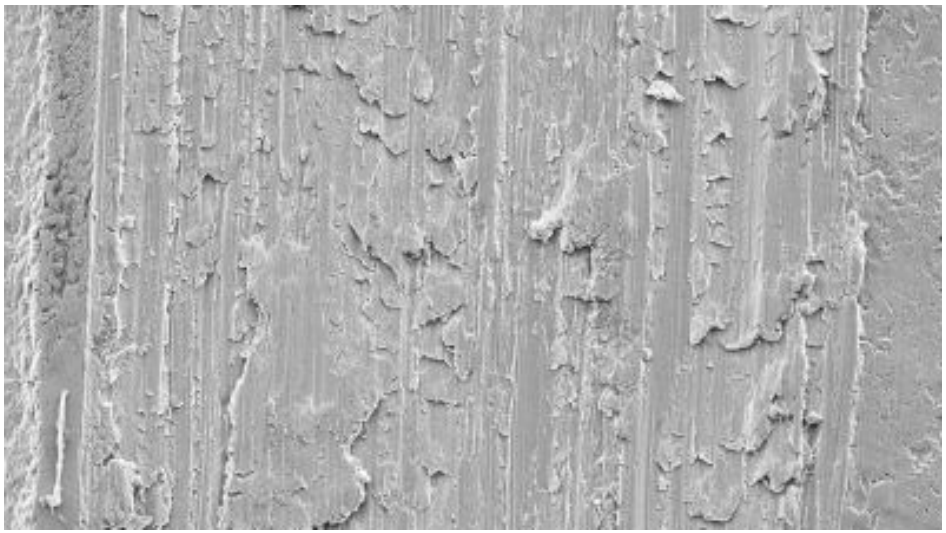
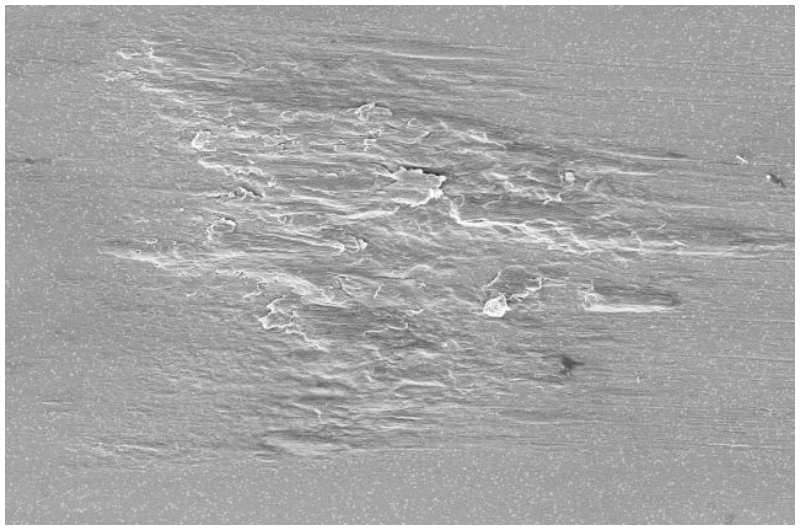
Lubrication and Surface Treatment

Introduction

Forming without lubrication:

- higher loads on the machine and tools
- cold welding of the workpiece and tool
- galling
- burring





To reduce the friction and its negative influences, it is essential to use lubrication between the tool and the workpiece.

Lubricants - roles

The roles of the lubricants

- **Separation** of the tool's and workpiece's surfaces
- **Decreasing of the friction forces** where they have disadvantageous effect on deformation of the workpiece and on stability of the process.
- **Decreasing of the tool wear** effect, increase the service life
- **Preserve or improve the surface quality** of the workpiece
- **Temporary corrosion protection** of the workpiece
- **Cooling effect** during the forming process.

Lubricants - requirements

Requirements regarding lubricants

- **Physical, chemical and rheological properties** must fit to the friction characteristics of the forming process and to the materials of the tools and workpiece
- Their physical, chemical and rheological **properties must be stable** (heat, pressure)
- **Good cohesion and easy removal** from the workpiece and die
- **Direction independent** properties
- **Must not be toxic and harmful** to persons and the environment
- Must **not cause corrosion**
- **Stability** of properties, and good **storability**
- **Must be able to apply** to the workpiece's or die's surface with the recent technologies and tools
- **Not to be too expensive**

Application and safety

Evenly distributed and **not excessive amount** of lubricant is needed.

Excessive amount: Does not further reduce the friction, but lowers the surface quality.

boundary friction - mixed friction exists

Environmental effect:

Most of the applied lubricants and chemicals are critical materials from the aspect of environmental protection. Therefore, their right removal is essential.

Additives:

These are chemically active materials given to lubricants to stabilize or modify specific properties.

Types of lubricants

Natural: vegetable, animal and mineral **oils** and their **emulsions**

Synthetic oils and their **emulsions** (e.g. esters)

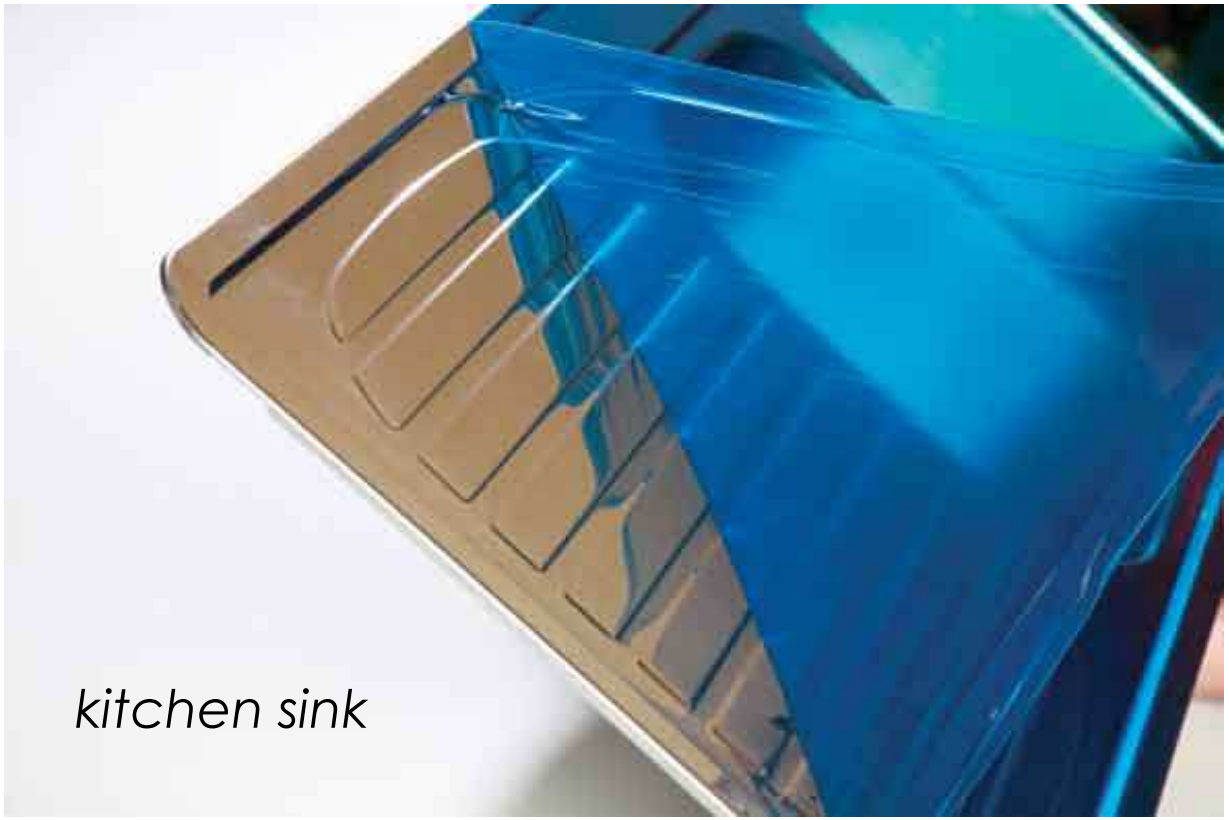
Pastes and **solid lubricants**

solid lubricant: in powder form, mixed with liquid to make the automatic lubrication processes easier.

Types of lubrication

Special lubricants: – thin ***metallic coating***
– ***polymer coating*** on sheet metals

Both protect the surface from mechanical damage
and corrosion during transportation and act as lubricant.



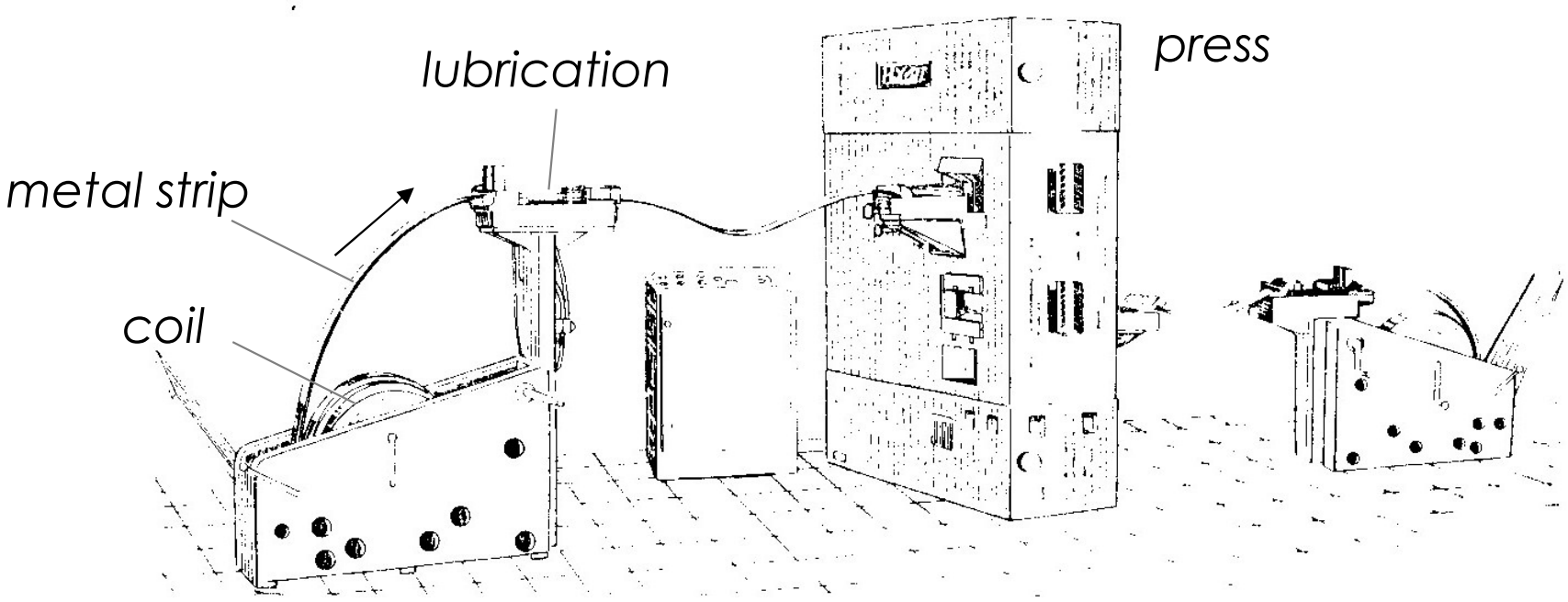
kitchen sink

Lubricants for forming processes

The **lubricants** and their **application methods** are different for:

1) Sheet forming
2) Cold forming
3) Hot forming (e.g. forging)

Example: Drawing oils or **drawing greas**es are applied



Lubricants for cold forming processes

Lime (liming)

Aqueous solution of lime (calcium hydroxide), for small deformations.

E.g. for steels: 8 w/w % at 90°C.

Soaps

Soap solution for medium lubricant requirements.

E.g. immersion into 4-8 w/w % soap solution at 80°C for 2-3 minutes.

Mineral oils („Press oils")

For high lubricant requirements, it allows automatic production and has a cooling function as well.

Molybdenum disulphide („molycote" suspensions)

For the highest lubrication requirements.

E.g. Immersion into a suspension for 2-5 minutes at 80 °C.

Lubricants for cold forming processes

Graphite

For high lubricant requirements in aqueous suspension.

Used for copper and copper alloys, aluminium and Al alloys.

Zink stearate

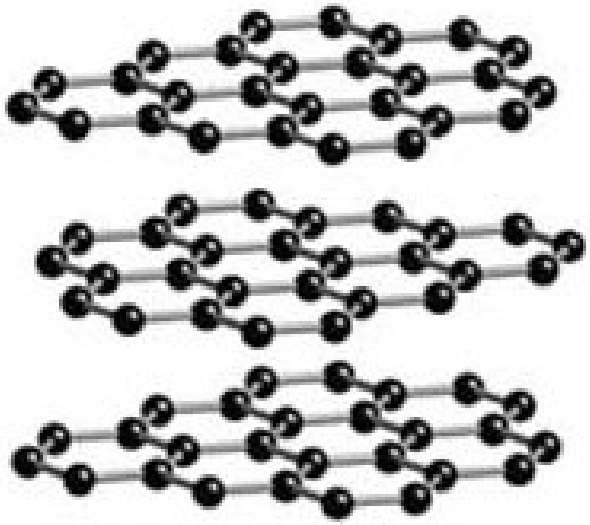
For high lubricant requirements for aluminium and Al alloys.

Graphite (and/or sawdust)

Suspensions in water or light oil.

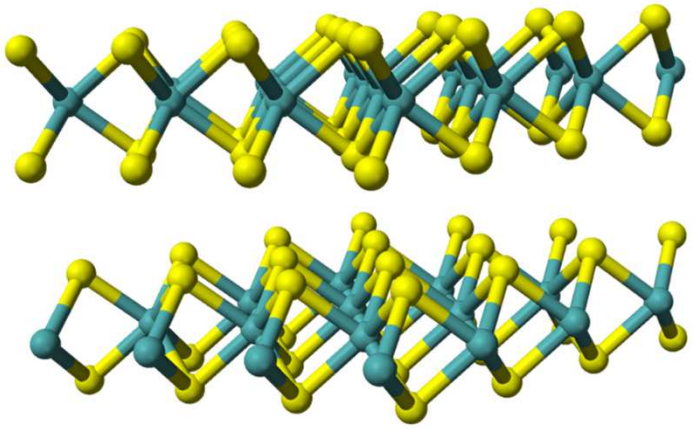
Examples of lubricants

Graphite



Molybdenum disulfide – MoS_2

layered structure



Zinc stearate

Lubricants for hot forming processes - forging

Saw dust

With increasing temperature the stability and viscosity of lubricants decreases. They also can catch fire on higher temperatures, or oxidize and disintegrate. Oil and grease based lubricants can burn onto the surface of the die, worsening the surface quality.

Even so there are multi-blow closed die fording operations, where saw dust (or coal dust) is strewn onto the surface between the blows.

It has two effects:

1) The burning saw dust reacts with oxygen, resulting less oxidization on the workpiece surface.
2) The evolving gases act as a thermal insulation and protect the die from softening.

Lubricants for hot forming processes - forging

For closed die forging graphite suspended in oil is used, which is blown with air onto the die's surface.

The blow

1. removes the scale and other impurities,
2. cools the dies and
3. allows the precise dosing of the lubricant.

Disadvantage of oil suspension:

Due to the contact with the high temperature workpiece, the oil-lubricant mixture can locally „explode" causing intrusion into the surface and worsening the surface quality.

Solutions and water suspensions: They have higher cooling effect as well.

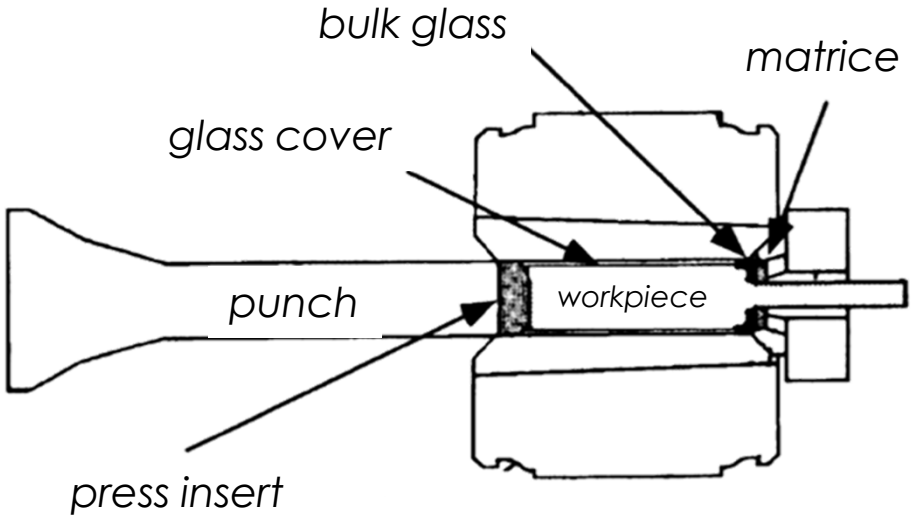
Lubricants for hot forming processes

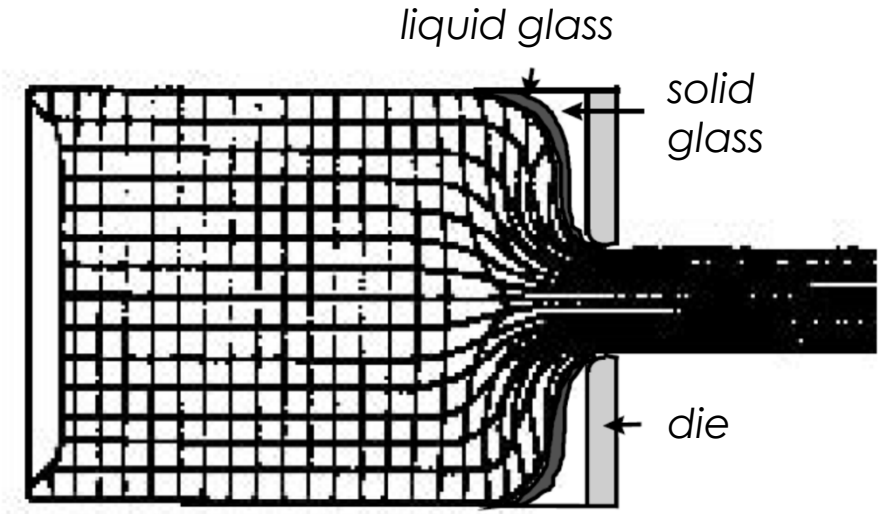
Glass

For hot forming glass can be applied as lubricant. It is carried onto the surface in powder form with soluble glass (water glass, liquid glass). Outstanding lubricant, its viscosity can be adjusted precisely for the given temperature range by altering the chemical composition.

Disadvantage: - the glass powder is expensive
- difficult to remove after the forming
- cases problems during machining
- danger of silicosis due to the glass powder

It is used for forging and hot forming of high alloyed steels, titanium alloys, and other special metals.





Surface treatment

Surface treatment processes:

– **Before forming:** prepare the work piece for forming

1) **pickling** *cleaning the surface*
2) **phosphating** *prepare for the lubricant*
3) **lubricating** *carrying the lubricant onto the surface*

– **After forming:** clean the surface & protect from corrosion

1) **shot blasting and/or pickling** *cleaning the surface*
2) **passivation**

Pickling

A process where the **oxydic coatings** (rust, scale) are removed, and such **contaminations** as grease, oil and atmospheric contaminations are also removed. The surface of the workpiece becomes metallically clean.

After pickling the workpiece must be **rinsed** (must take care on the environment).

Steels:	diluted acids e.g. 10 v/v % sulphuric acid
Aluminium alloys:	sodium hydroxide, nitric acid
Copper and alloys:	diluted sulfuric acid

Phosphating

In some cases, if the lubricant were directly applied to a pickled, metallically clean workpiece, there was no effect:

> *The lubricant film would come off during pressing due to the high pressure, so cold welding and galling would take place.*

Therefore a lubricant carrier coating (5–15 µm) must be applied first, forming a layer between the die and the workpiece. **Phosphating** is such a technology.

Phosphating applies for steels, zinc, zinc alloys, aluminium and aluminium alloys.

Zink phosphate $Zn_3(PO_4)_2$

non-metallic
prevent cold welding
high plastic deformation
porous – stores lubricant
cold forming - high local pressures

Production of screws and nuts:

https://www.youtube.com/watch?v=3kxcw08p_oY

Thank you for your attention!