# Maintenance of a degreasing bath by membrane filtration

**Introductory remarks**

In this script, we present the system solution for the care of degreasing baths.

The problem is briefly described and the treatment by membrane technology is shown.

In the following a plant concept is described.

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**1. Metalworking industry**

The metalworking industry has historically had a special significance in Germany and Europe. It is well known that the different manufacturing processes produce different types of waste water. Tons of cooling lubricants mixed with water must be disposed of every year. Due to the continuous modernization of the plants and the increasing efficiency of the machine tools, the contents of the cooling lubricants have changed. In addition, there are requirements from the areas of environmental protection and occupational safety. The suppliers of these substances have to react flexibly to the different and changed customer wishes and requirements.

Newer cooling lubricants do without zinc, nitrite and chlorine compounds, non-degradable surfactants and diethanolamines. Modern cooling lubricants contain anion-active emulsifiers based on fatty acids and fatty alcohols.

In practice, these substances are later present in an oil-water mixture – an emulsion. An emulsion is a disperse system in which two immiscible liquids form an optical unit. The one liquid (disperse phase: oil/fats, etc.) is the smallest droplet in another liquid (dispersant: water). The emulsions are stabilized by surface-active substances (surfactants). Its lipophilic “arm” attaches itself to the oil droplets and its hydrophilic part provides the electrical repulsion mechanisms of the emulsion.

Materials used such as non-ionized emulsifiers form a stable shell around the dispersed oil particles and thus prevent coagulation. Highly volatile hydrocarbons, alcohols and glycols serve as solubilizers.

The problems of oil/water emulsions for the environment and water bodies are known to the public and do not require detailed consideration. The necessity of the treatment of this waste water is therefore considered to be given.

In addition, the legislator has formulated guidelines and limit values which must be complied with when discharging (both direct dischargers and indirect dischargers).

The complex waste water constituents consist of organic or inorganic, biodegradable or non-degradable, colloidal and emulsified substances. The changed conditions place new demands on existing and new processes to be developed in processing technology.

The separation of emulsions is intended to eliminate the stabilizing effect of the emulsifiers and separate the undissolved and dissolved substances from the water. Most wastewater is treated using chemical or mechanical/physical processes. Both processes have been successful and represent the state of the art today. Emulsion separation can therefore be brought about by thermal or mechanical energy supply and/or by chemical or physical reactions.

In practice, however, the mechanical process of membrane technology is widely used. This offers high operational reliability and low operating costs.

Essentially one differentiates between two procedures which are to be explained here:

**1.1 Chemical emulsion separation:**

The use of inorganic reaction chemicals (e.g. iron and aluminium salts) can neutralise the boundary layer-active effect of an emulsifier, i.e. its charge. This causes coagulation. The hydroxide flocculates out and the oils and fats accumulate in the chemicals. This process is called adsorption coagulation.

More recently, the use of organic decomposition agents has met with broad approval. These splitting agents are synthetic, highly polymeric substances which neutralize the charges on the surface of the oil particles. The polymers used cause the emulsified oil and fat droplets to cross-link, resulting in additional buoyancy. Phase separation takes place.

**1.2 Mechanical emulsion separation:**

By supplying mechanical and thermal energy, dispersed particles are continuously broken up until the stability limit is exceeded, thus initiating a reversal process. The mutual repulsion behaviour is overcome and the particles coagulate. The emulsion is decomposing.

Membrane technology (micro-/ultrafiltration) has established itself as the main mechanical process. Today it is one of the most economical and reliable ways of processing emulsions.

### 1.2.1 Membrane filtration

Micro-/ultrafiltration is a purely physical separation process in which dissolved, dispersed or colloidal substances from predominantly aqueous media are separated in the molecular range using membranes. Membrane filtration uses the physical principle of molecule transport through a semi-permeable membrane based on a pressure difference (transmembrane pressure). Molecules or particles are retained at the membrane due to their size, weight or structure. The solution to be separated flows with a certain velocity at a certain pressure across the membrane (cross-flow principle).

The larger molecules (e.g. oils, fats, polymers) are retained at the membrane, while smaller molecules (e.g. salts and water) can pass through the membrane. The retained partial flow is called retentate, the partial flow passing through the membrane is called permeate (filtrate).

### 1.2.2 Process description of cross-flow filtration

The process differs from traditional filter processes in that the phase to be separated does not collect on the surface and forms the known filter cake, but the concentration takes place in the liquid itself.

Abb. 1: Vergleich zwischen Querstrom- und Frontalfiltration

The phase to be separated, in this case the emulsified oil and any solids present, is built up in a closed circuit up to the desired concentration. The main advantage of cross-flow filtration is the conversion of a traditional discontinuous filtration process into a continuous process that can run automatically without monitoring.

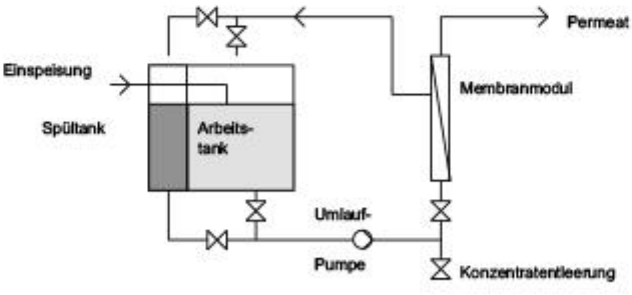

Abb. 2: Prinzipschema einer Querstromfiltrationsanlage

### 1.2.3. Description of an ultrafiltration system

The liquid to be treated is pumped into the receiver (tank) by means of a feed pump via a riser pipe. This is intended as a calming section and is hydraulically connected to the neighbouring coalescence chamber on the ground. In the chambers, the free oil separates from the solution and can be drawn off via a drain cock by means of height-adjustable funnels. The pre-cleaned solution is gravity-fed back into the feed tank and into the working tank for cross-flow filtration. Cross-flow filtration takes place in a circuit consisting of a circulation pump, membrane module and working tank. Due to the permeate drawn off at the membranes, the circulating liquid is continuously enriched with the phase to be separated (oil emulsion and/or solids). The working tank must therefore be emptied periodically once a corresponding final concentration has been reached. The circulation pump is designed in such a way that a sufficient longitudinal speed is achieved in the diaphragm. This high speed generates considerable shear forces which prevent the formation of a filter cake on the membrane surface and thus guarantee high permeate throughputs over a long period of time.

The part of the liquid that has passed through the membrane wall is the clarified permeate that has been freed from emulsions. This permeate can either be returned to the production process or, with a low hydrocarbon content, be used for further waste water treatment. In addition to the three tanks already mentioned, the plant is equipped with a fourth one, the flushing tank. Despite the high axial speed due to the modules and the oil-repellent nature of the polymer, the membrane surface is gradually becoming covered and regeneration is necessary. However, with a well-chosen pore spectrum of the membrane, this necessity arises only after a relatively long period of operation (one week to several months!).

The membrane is then regenerated with a special cleaning agent, which is circulated over the modules and the rinsing tank with the same circulation pump instead of the solution to be treated. The working tank is removed from the circuit and the flushing tank is switched on. After cleaning, the system is ready for operation again.

## 2. Example of the operation of a degreasing plant

Schaeffler AG (formerly FAG) with locations in Wuppertal and Schweinfurt is a manufacturer of bearings for various applications. During the surface treatment of the various bearing parts, the surfaces must be degreased again and again so that they can be further processed. Either spray systems or immersion systems are used. Both systems use an aqueous solution supported by wetting agents.

The degreasing of the surfaces causes fats, particles and oils to enter the bath. This exhausts the bath and after a certain service life (depending on the bath volume, the throughput times and the size of the surface to be cleaned) it can no longer absorb any greases/oils. Then the bathroom must be cleaned.

In order to avoid exhaustion, the impurities must be permanently separated from the bath. Membrane systems that are placed next to the bathroom are used for this purpose.

Schaeffler AG has successfully established corresponding systems in both Wuppertal and Schweinfurt. The systems were previously piloted on site for several months.

**2.1 Plant design (basic data)**

Output data:

pH value: 2 – 12
Temperature: max. 60 °C
Operating time: 6 days / 20 h/d
Assumed flux: 60 – 100 l/[m²h]
Membrane area: 2.0 m²
Membrane area/module: 1.0 m²
Number of modules: 2 pieces
Strands: 1 piece
Inlet pressure: 1.2 – 2.0 bar

**2.2 Diaphragm selection**

Type: Pipe module
Diaphragm material: PVDF
Separation limit: 150 kD
Expected permate flow: 80-100 l/[m²h]*

*(Depends on the medium and its contents and can therefore not be definitively determined in advance)

The membrane used is hydrophobic ultrafiltration membrane with an exclusion size of 150 kD. In this way even the smallest particles are separated. The wall thickness of the membrane is 0.5 mm and is very robust due to the backing. The design is a tube module in which each membrane tube has an inner diameter of 5.2 mm. The module is therefore very resistant to blocking by solids.

**3. Detailing of a membrane plant to extend its service life**

**3.1 Basic unit**

Essential components:

sturdy polypropylene construction built on pallet frame suitable for pallet trucks
PP – working tank approx. 500 l usable volume with hopper bottom and 2″ PP safety bottom outlet valve, as well as two bayonet hinged covers with aeration and ventilation valve
Level control with ceramic pressure sensor
PVDF turbine with Hall sensor for non-contact measurement of filter performance
2 membrane filter modules with a total of 2 m² filter area
Microprocessor control with four-line LCD display.
Control of the automatic, periodic backwashing of the modules
Manual triggering of backwashings
Setting the backwash times
Dry-running protection of the process pump
automatic backfeed
Setting the working level in the working tank
Power display of the filter power as average value
Various error checks and error displays in plain text
Backwash container made of borosilicate glass for easy optical quality control of permeate
Process pump with VA pump head and SiC/SiC/Viton mechanical seal
Self-priming feed pump (pump head stainless steel and Noryl impeller / diffuser)
Various manometers for easy monitoring of the system
Pressure regulator for limitation and adjustment of the backwash pressure
Shut-off and drain valves for low-maintenance operation of the system

**3.2 Extension**

**3.2.1 Temperature monitoring**

For switching off the backwashing or the entire system.

Thermostat sensor internally adjustable to limit temperature
Protection tube made of stainless steel
Software module for evaluation and control of backwash or plant
Threaded connection sleeve for immersion pipe / protective pipe in working vessel
Temperature monitoring completely installed and wired (for original equipment; installation for retrofitting according to expenditure)

**3.2.2 Drainage pump**

Emptying pump for manual or programmed (partial) emptying of the microfiltration plant, if the waste water tank is to be placed on the same level or higher than the microfiltration plant.

If the waste water tank is lower than the upper edge of the membrane plant, care must be taken to lay the waste water pipe so that the working tank does not run empty.

The pump unit consists of:

VA pump with vortex impeller and SiC/SiC mechanical seal
PP base with pump ready assembled
Connection on suction side to microfiltration plant
Pump completely connected and assembled (for original equipment; assembly for retrofitting according to expenditure)

**3.2.3 Signal output and collective fault**

The collective fault signal is set when monitored events occur on the microfiltration system, when the event requires operator intervention.

The message appears on the microprocessor control display.

Extension of the microprocessor control with additional output
Software module for evaluation and linking of the monitored states and generation of the collective fault
Installation and wiring within the MFA (for original equipment; assembly for retrofitting according to expenditure)

**3.3 Cleaning unit**

Cleaning unit ready for connection consisting of:

Chemical-resistant container made of PP with approx. 70 l full volume with various connections and screw cap

Built-in heating VA with thermostat control

Chemical-resistant, magnetically coupled centrifugal pump for filling the module(s) with PVDF pump head

Electropneumatic diaphragm shut-off valve for optimum use of cleaning fluid

Separate dry run protection for centrifugal pump and heater

Equipment circuit breaker for centrifugal pump and heater

Compressed air membrane emptying pump for module emptying in the microfiltration plant and residual emptying of the container of the cleaning unit with individual shut-off valves

Connection set for microfiltration plant

Hose set and fittings for connecting the cleaning unit to the microfiltration system

**4. Photos of the membrane plant**

Membrane plant for extending the service life of degreasing baths

Membrane plant for extending the service life of degreasing baths