Economic Service Life Extension by Optimal Bath Care

Content

1. Metal-processing industry

In Germany and Europe, the metal-processing industry has been of special importance already in the past.

It is known that most different types of waste water result from the different production processes. Five million tons of cooling lubricants mixed with water, for example, have to be disposed of every year. Due to continuous modernization of the plants and increasing performance of the machine tools, the material contents of the cooling lubricants have changed. Not to forget the requirements in the fields of pollution control and industrial safety. The supplier of these materials have to react with flexibility to the different and also modified wishes and requirements of their customers.

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

In practice, these substances are present later in an oil-water mixture, i.e. an emulsion. This is a dispersed system in which two immiscible liquids result in an optical unit. The dispersed phase is present as very small drops (oil, fats, etc.) in another liquid (dispersing agent: water). The emulsions are stabilized by surface-active substances (surfactants). This means that their lipophilic branch becomes attached to the oil drops, and their hydrophilic part ensures the electric repulsive mechanisms of the emulsion.

Substances 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 solutizers.

Oil-water emulsions give rise to problems in the environment, especially in water bodies. This is known in the general public and needs no further remarks. Thus the necessity to treat these waste waters is obvious.

In addition, the legislator has formulated guidelines and limit values which absolutely have to be observed not only by direct but also by indirect dischargers.

The complex waste water contents consist of organic or inorganic biodegradable or non-biodegradable colloidal and emulsified compounds. Due to changed conditions, new requirements are made on existing treatment processes and those to be newly developed.

De-emulsification aims at neutralizing the stabilizing effect of the emulsifiers and at separating undissolved and dissolved substances from the water. Today, most waste waters are treated by chemical or mechanical/physical processes. Both of them have proved successfully their efficiency and represent the state of the art. However, in practice a tendency towards a mechanical process is emerging: membrane technology. This technology offers high operational safety and low operating costs. Thus de-emulsification can be realized by thermal or mechanical energy input or/and by chemical or physical reactions.

Roughly, we distinguish two processes:

Chemical de-emulsification:

Using inorganic reaction chemicals (e.g. iron- and aluminium salts), the surface-active effect of an emulsifier, i.e. its charge, is neutralized so that coagulation takes place. The hydroxide flocculates, fats and oils adsorb at the chemicals. This process is called adsorption coagulation.

Recently, the utilization of organic decomposition agents has met with unanimous approval. These are synthetic and highly polymerized substances which cause neutralization of the charges at the surface of the oil particles. By these polymers, the emulsified oil- and fat drops are linked and in addition flow up. Phase separation takes place.

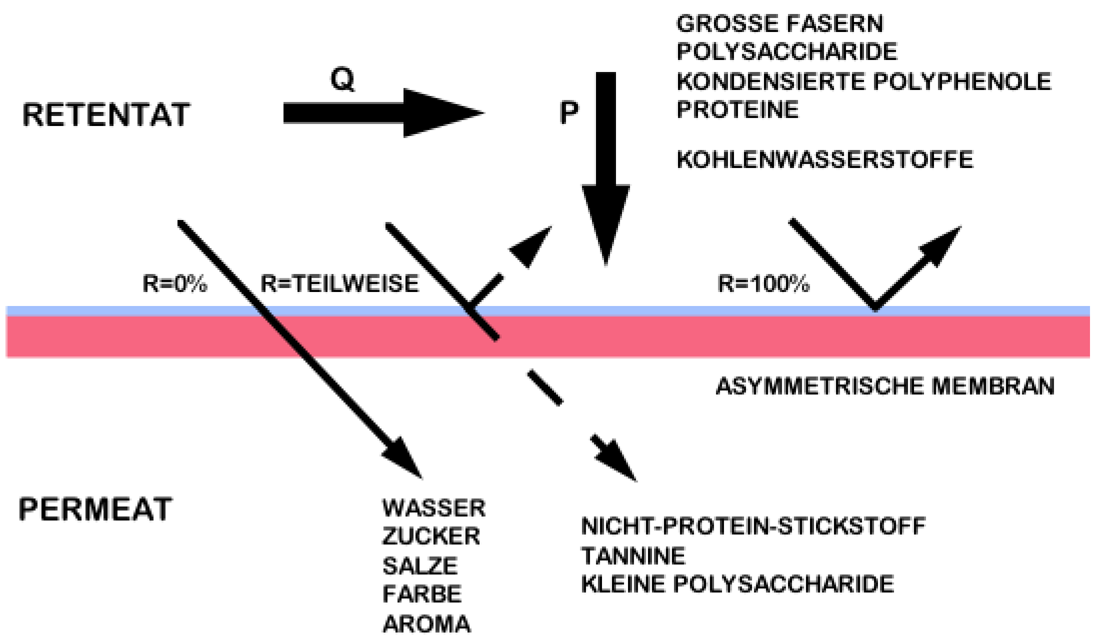
Mechanical de-emulsification:

By input of mechanical and thermal energy, dispersed substances continuously are broken down until the stability limit is exceeded, so that a reverse process starts. The reciprocal repulsive behaviour is overcome, and the particles coagulate. The emulsion undergoes decomposition.

Recently, especially membrane technology has gained acceptance as mechanical process. Today it belongs to the most economic and operationally safest processes in the treatment of emulsions. For this purpose, ultrafiltration is the best choice.

2. Ultrafiltration

Ultrafiltration is a purely physical separation process. Dissolved, dispersed or colloidal substances in the molecular range are separated with the help of membranes from mainly liquid media. Membrane filtration makes use of a physical principle known from nature: molecule transport through a semi-permeable membrane due to a pressure difference (transmembrane pressure). Molecules or particles are kept back at the membrane due to their size, weight, charge or structure. The solution to be separated flows across the membrane (cross-flow principle) at a certain velocity and a certain pressure. The larger molecules (e.g. oils, fats, pigments) are kept back at the membrane, while the smaller ones (e.g. salts and water) can pass. The part kept back at the membrane is called retentate, the part having passed is the permeate (filtrate.).



3. Description of function and process

General information / Modules

The modules most frequently applied are subdivided into three categories:

- Spiral-wound modules,
- Hollow-fibre modules and
- Tube modules.

The choice of the module type depends on the medium to be filtered, its material content, temperature, viscosity, pre-treatment, the process conditions and the expected permeate quality. For his decision the user should consult a manufacturer or supplier experienced in plant technology and utilization. Membrane and module should be provided by the same manufacturer, and objective choice of the module type should be ensured.

A large number of module types exists, but in practice only some of them have gained acceptance by their advantages and performance.

Description of the process

The process differs from the traditional filtration process by the fact that the phase to be separated does not accumulate at the surface, forming the well-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 emulsified oil and possibly existing solids – is concentrated in a closed cycle up to the desired degree. Main advantage of cross-flow filtration is the transformation of a traditional discontinuous filtration process into a continuous one which runs automatically without monitoring.

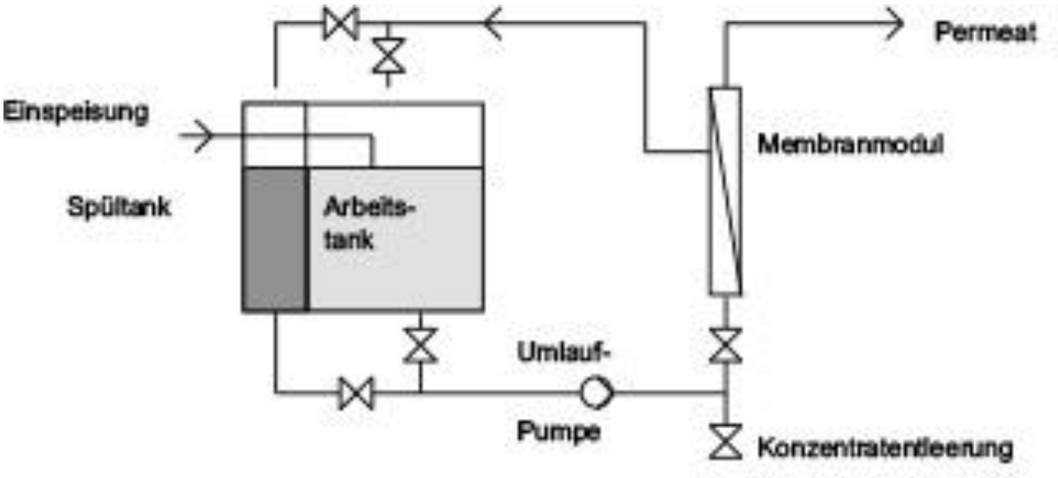


Abb. 2: Prinzipschema einer Querstromfiltrationsanlage

Description of the ultrafiltration plant

The liquid to be treated is pumped by a feed pump through a rising pipe into the first pre-treatment chamber. This chamber serves as equalization line which is connected hydraulically with the neighbouring coalescence chamber. In these chambers, the free oil separates from the solution and is withdrawn by means of vertically adjustable hoppers and a discharge cock. By gravity the pre-treated solution partly gets into the return pipe to the feed tank, partly into the working tank and flows to cross-flow filtration. Cross-flow filtration takes place in a cycle consisting in circulating pump, membrane module and working tank. The liquid in this cycle is concentrated continuously with the phase to be separated (oil emulsion and/or solids), due to permeate withdrawal at the membranes. Therefore the working tank has to be emptied periodically after having reached an adequate final concentration. The circulating pump is designed in such a way that a sufficient longitudinal velocity is reached in the membrane. This high velocity generates considerable shear forces which prevent the development of a filter cake at the membrane surface and thus ensure high permeate flow rates over a long period.

The part of the liquid that has passed the membrane is the clear permeate which is free from emulsions. This permeate can either be recycled into the production process or, in the case of low hydrocarbon content, forwarded to further waste water treatment. Besides the three tanks mentioned above, the plant is equipped with another one, the rinsing tank. In spite of the high axial velocity of the modules and the oil-rejecting nature of the polymers, the membrane surface gradually gets covered so that regeneration becomes necessary. However, if the pore spectrum of the membrane was carefully chosen, this will be the case only after a rather long operation time (1 week up to several months!).

The membrane is then regenerated by a special cleaning agent which is recycled, instead of the liquid to be treated, by means of the same circulating pump across the modules and through the rinsing tank. For this purpose, the working tank is disconnected from the cycle and the rinsing tank is connected. After cleaning, the plant is operational again.