Lubricating Greases

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Agenda

- Definition of greases
- Composition and classification of greases
- Production
- Applications
- Development

Definition of grease

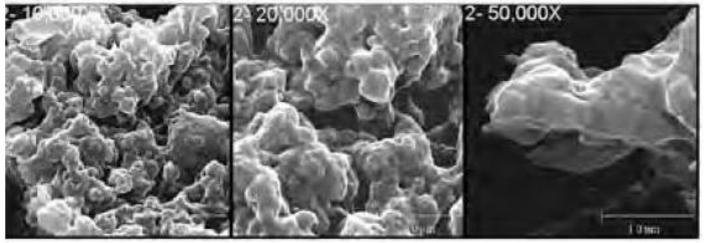
- ASTM D288: „a solid to semifluid product of **dispersion** of a thickening agent in a liquid lubricant”
  - Dispersed phase: **thickener**
  - Continous medium: **lubricant** (base oil)

- Sinitsyn: „a lubricant which under certain loads and within the range of temperature application, exhibits the properties of a solid body, undergoes plastic strain and starts to flow like a fluid should the load reach the critical point and regains solid body properties after the removal of the stress”

Solid ⟷ Semifluid

Temperature/pressure/shear

- Ishchuk: dispersion of theickener and oil, where the dipersed phase:
  - Forms a 3D skeleton penetrating the dispersion medium
  - Skeleton elements have colloidal sizes in two measuring directions
  - Is held in solution by Van der Waals and capillary forces



Composition

~20% additives

~ 80% base oil

~0-10% additives

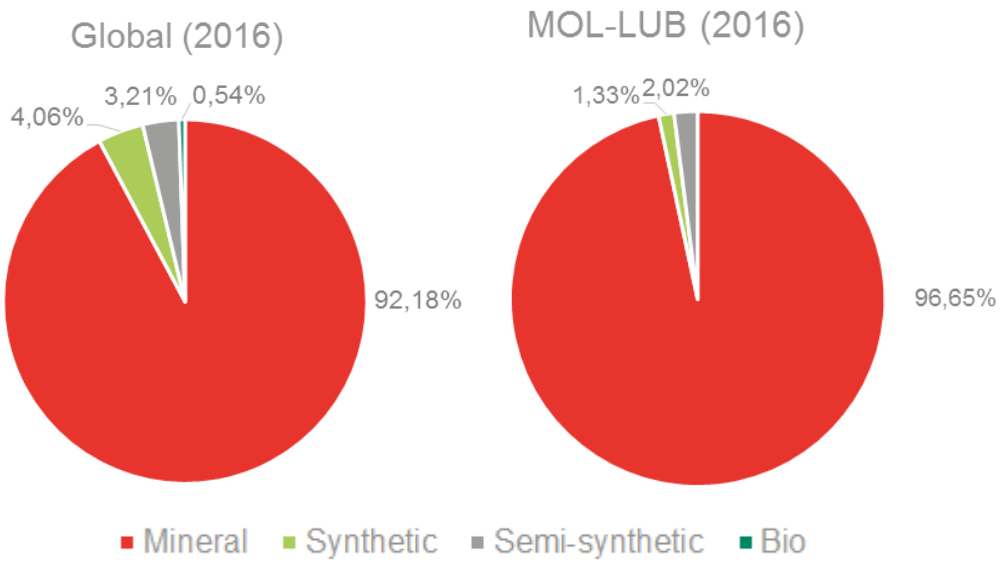
~4-18% thickener

~ 70-96% base oil

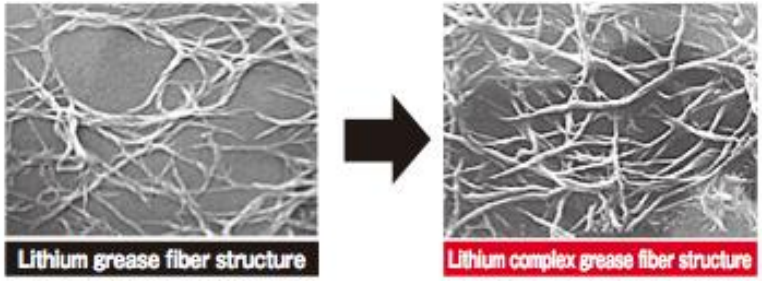
- Base oils (MOL-LUB)
  - Group I base oils (60-500 cSt V40)
  - Group IV base oils (poly-alpha-olefins)
- Additives
  - Like conventional lubricant additives (EP/AW, polymers, corrosion inhibitors, etc.)
  - Other solid additives (graphite, molybdenum-sulfide.)

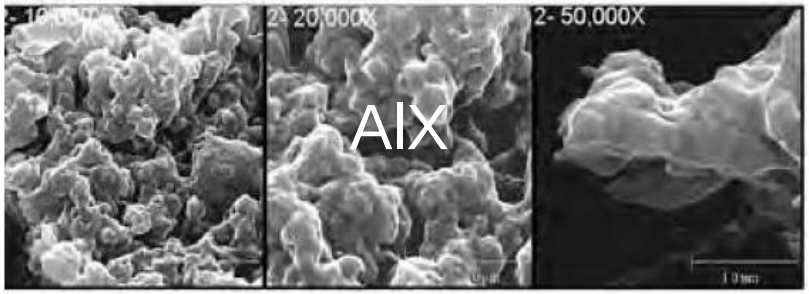
Classification of greases

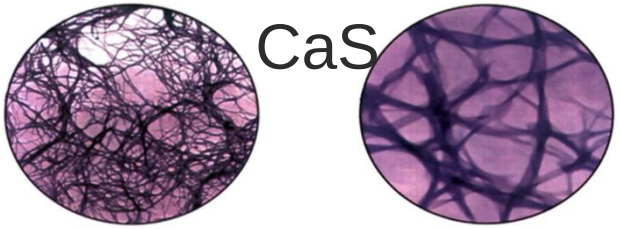
- By composition
  - By base oil
    - Mineral
    - Synthetic
    - Semi-synthetic
    - Bio
  - By thickener
    - Soap thickeners
      - Conventional
      - Complex
    - Non-soap thickeners
- By NLGI consistency grade
- By application

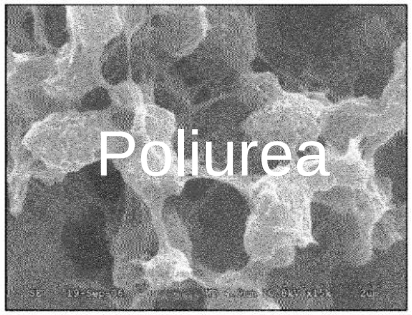


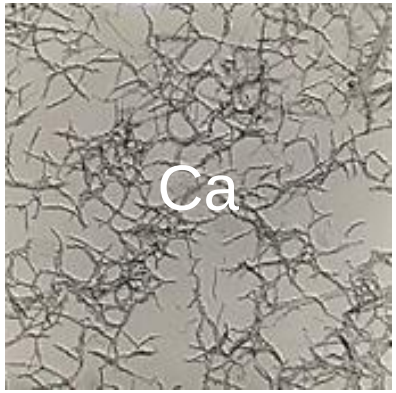
Type of thickeners

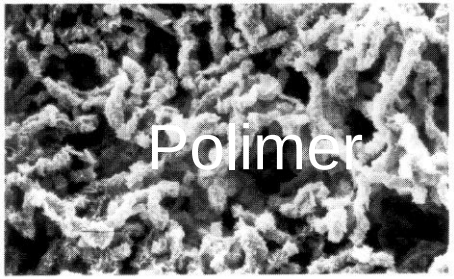










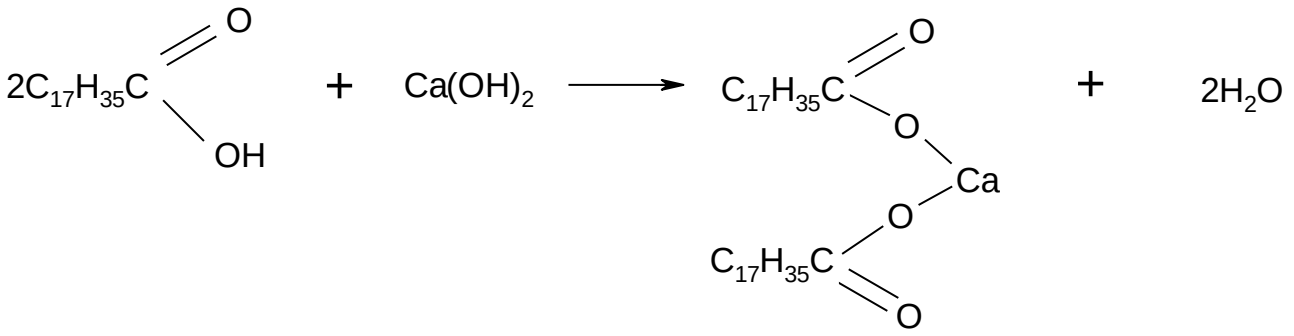


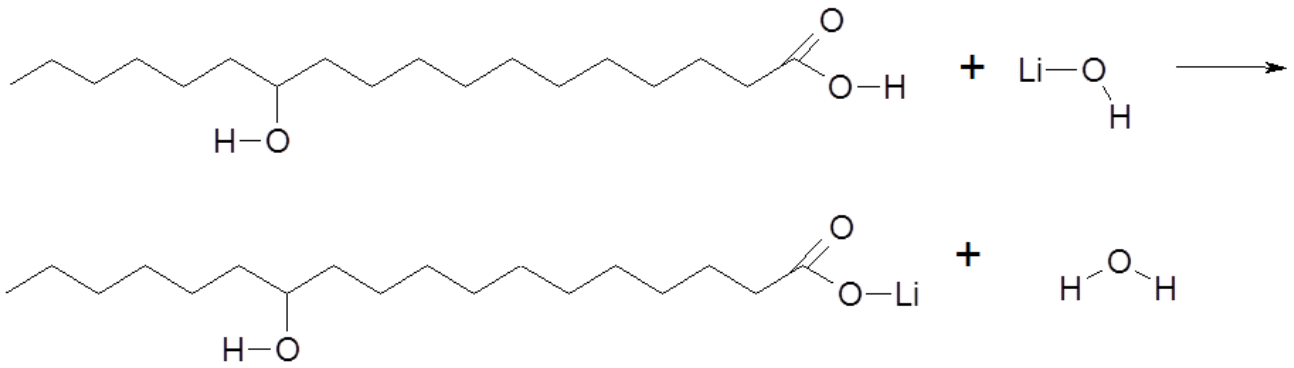
Typical characteristics of main thickeners

Thickener	High temperature application (°C)	Mechanical stability	Water resistance	Main application
Lithium	120	good	good	Bearings
Lithium-complex	140-160	very good	good	Bearings
Ca (hydrous)	60-70	moderate	good	Seals, chains
Ca (unhydrous)	90-100	good	very good	Bearings
Ca-complex	150-180	good	good	Bearings, seals, chains
Calcium-sulphonate	140-160	very good	very good	Heavy industry, bearings
Aluminium-complex	140-160	good	very good	Heavy industry, gears
Bentonit	200-220	moderate	good	High temperature bearings

Thickeners

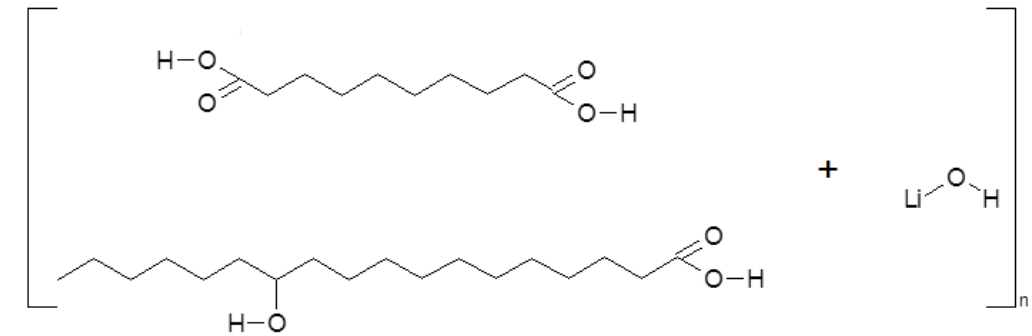
- Conventional metallic soaps
  - By reaction of a carboxylic acid and metal hydroxide

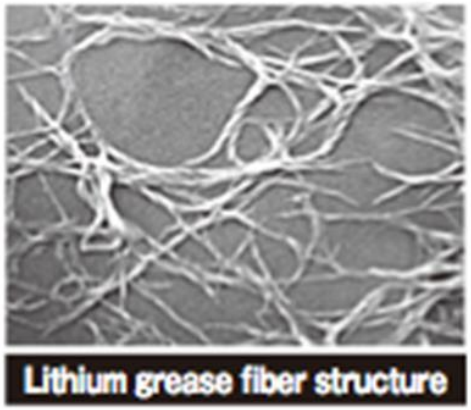


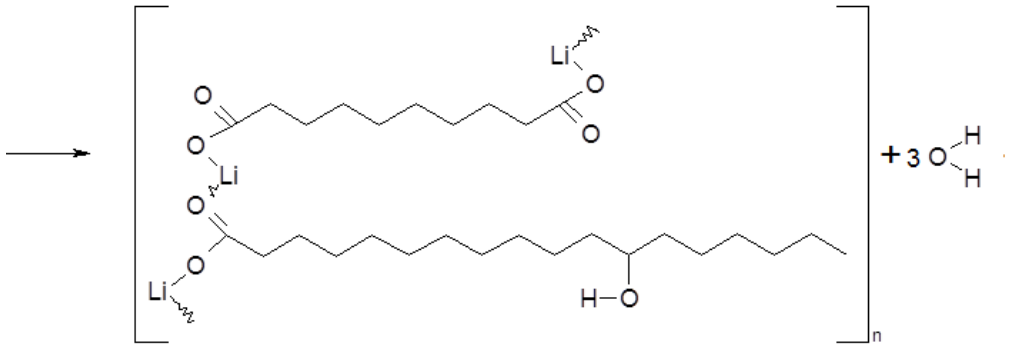


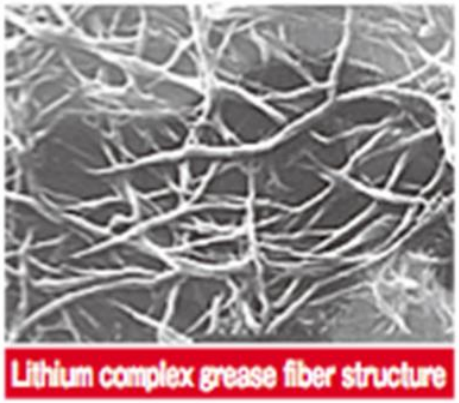
Thickeners

- Complex thickeners
  - Metallic soaps containing more than one anion





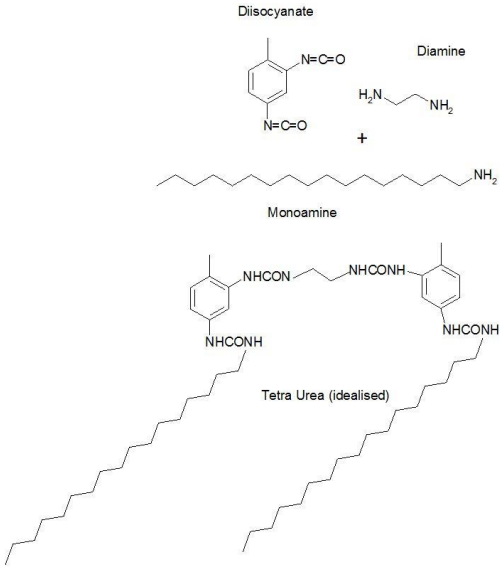


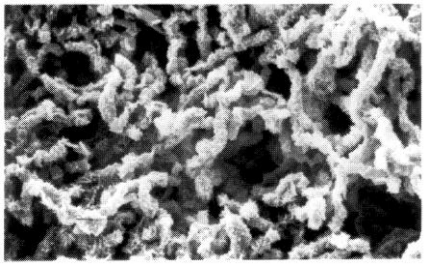


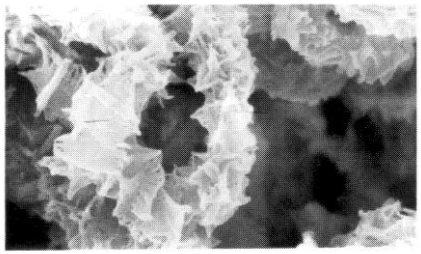
Thickeners

- Non-soap thickeners
  - Clays (bentonite)

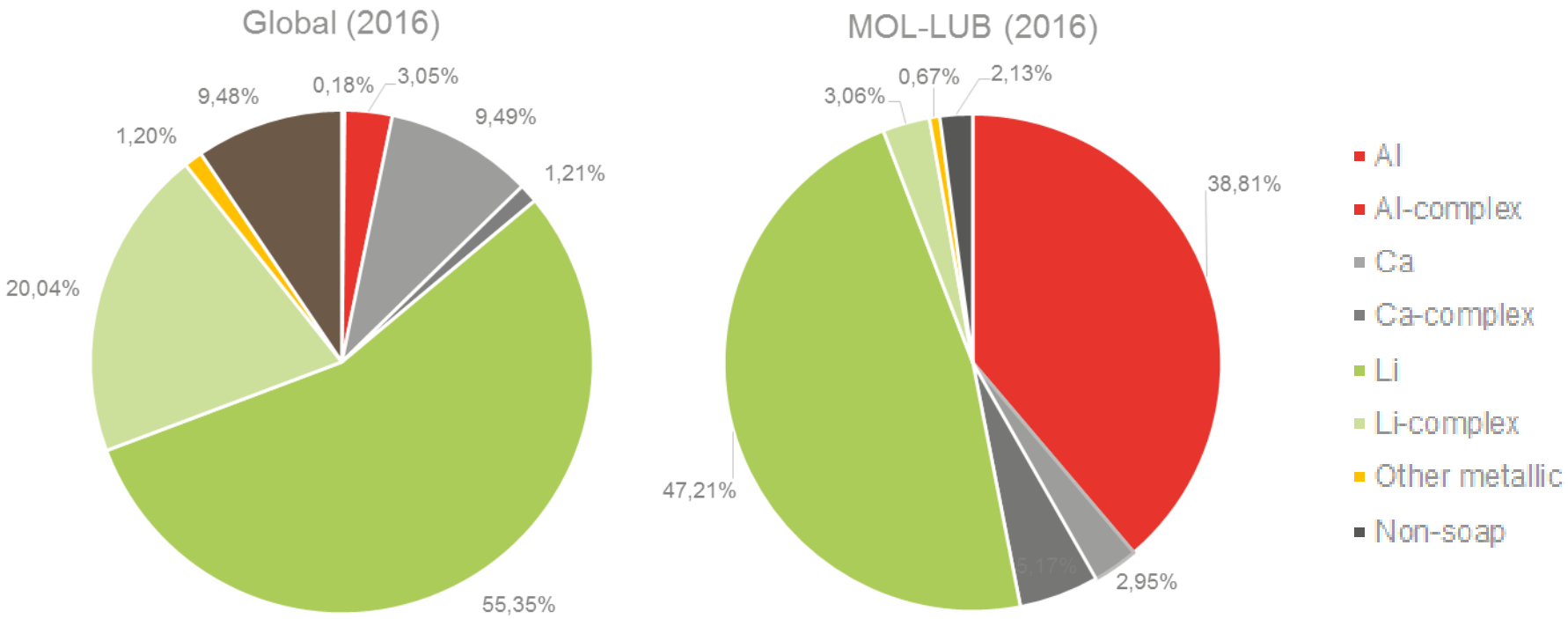
  - Polymers
    - Polyurea
    - PE, PP, PTFE







Ratio of manufactured greases by thickener type



Additive inload

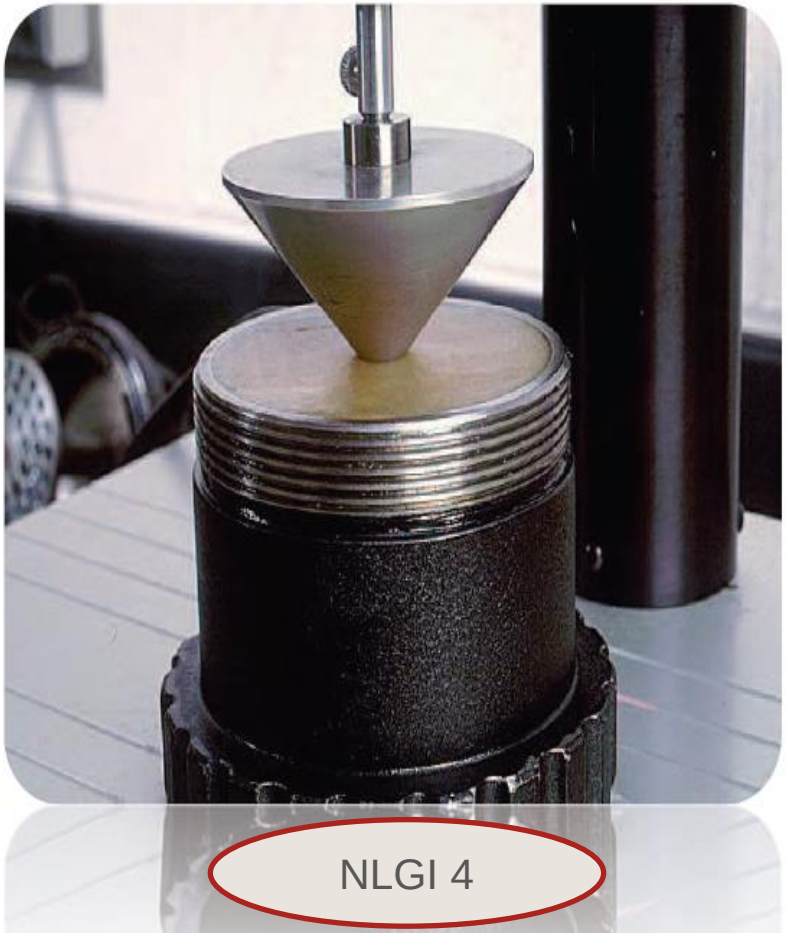
- Negatively affects grease structure and some grease properties
- Grease structure may collapse after a certain percentage
- More than one additiv could perform synergic or antagonistic effect with each other
- Additive efficiency depends oh the type of the thickener and base oil

NLGI Consistency Grade

- NLGI: National Lubricating Grease Institute
- Penetration: after 60 strokes,at 25 °C

NLGI grade	Penetration [0,1 mm]	Appearance of grease
000	445-475	Fluid
00	400-430	Fluid
0	355-385	Very soft
1	310-340	Soft
2	265-295	„Normal” grease
3	220-250	Firm
4	175-205	Very firm
5	130-160	Hard
6	85-115	Very Hard

NLGI Consistency Grade



NLGI 4

NLGI 1

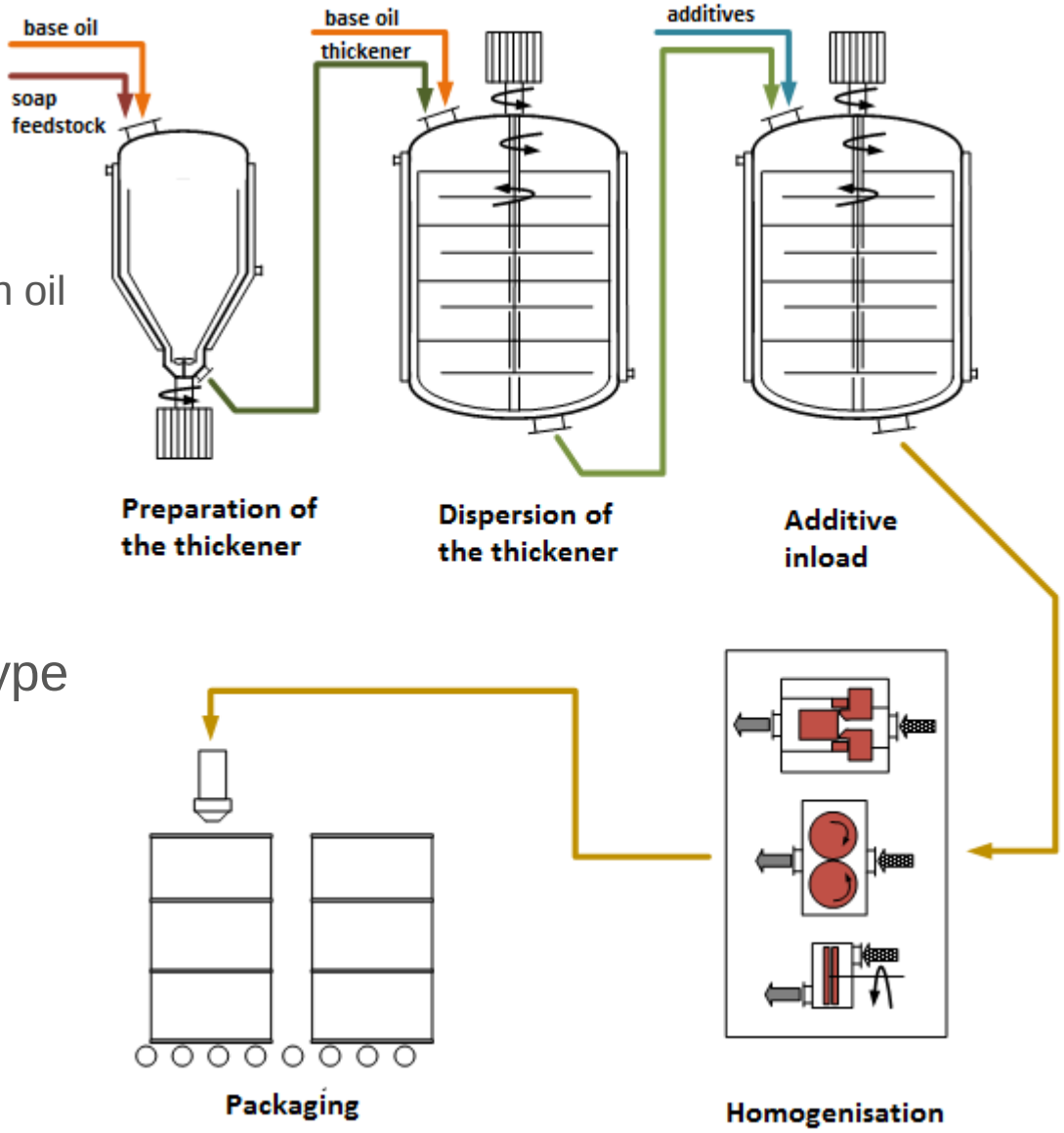
Production of greases

- Batch process
- Main stages
  - Preparation of the thickener
  - Dispersion of the thickener in oil
  - Cooling, additive inload
  - Homogenisation
  - Packaging
- Technology parameters

depending on the thickener type

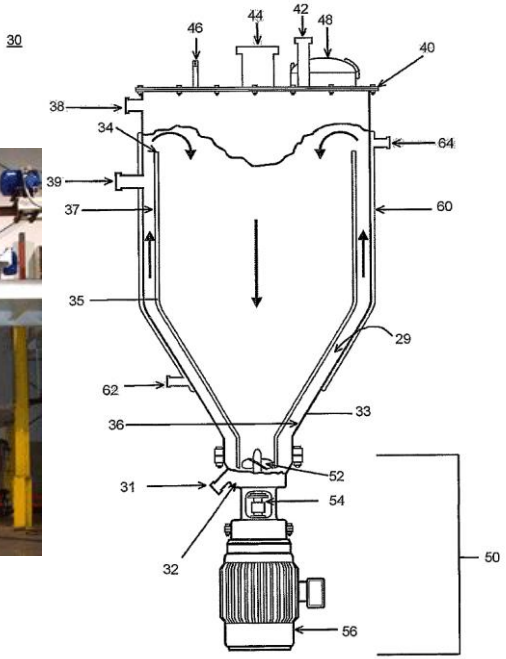
T_{max} = 100-250 °C

P_{max} = 0-6 barg

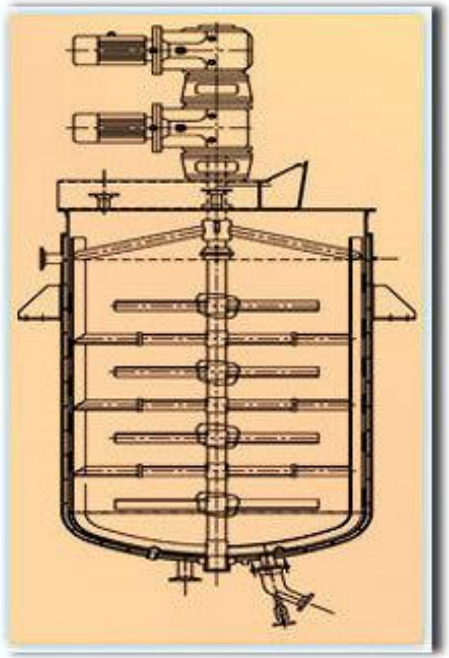


Grease cooking vessels

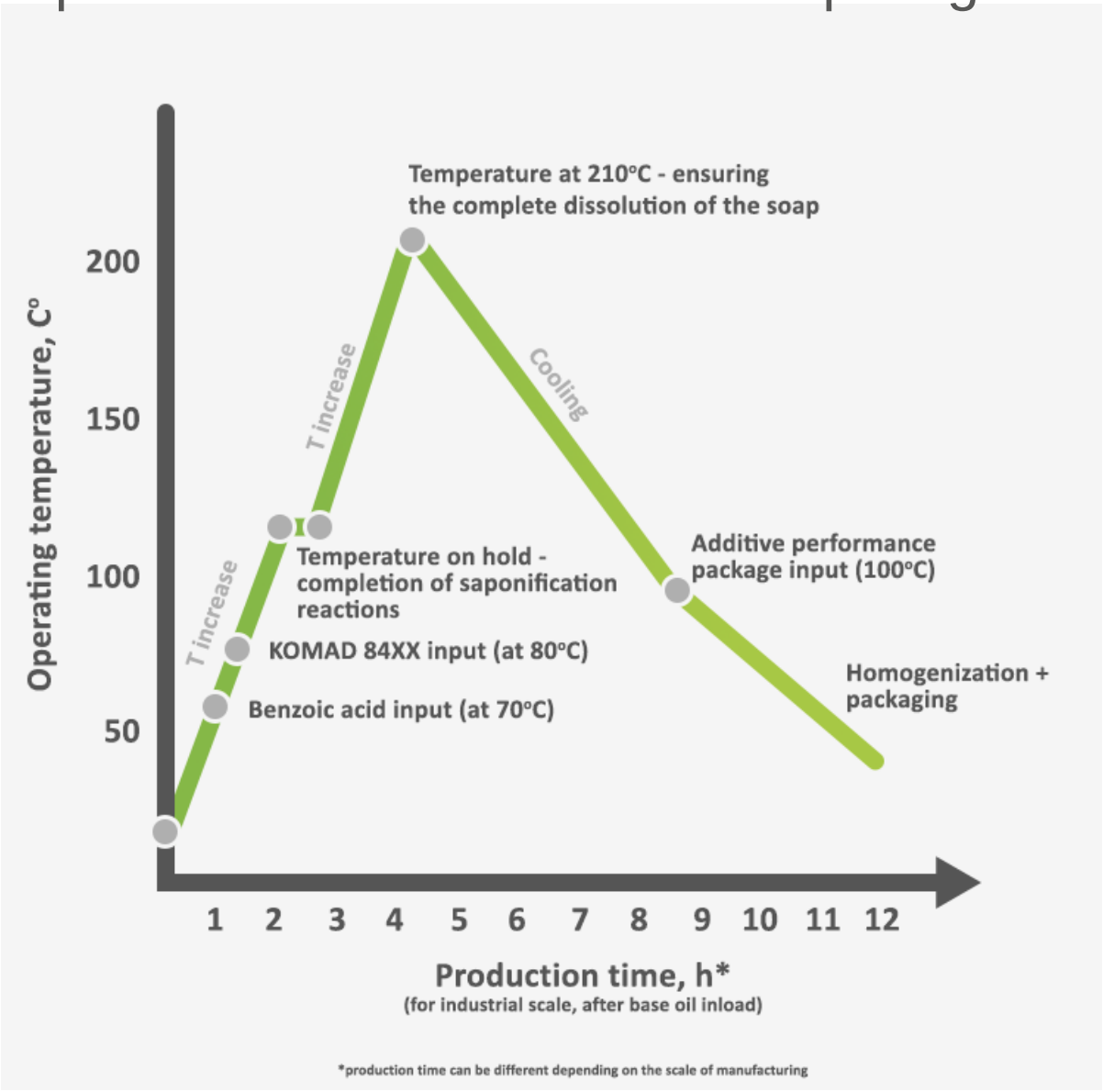
Contactor (autoclave)



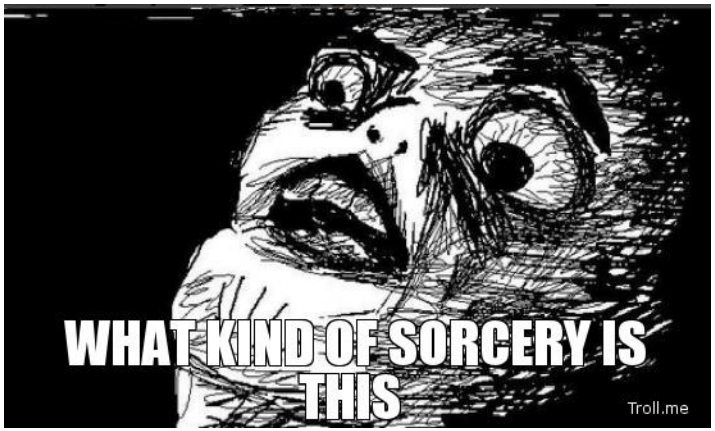
Duplicator



Production process of an Aluminium complex grease



Production process of a Li-12HSA grease



Preparation of the thickener

- Base oil inload (30 percent of base oils)
- 12-HSA) inload
- Mixing, heating
- LiOH inload
- Mixing, heating, pressurizing
- Temperature on hold
- Cooling and mixing at different rates
- Depressurizing

Dispersion of the thickener

- Base oil inload (the remaining 70 percent, cooling oil)
- Mixing, heating
- Polymer inload
- Heating, temperature on hold, intensive mixing

Cooling, additive inload

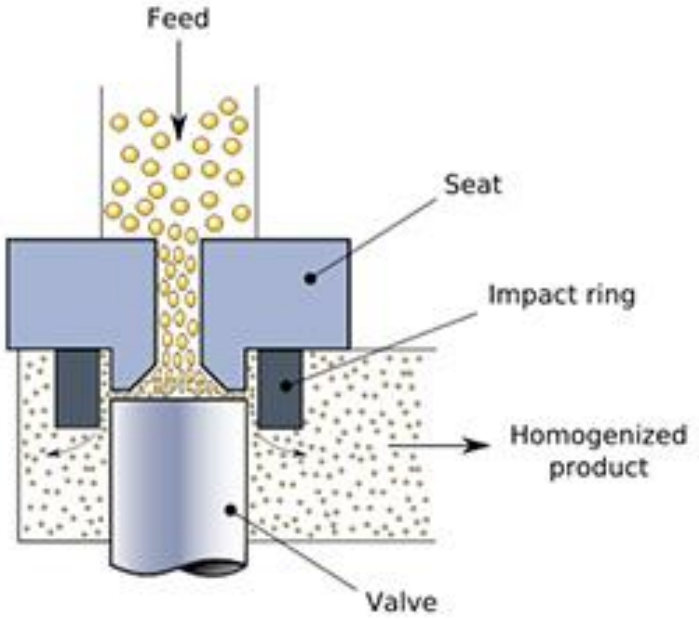
- Cooling and mixing
- Additive inload
- Cooling

Homogenizing

Packaging

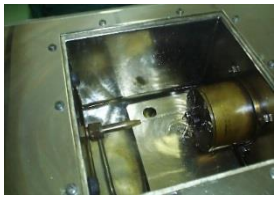
Homogenisation

- Increases uniformity of the thickener distribution
- Improves appearance of greases
- Improves mechanical and colloidical stability
- Homogenizers
  - Pressing the grease through a narrow gap
  - Gaulin homogenizer



Analytics

- Penetration
  - Without strokes
  - After strokes
- Dropping point
- Corrosion properties
  - Copper
  - Steel
- EP,AW properties
  - 4-ball
  - Timken
- Cold flow properties
  - Flow pressure
  - Low temp torque
- Oil separation
  - Under storage
  - At high T
- Water resistance
  - Static
  - Spray-off



- SKF V2F
- FAG FE9
- SKF ROF, ROF+
- Water washout
- EMCOR

Grease packaging

Advantages of grease lubrication

- Resists leakage through dripping, splattering
- Acts as a seal against water and other contaminants
- Lubricating sealed for life bearings
- Might be biodegradable
- Reduces noise and wibrations

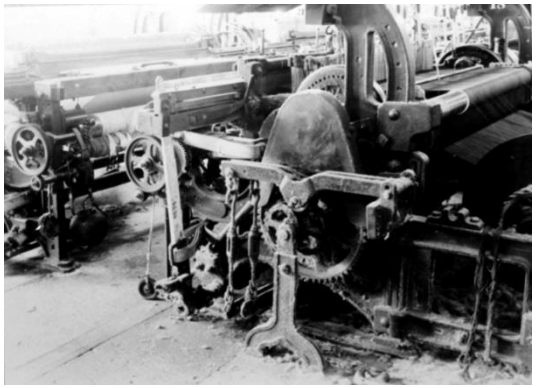
Grease lubrication is not appropriate when

- Bearing rotational speed is too high
- Cooling is needed simultanously with lubrication
- It is essential to reduce frictional loss in the bearing
- If the same machine uses lubricant oils

Application of greases

- Antique and medieval applications (animal fats)

- Industrial revolution: petroleum based products (fatty acids, distillates)



Application of greases

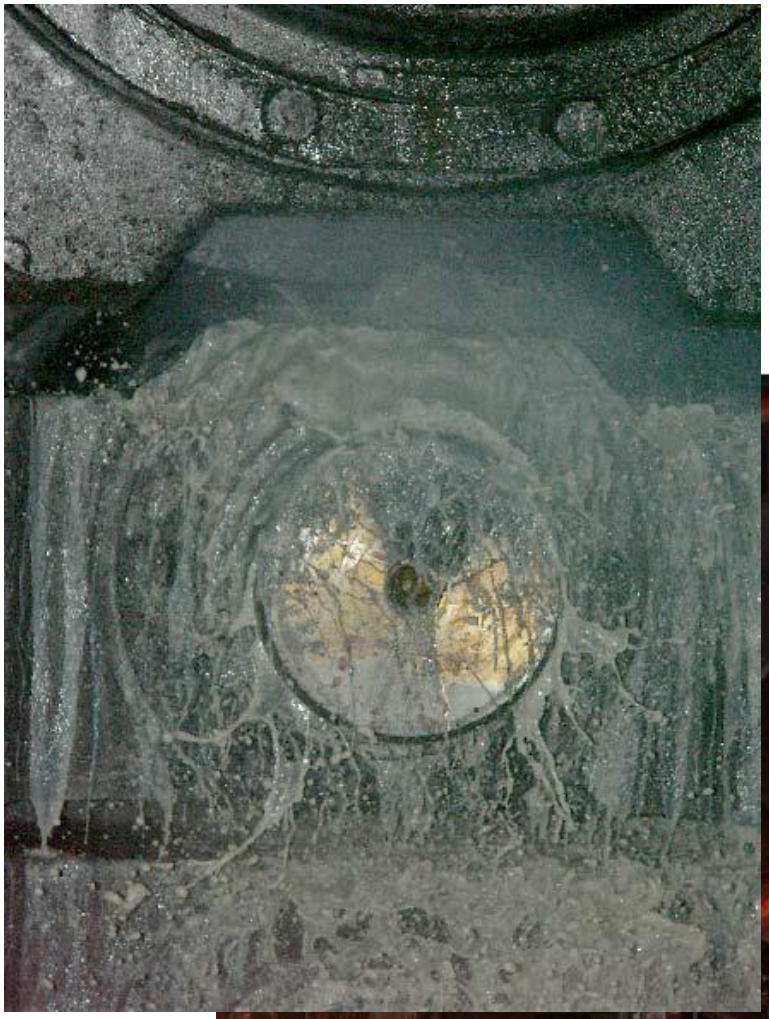
- Today: wide applications, special requests, wide portfolio
  - Synthetic oils, complex thickeners, polymers, zeolites, modern additives

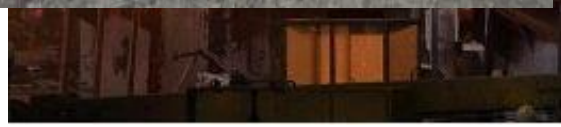
Application of greases

- Nowadays
  - Thickener type
  - NLGI grade
  - Special demands
    - Food industry
- Main applications
  - Bearings
  - Propulsions
  - Chain drives
  - Cables

Type of thickener	T_{max} [°C]	Mechanical stability	Water resistance	Colloidal stability
Na	120	Fair	Weak	Fair
Ca	60	Fair	Excellent	Good
Ca complex	150-200	Fair	Good	Good
Li	150	Good	Good	Good
Li complex	150-200	Excellent	Good	Good
Al	70	Weak	Good	Good
Al complex	140-170	Good	Excellent	Good
Polyurea	180	Good	Excellent	Good
Bentonite	200-220	Fair	Good	Good

Environmental requirements & answers





Inter-grease compatibility

	Al-komplex	Ca	Ca-complex	Bentonite	Li (12-HSA)	Li-complex	Polyurea
Al-complex	-	I	B	I	I	C	B
Ca	I	-	I	C	B	C	B
Ca-complex	B	I	-	I	I	C	C
Bentonite	I	C	I	-	I	I	I
Li (12-HSA)	I	B	I	I	-	C	B
Li-complex	C	C	C	I	C	-	B
Polyurea	B	B	C	I	B	B	-

C: compatible
I: incompatible
B: limited compatibility

Selecting of lubricating greases

Environmental factors
- Temperature
- Contamination
- Aggressive environment

Working conditions
- Load
- Speed
- Vibration

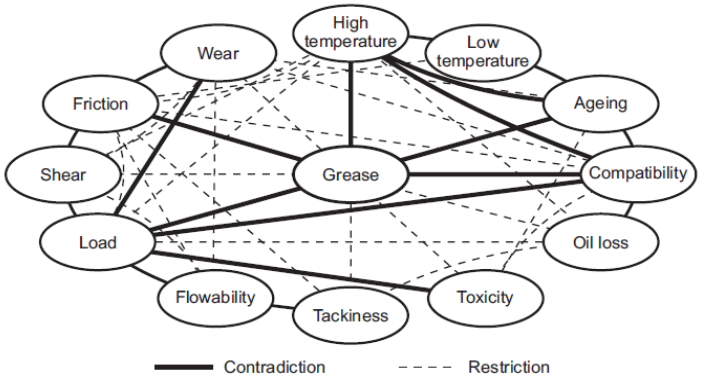
Maintance
- Individual lubrication
- Central lubricating system
- Lifetime lubrication

Construction
- Horizontal, vertical
- Configuration

Present lubrication
(compatibility)

Grease development

- analysis of request (from various sources)
- rejection of non-realistic requests
- starting of development – only a few requestor needs common work
- why would it be important?



continuous communication from both sides is a must because the complexicity!

Theoretical steps of grease formulation

1. **choosing the viscosity of base oil**
2. **choosing the type of base oil**
3. **choosing the thickener based on expected application, consistency and mechanical stability**
4. **balancing the oil and the thickener type based on expected thermal-oxidation stability**
5. **additive selection to ensure the other expected properties**

Grease tendencies in the future

- **Going to high performance greases**
  - **Share of non-soap greases will slowly rise**
  - **Application of synthetic base oil will slowly rise**
- **Slow decrease of grease use**
  - **(E.g.: automotive industry)**
- **Taking the environment into consideration more**
- **Developments based on special requests**