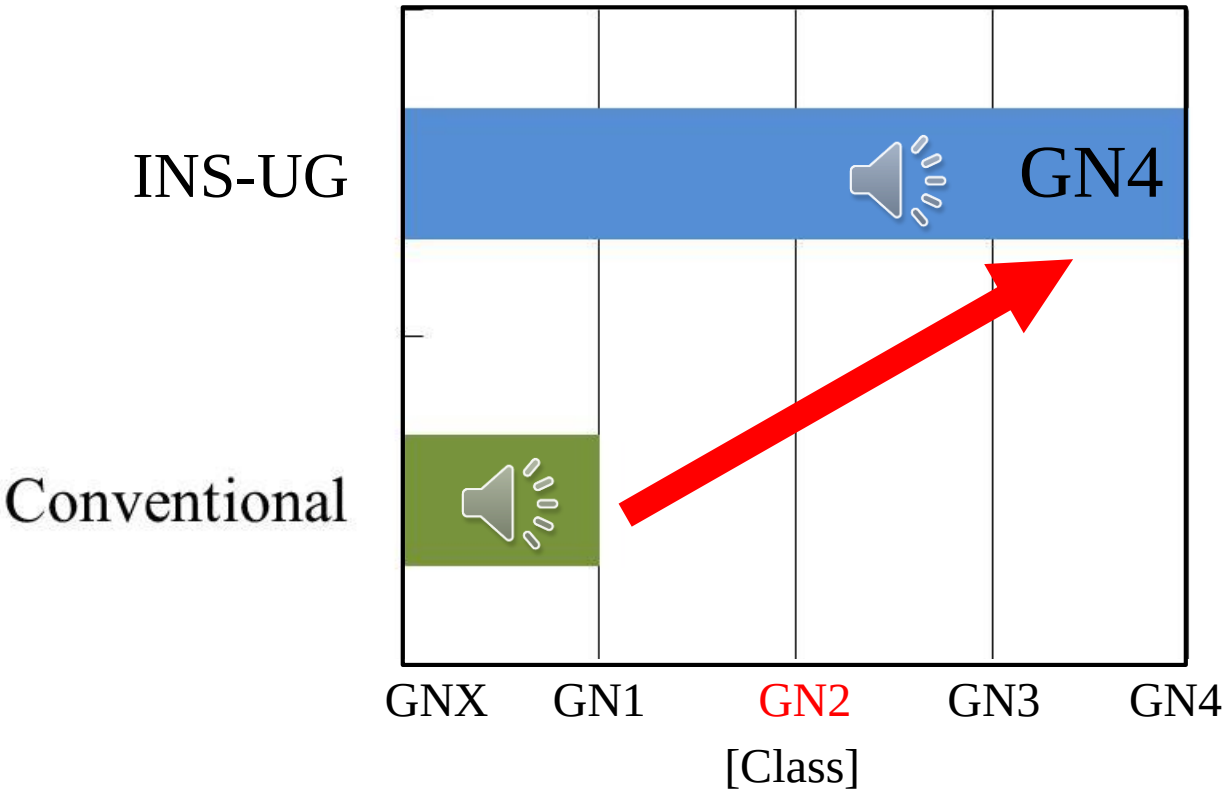


2. Nano Structure Urea Grease (INS-UG)

2) Performances

2. INS-UG 2) Performances

1. Acoustic Characteristics (BeQuiet+)

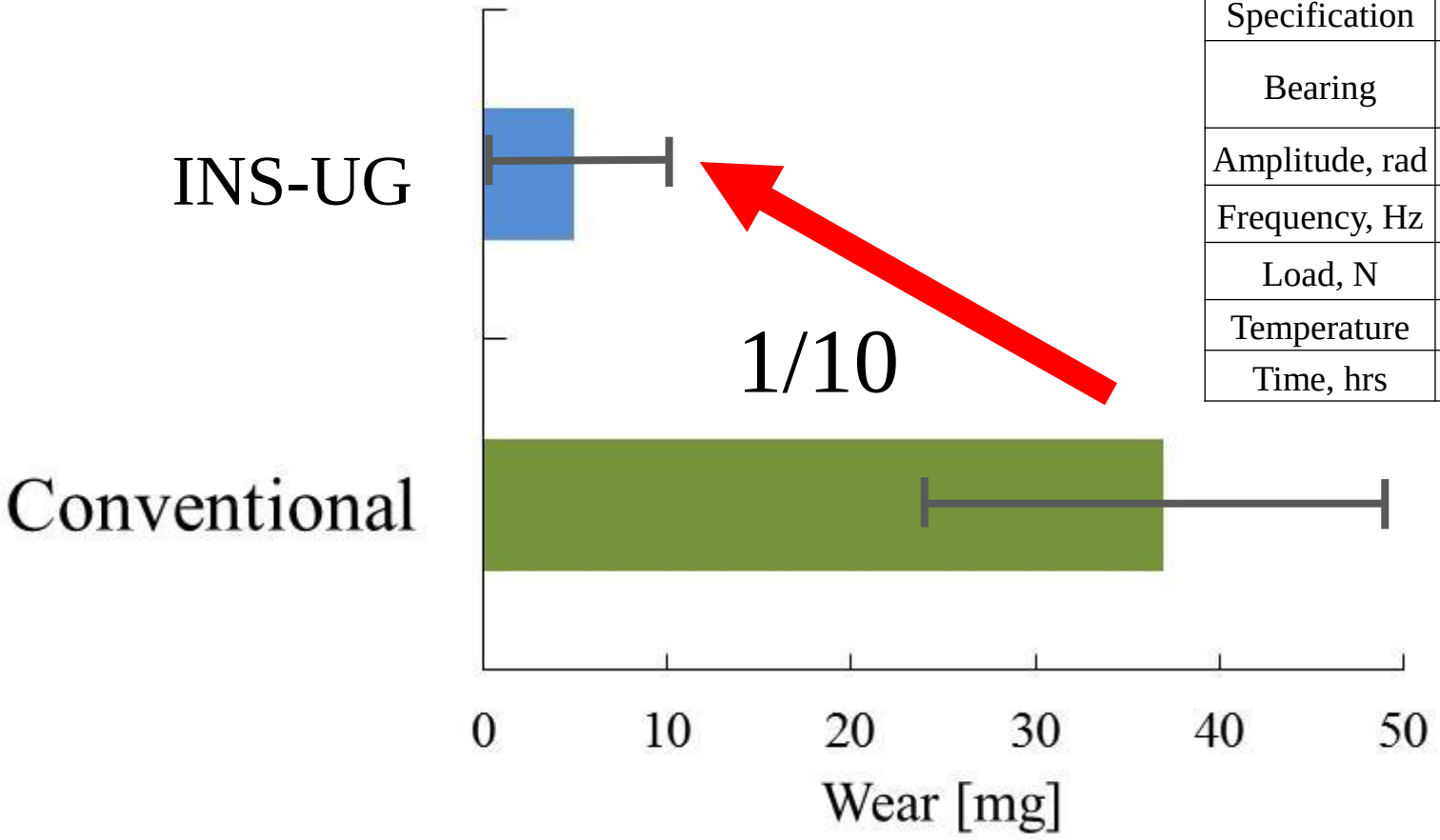


BeQuiet+	
Bearing	608
Fill amount	0.15g
rotation speed	1800rpm
axial load	30N
measurement times	10
running time	32s
repeat times	10

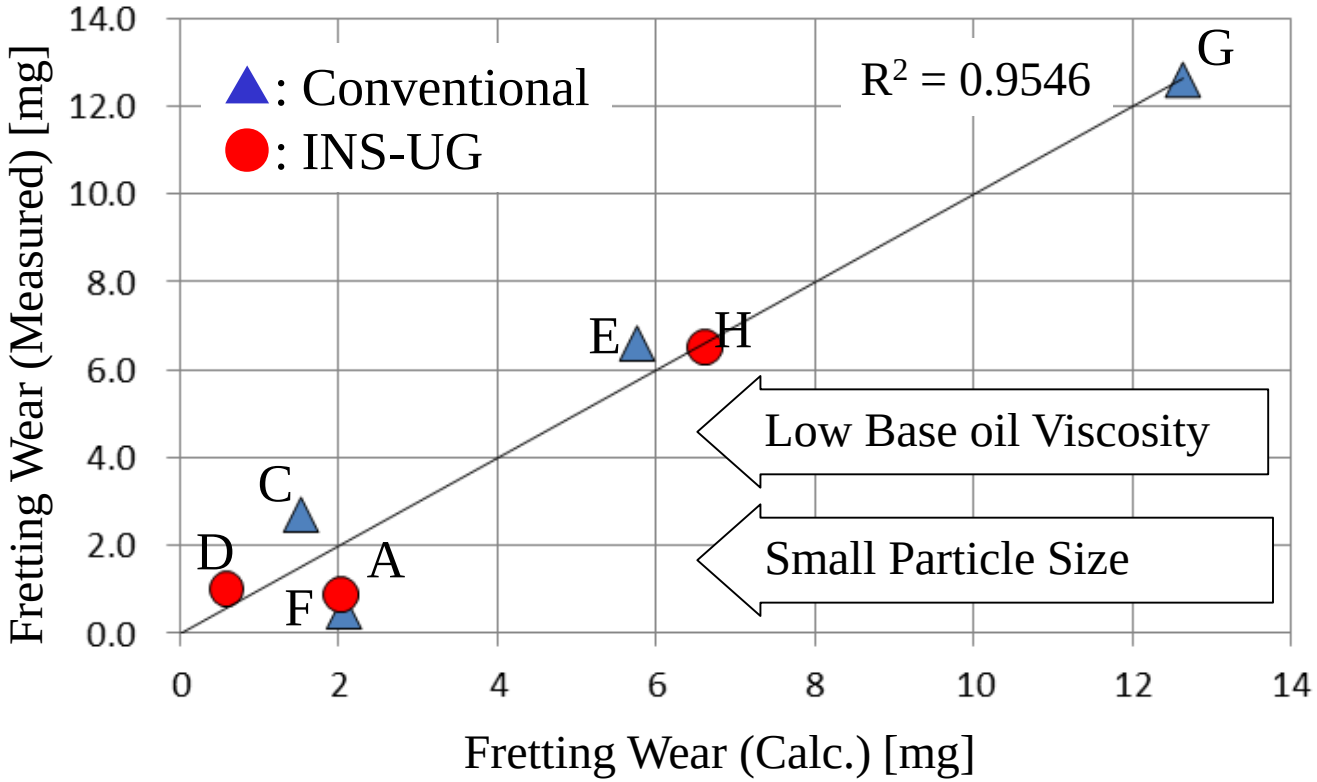
Ultra low noise grease ⇒ Automotive electrical components
High Performance Bearings

2. Fretting Wear Property (ASTM D 4170)

Fretting wear test	
Specification	ASTM D4170
Bearing	Thrust bearing 51203
Amplitude, rad	±0.105
Frequency, Hz	25
Load, N	2940
Temperature	Room temperature
Time, hrs	22



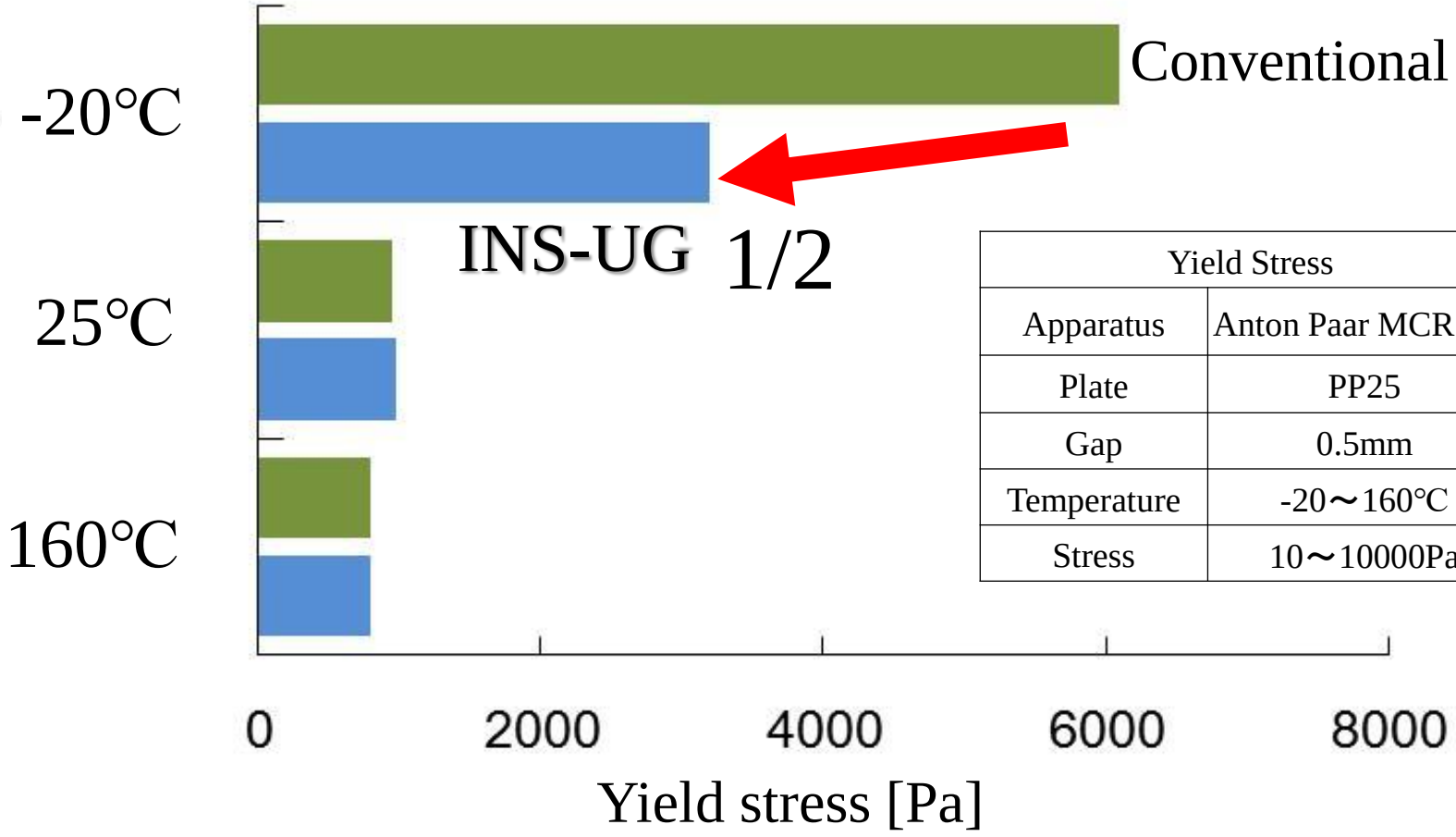
2. Fretting Wear Property (ASTM D 4170)



Fretting Wear (mg) = 0.0835 × Kinematic Viscosity of Base Oil (mm^2/s)
+ 0.538 × Arithmetic Mean Diameter of Thickener (μm) - 2.10

Smaller particle diameter ➔➔➔ Lower fretting wear

3. Low Temperature Characteristic (Yield Stress)



Yield Stress	
Apparatus	Anton Paar MCR 301
Plate	PP25
Gap	0.5mm
Temperature	-20～160℃
Stress	10～10000Pa

Small Fiber Structure ⇒ Low Stirring Resistance

4. Performance of INS-UG

Characteristics		INS-UG	Conventional	Evaluation
Noise	Be Quiet [-]	GN4	GN1	◎
Anti-Weld	FALEX [N]	1050	700	◎
Fretting Wear	ASTM D 4170 [mg]	4	37	◎
Durability	ASTM D 3336 [h]	2256	1181	◎
Low Temp. Property	Yield Stress @-20℃ [Pa]	2500	5500	◎
Heat Resistance	Dropping Point [℃]	260<	260<	○
Rust Prevention	Bearing Rust Prevention [-]	Pass	Pass	○
Water Resistance	ASTM D1264 [wt%]	0.1	0	○
Shear Stability	Roll Stability @80℃, 20h [-]	46	55	○
SHELL EP	ASTM D2783 WL [N]	1236	1236	○
SHELL Wear	ASTM D2783 [mm]	0.48	0.53	○

5. Estimated Mechanism of INS-UG

<table>
<tr><th>Performances</th><th colspan="3">Characteristics of INS-UG</th></tr>
<tr><td>Low Noise</td><td>Stirring Resistance</td><td>Small</td><td rowspan="5">[Mechanism]
① Oil Film Formation
② Additive Film Formation
③ Urea Film Formation</td></tr>
<tr><td>Anti-Weld</td><td>Fracture Resistance</td><td>Small</td></tr>
<tr><td>Abrasion Resistance</td><td>Base Oil Tranport</td><td>Lot</td></tr>
<tr><td>Durability</td><td>Additive Transport</td><td>Lot</td></tr>
<tr><td>Low Temp. Property</td><td>Thickener Transport</td><td>Lot</td></tr>
<tr><td>Heat Resistance</td><td colspan="3" rowspan="4">Same as Conventional UG</td></tr>
<tr><td>Rust Prevention</td></tr>
<tr><td>Water Resistance</td></tr>
<tr><td>Shear Stability</td></tr>
</table>

2. INS-UG 2) Performances

New Grease (INS-UG)

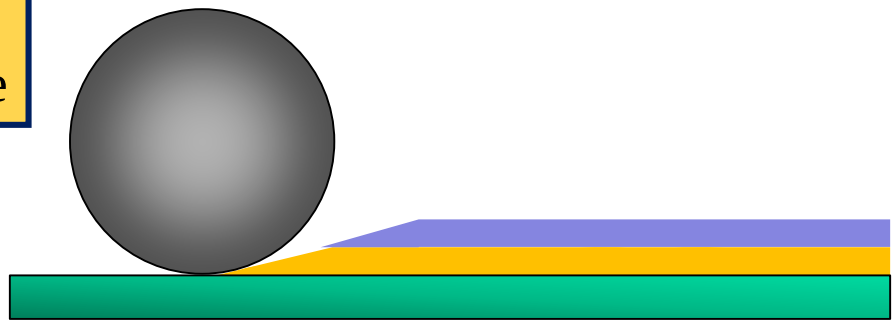
Fiber : Fine

Specific Surface Area: Large
Number of Particles: Lot

Oil Hold: Lot

Oil Transport: Lot

Urea Supply to Friction Surface



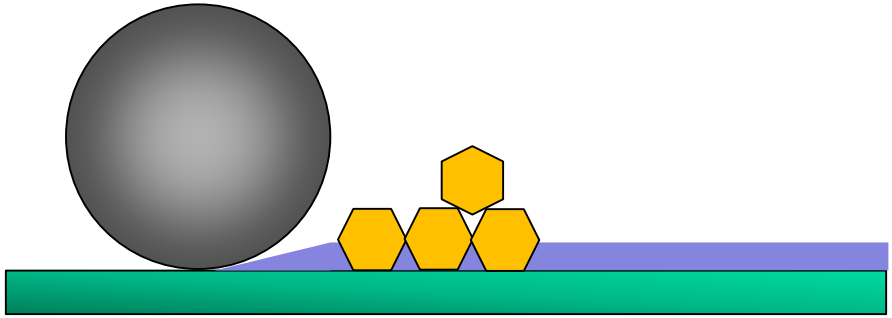
Oil Film

Urea Film

Conventional Grease

Fiber: Large

Removal Urea from Surface



Oil Film

6. Application Area of INS-UG

- Automobile (e-Mobility)
- Construction Machine
- Agricultural Machine
- Forestry Machine
- Wind Turbine
- Hot Metal Working Machine
- Electric appliances (Motor)
- Robot (Gear)
- Bearings

3. Application of INS-UG For Robot's Speed Reducer

Speed Reducers for Robots

Planetary Differential Gear (RV Gear)

Ball Bearing, Needle Bearing, Taper Roller Bearing, Spar Gear, Pin Gear

Strain Wave Generator (Harmonic Drive)

Ball Bearing (Wave Generator), Cross Roller Bearing, Flexspline, Circular Spline

Inscribed Planetary Gear (Cyclo Gear)

Ball Bearing, Needle Bearing, Pin Gear

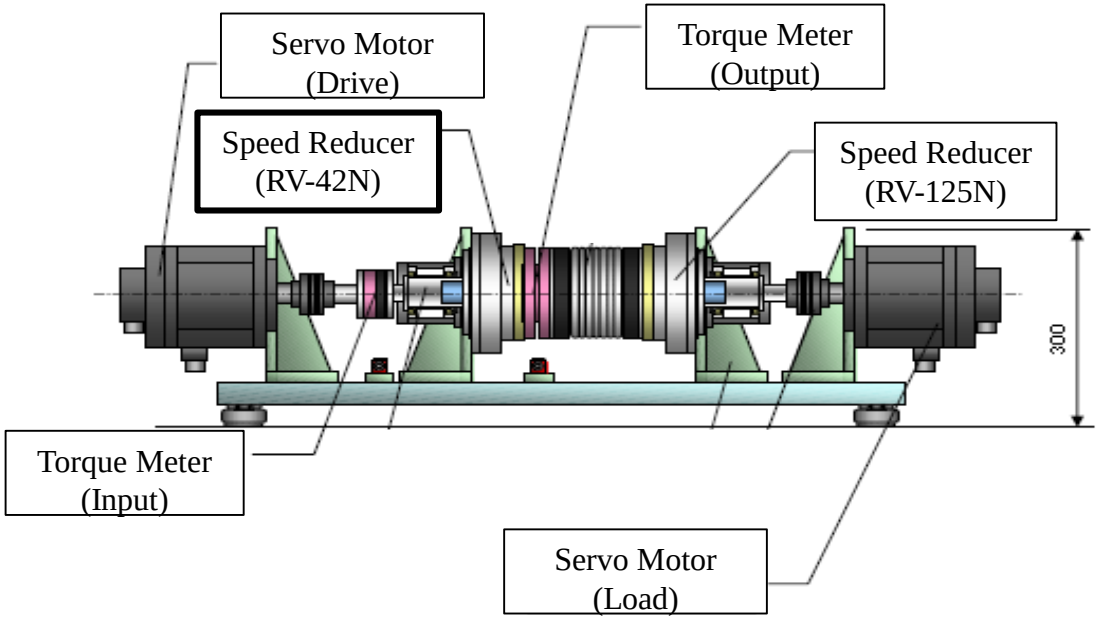
3. Application for Robot

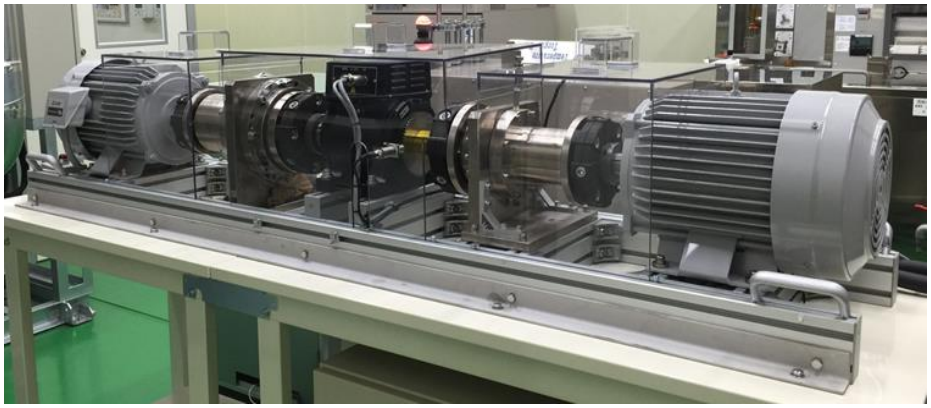
Durability Test Equipment of Robot's Speed Reducer

Test Conditions

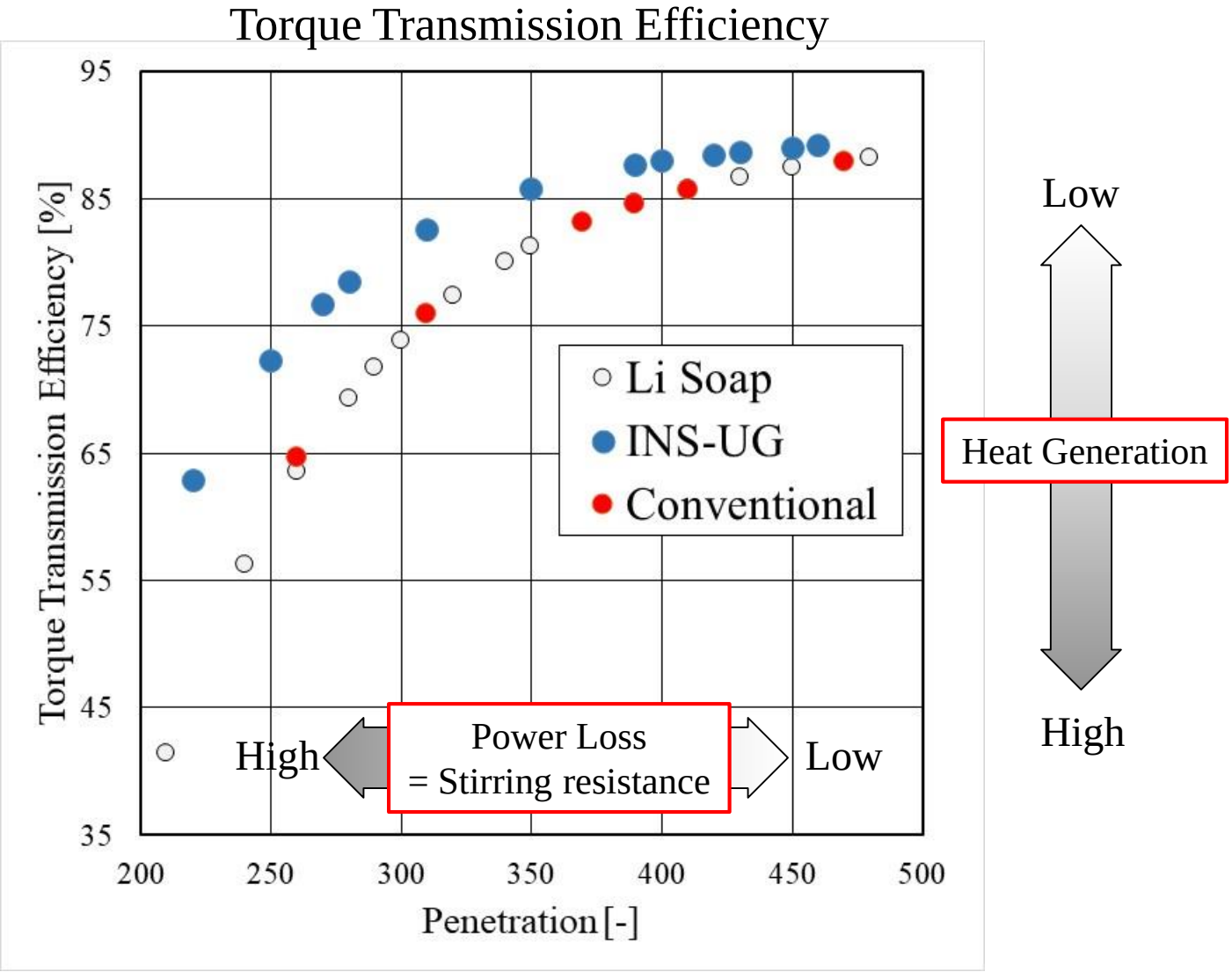
Speed Reducer:
RV-42N (Nabtesco)
Input: 2015 rpm
Output: 15 rpm
Load: 1030 Nm
(Rated: 412 Nm)
Temperature:
No Control

Rated Life (calc.): 283 h



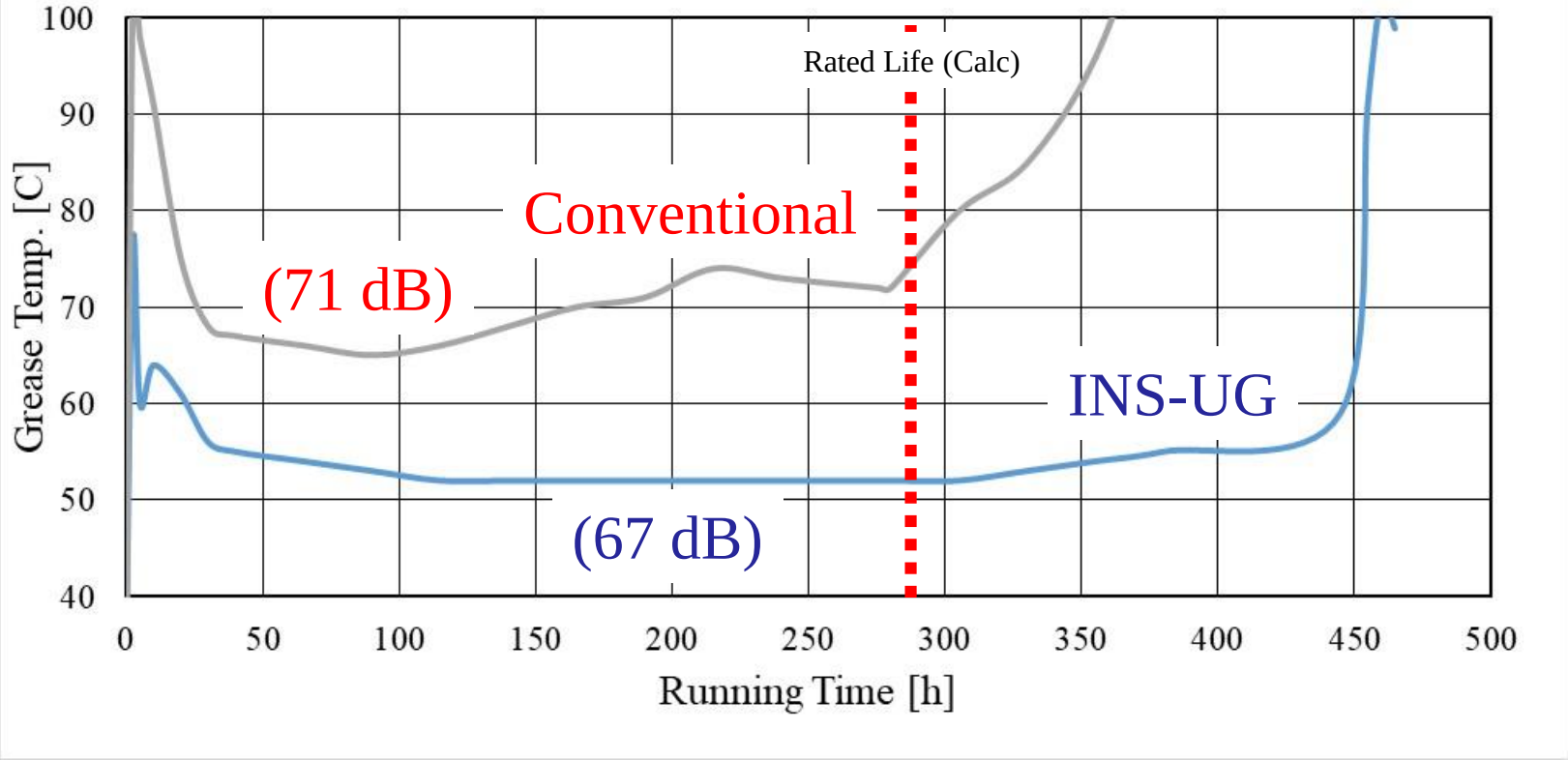


3. Application for Robot



3. Application for Robot

Grease Temperature & Noise



Nano Structure → Low Power Loss → Low Heat Generation
→ Long Running Time

5. Conclusion

Nano structure urea grease (INS-UG) was produced by a special designed ultra-high shear reactor.

The particle (fiber) size of urea thickener was under submicron size.

Ultra low noise (BeQuiet+ test)

Low fretting wear (ASTM D 4170)

[Application: robot's speed reducer]

- High power transmission efficiency
- Low heat generation
- Long running time

Thank you!!!

Samples

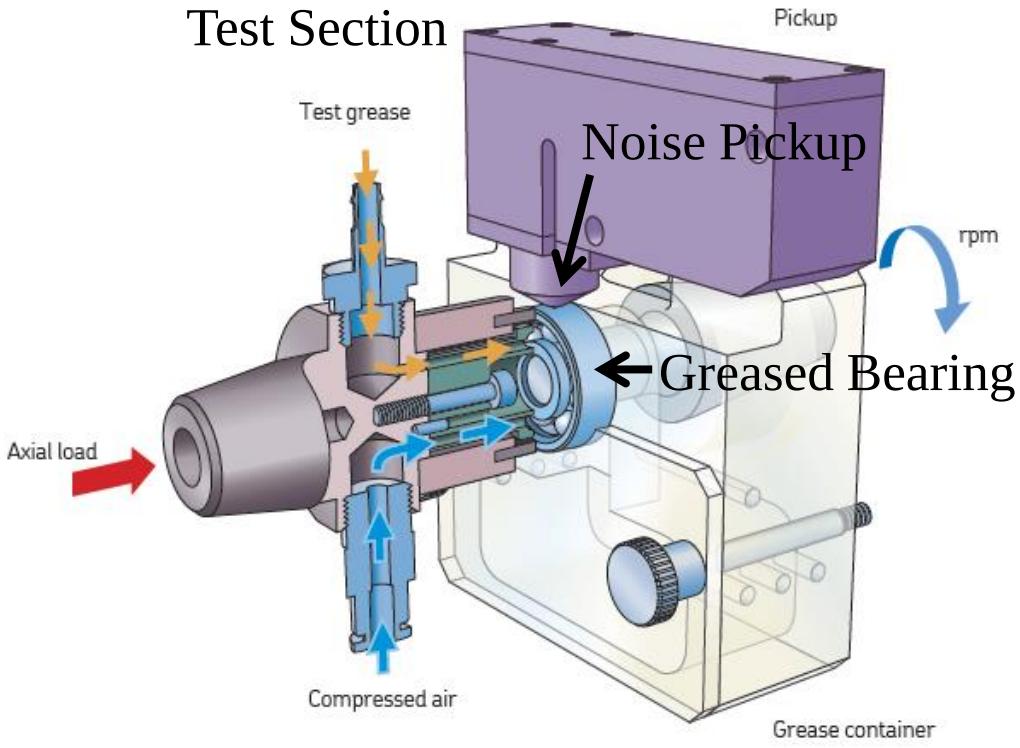
Composition		
Thickener	Alicyclic + Aliphatic Urea（10wt%）	
Base oil	PAO (50mm^2/s)	
Additives	Antioxidant Antirust agent	
Properties		
	Conventional Process	New Process (INS)
Worked penetration (25℃、60W)	265	272
Dropping point （℃）	260＜	260＜
Oil separation （wt%）	0.1	0.2
Oxidative stability (kPa)	25	25
Water resistance (wt%)	0.1	0.1
Shell EP WL (N)	1236	1236

BeQuiet method

Automatic grease feed
Peak noise → "GN class" determined

Bearing 608/QE4
1800 rpm
Axial load 30N

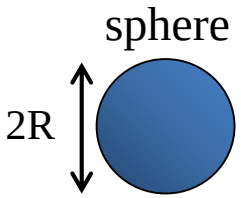
Test Section



The classification of grease noise is set in GN classes in the following way:

GN0: > anything worse than GN1
GN1: > 95 percent of all peaks are = 40 µm/s
GN2: > 95 percent of all peaks are = 20 µm/s Commercial Level
GN3: > 95 percent of all peaks are = 10 µm/s
> 98 percent of all peaks are = 20 µm/s
100 percent of all peaks are = 40 µm/s
GN4: > 95 percent of all peaks are = 5 µm/s
> 98 percent of all peaks are =10 µm/s INS-UG
100 percent of all peaks are = 20 µm/s
GN5: > 95 percent of all peaks are =2.5µm/s
> 98 percent of all peaks are =5 µm/s
100 percent of all peaks are =10 µm/s

Light Scattering

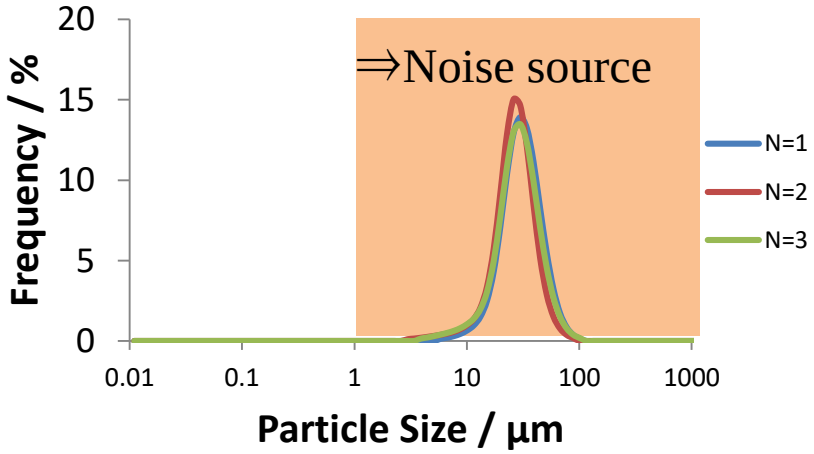


$$\ln qI(q) \propto \exp(-\frac{q^2R^2}{5})$$

I(q) :Scattering intensity
q : Scattering vector

HORIBA Particle Size Distribution Analyzer LA-950A
Wave length : 650 nm, 405 nm
Detector : silicon photo diode
Theory : Mie scattering
Size range : 10 nm～3000 μm

Conventional Process



New Process (INS-UG)