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WPF – WISSER - FLOTATION

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ABSTRACT

The word **flotation** is generally understood to mean something that is floating. It is used even in frothing. This presentation focuses on flotation where only microbubbles formed from pressurised dissolved gas raise the solid matter in a liquid to the surface of the liquid in a flotation basin, and the liquid is thereby purified.

Flotation is becoming an economical factor in purifying liquids and, above all, waters in internal circulation loops of industrial plants as well as in municipal effluent treatment. The theoretical background of flotation and its applications in **WISER FLOTATION** will be described in the following. Flotation will also be compared with water purification by sedimentation. Finally, two applications will be described in general outline.

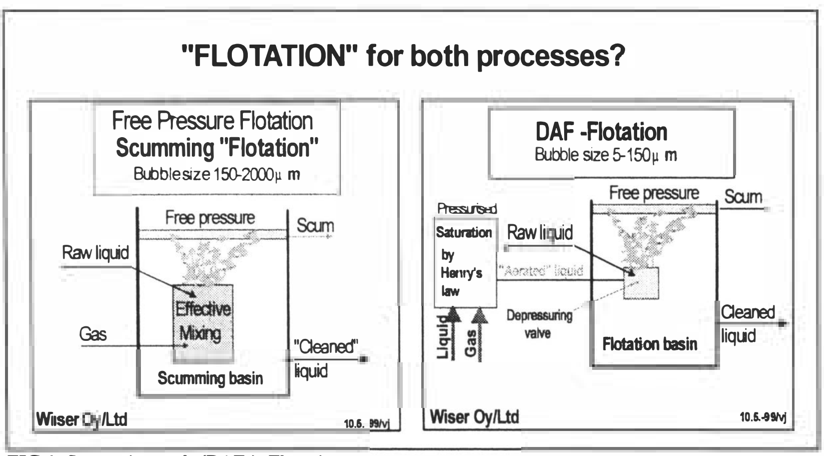

FIG 1 Scumming and (DAF-) Flotation

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DAF Flotation (DGF-Flotation?)

This presentation will however be confined only to Dissolved Air Flotation, or DAF flotation, (FIG 2), which is accomplished by means of gas bubbles. These bubbles are formed when a liquid in which a gas is dissolved in different ways in a pressurised space more or less to a saturation point, is released from the dissolving pressure to a lower pressure prevailing in the release environment by using various depressuring valves, which are known in themselves and also patented (1, 7, 8).

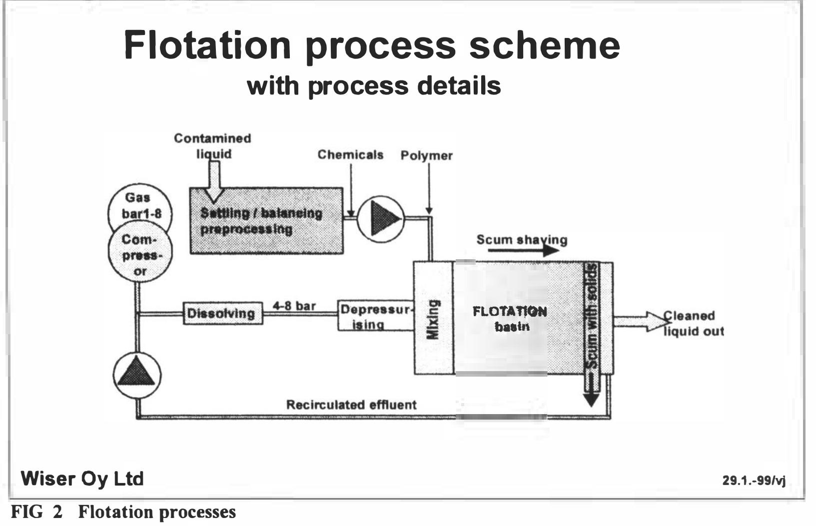


FIG 2 Flotation processes

Flotation gases and dissolution of gases

The gas which is most commonly used in flotation is air. Its solubility in water is shown in FIG 3. As seen in this figure, the solubility of air is in accordance with Henry's law, that is, it is directly proportional to pressure (2, 4). Different temperatures produce only different slopes. FIG 4 in turn shows how air dissolves in water at different temperatures. This figure also shows how the constituents of air, oxygen, nitrogen and carbon dioxide, dissolve in water. It is interesting to note that, when oxygen dissolves, the considerably greater proportion of it in air makes it possible to concentrate the composition of the gas released from water in said way.

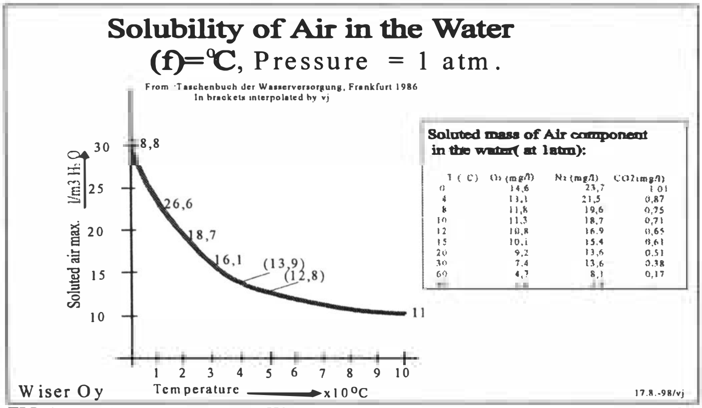


FIG 4 Dissolving of Air in the Water

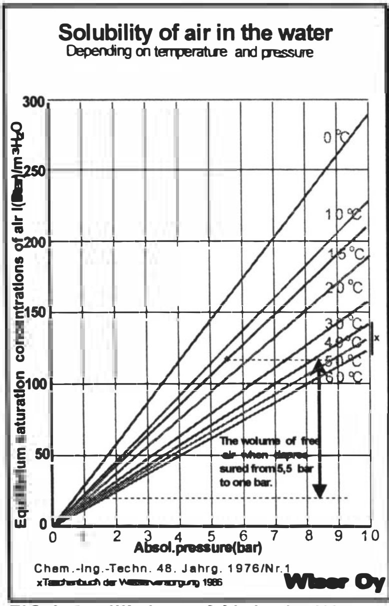


FIG 3 Equilibrium of Air in the Water at some Temperatures by Henry's law

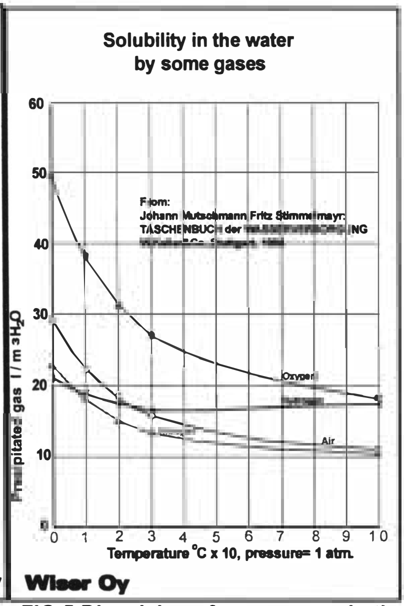


FIG 5 Dissolving of some gases in the water depending on temperatures at 1 atm.

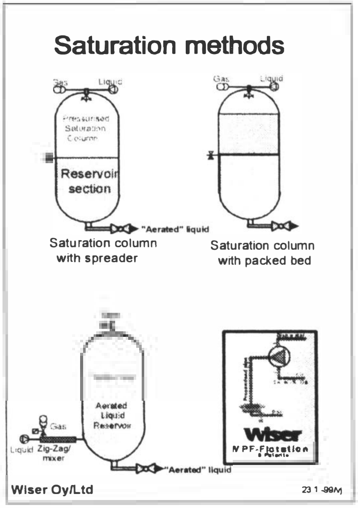
Thus it is understandable that the dispersion water produced directly by means of air may oxidise, for instance, ferro-ion into ferri-ion and disintegrate low H_2S contents (3).

In a research (9) it was found, that the atmosphere in the pressured dissolving column contains oxygen 12 vol%, which is about 43 % lower volume part than in the normal air. That is equal with the information in the FIG 5.

As is clear from these figures, several gases can be used as dispersion gases (FIG 5). In some cases this is of significance, for instance, when anaerobic waters are treated by flotation and it is desirable to return the flotated anaerobic bacteria back to the bioprocess. In practice, the commonest gas is air because the necessary equipment is designed for production of compressed air and for operation by compressed air.

Dissolution of dispersion gas

The figures also show that, for example, the solubility of air in water, up to the saturation point e.g. at 15 °C and at a pressure of 5.5 bar, is 10 vol% at the maximum. It is clear that such solubilities are not reached in practice, but 70-90 vol% of the maximum amount have to be considered satisfactory.



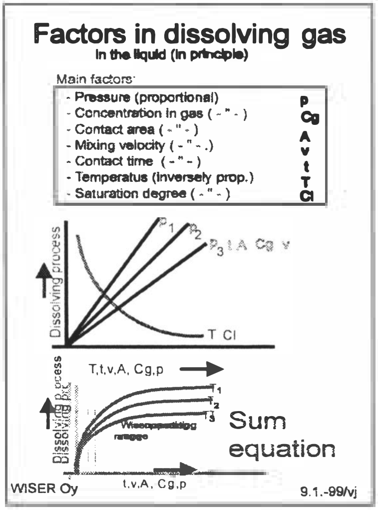


FIG 6 Some methods of dis- solving gases in the liquid

FIG 7 Saturation factors(in principle)

There are several methods of dissolving gas. FIG 6 shows the principle of some dissolution arrangements. In a saturation column it is possible to spray the dissolving water, i.e. dispersion water, from above downwards or the other way round. In the latter arrangement, the time during which the droplets are in contact with the gas is longer. By using a packed bed arrangement in the same saturation column, solubility can be brought considerably closer to equilibrium saturation (2). The air supplied to the suction side of a pump dissolves poorly if sufficient dispersion does not occur in the pump. This matter is taken into account in the Wiser Flotation constructions. The operation of a Zig-Zag mixer, which has been developed, for instance, by Wiser for their own constructions, has proved to be good provided that it also has adequate dispersion. The plotted curves in FIG 7 show, in principle, the factors affecting the solubility.

Depressuring of dispersion water, microbubbles and their ability to flotate

One of the most critical factors in DAF flotation is the depressuring of the pressurised dispersion water containing dissolved gas (1, 7, 8). Microbubbles are being formed in that connection. Their size determines not only the number of the bubbles but also the life of said bubbles. The smaller the size of the bubble, the longer its life. This makes it possible to utilize, for instance, mixing ducts and flows of the liquid to be purified as well as the dispersion water in such a way that the flotation basin will contain a sufficient amount of "milk" to produce flotation.

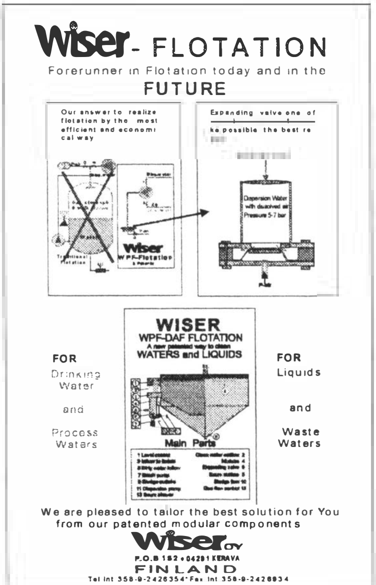
More specifically, it may be noted that the same amount of gas yields with bubbles half the size an eightfold (8x) amount of bubbles while the adhesive area increases twofold. Thus, small bubbles substantially increase the efficiency of the flotation unit in “finding” and grasping contaminants, i.e. flocs, and in maintaining them on the surface of the liquid in the flotation basin until scum is collected.

Method of making microbubbles in the Wiser Flotation and one way of dissolving gas

FIG 8 and FIG 9 show the most important operations and technical solutions of the Wiser Flotation. The figures illustrate one of the ways developed by Wiser Oy/Ltd for dissolving a desired gas in a dispersion liquid. In it, the gas is sucked into a pump together with the liquid by the suction action of the pump. The impeller of the pump mixes both components, the gas and the liquid, to a very disperse phase, which leads to maximally complete dissolution of the gas in the dispersion liquid in a duct situated after the discharge opening of the pump. The suction amount of the gas is controlled and regulated by means of a rotameter.

Another important component in the Wiser Flotation is a depressuring valve allowing to produce gas bubbles as small as 10-20 µm. A third very important method invention is to place the depressuring valve in a mixing tube, whereby the microbubbles are mixed with the liquid which contains flocs and is to be purified. After that, the mixed flow is guided to a flotation basin. Stoke’s law can be circumvented by the Wiser Flotation. This allows the flotation basin to be dimensioned for hydraulic surface loads of 4-8 m^3 / m^2 h, and the solids content can be raised freely to a value as high as 3-6 g/l, since some of the recirculated effluent can be introduced, as needed, into the mixing tube as dispersion water.

In literature, it is considered that the lower limit of the particle size of solids removed by normal flotation is 10 µm (3). By the Wiser Flotation it has been possible to flotate more than 50 % of SiO_2 solid material having a particle size of 2 µm (6). An essential factor contributing to this can be considered to be the operating principle of the WPFS depressuring valve. Owing to the small size of the microbubbles, the number of bubbles can be substantially increased and, in addition, the consumption of chemicals can be reduced. It is self-evident that the high amount of bubbles and their thorough mixing with the liquid being treated enhance the efficiency of flotation. This in turn causes that the needed dispersion water amounts are lower, which means a lower pump capacity and thus lower consumption of energy. In this regard, the Wiser Flotation has proved to be an effective system in field conditions.



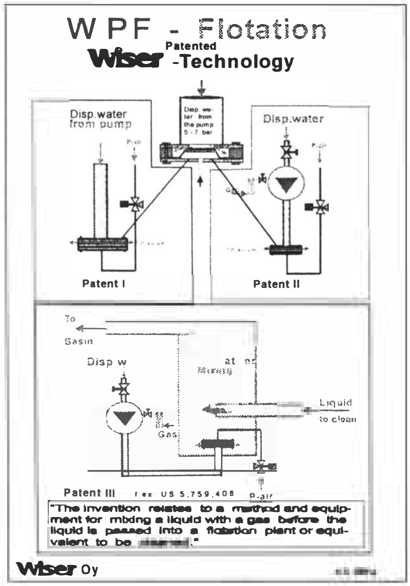


FIG 8 Wiser-Flotation principles

FIG 9 Patents for Wiser-Flotation. More patents under pending

New innovations being introduced

In practice, a substantial drawback in flotation systems is the sedimentation of the non-flotated solid material at the bottom of a flotation basin. For this reason, the flotation processes are provided with a grit scraper. The sedimentation is caused by solid matter separating from scum when the gas is liberated from microbubbles. Shutting down the flotation process also leads to the same result. However, one essential factor to be noted in this connection is that solids and microbubbles are equally static. Therefore, a suitable polymer must be found in order to change the static forces. It is also possible that the influent, i.e. the liquid/water passed for flotation, contains so heavy and large particles of solid material that they settle without floating. New devices and processes are being developed for removal of said settling solids.

Brief numerical comparison between flotation and precipitation processes

It is stated in literature that the flotation method provides a very good treatment result with a basin whose size is only 20...40 % of the basin used in the sedimentation/precipitation method (4, 5). The consumption of chemicals is also 20...30 % lower in the flotation method when these two methods are compared with each other (4, 5).

It is also essential to note that the solids content of the sludge obtained by flotation is considerable, i.e. 3...7 % (SS content) (3, 5). In suitable conditions and in mineral flotation, even substantially higher solids contents ofup to 9 % have been achieved (3). In precipitating separation of solids, only half of the above-mentioned values are usually achieved (5). The amount of dispersion gas may be counted to be 0.1...1 wt% of the flotated solids amount (5), and the amount of the required energy is generally 0,03...0.12 kWh/m^3 (3,4).

Two examples of delivered Wiser Flotation systems

Example 1

The efficiency of the WPFS depressuring valve was established in connection with modification of dispersion water equipment in a flotation plant that had already operated for 16 years. It was a question of cleaning oil refinery process waters by flotation mainly from oil before a biological water purification plant. The amount of dispersion water is 200-240 m^3/h. Right from the beginning, the plant had not operated satisfactorily because too high oil contents in the cleaned water passed through the treatment process. This resulted in the death of a biological bacterial strain several times a year. This was due to too large a size (50-150 μ m) of microbubbles whose life was too short for them to live as far as the flotation basin in order to raise oil to the surface. The inflow distance from the point of formation of microbubbles to the basin is about 11 metres, which means that the life of the bubbles must be at least 20-25 seconds

FIG10 shows a Wiser construction which generates microbubbles having a size of less than 30 μm. The life of the microbubbles will then be two to three times the previous one. The oil contents during the operation period of the past eighteen months have been 2.8 mg/l on an average.
There have been even contents of 0 mg/l in several samples. The plant has operated after start-up continuously without a single renewal of the bacterial strain, and there has been no need for any service shutdown.

An annual overhaul was performed, which could be accomplished while the plant is operating since an adequate flotation result is achieved at half capacity

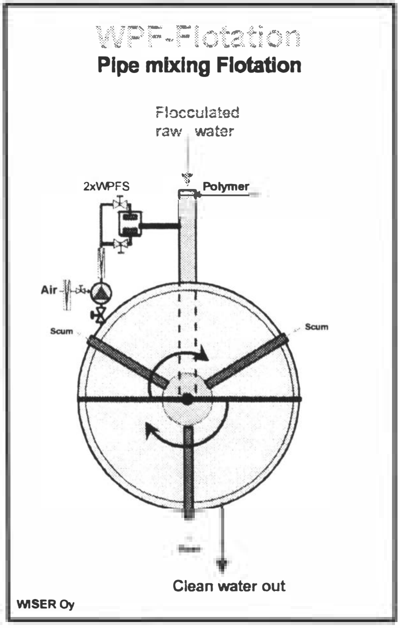


FIG 10. WPF-Flotation with Pipe Mixing

Example 2

In this system, oil-containing waters are treated by flotation. Such waters may be called "sludge" waters. The waters also comprise other chemical solvents but they mainly comprise light and heavy oil residues. The volumetric flow was dimensioned to be 100 m^3/h. When designing the process, the temperature of the waters fed to flotation was considered to be 40 °C, but during operation of the plant there may flow in waters with a temperature as high as 90 °C. The temperature of dispersion water was designed to be 40 °C at the maximum.

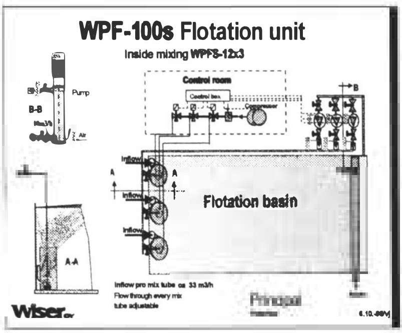


FIG 11. WPF 100s Flotation unit

FIG 11 shows a WPF-100s flotation unit. In it, the inflow is divided into three parts, i.e. into three different mixing tubes. The WPFS depressuring valves are situated at the bottom of each mixing tube, so that the oil-containing feed is mixed very thoroughly with the microbubbles rising from the bottom of the mixing tube, after which the thus dispersed mixture rises to the surface of the flotation basin.

The oil is collected to its own outtake while the purified water sinks down to be discharged from the bottom. It is characteristic of the process that it does not employ any chemicals or polymers as yet. However, the Wiser Flotation allows polymers to be mixed with the inflow, if it is considered necessary. The oil contents in the inflow has been 500 mg/l on an average and in the outflow =10 mg/l.

The start-up of the plant was in January 1999, and thus the operation experience is short. However, it may be stated that the start-up succeeded immediately without any problems. The plant has been in operation continuously and there have been no operational malfunctions.

Summary

The **Wiser Flotation** has a strong technological basis and background. With its technique, it reliably produces very small microbubbles as compared with the flotation arrangements currently on the market. The bubble sizes can be selected from the range of 10…40 μm according to the need.

The operation of the Wiser depressuring valve is independent of the method by which the dispersion water is produced and the gas is dissolved. Moreover, the WPSF valve does not clog although the dispersion liquid would contain solid material too.

As the Wiser Flotation includes an operation in which microbubbles are mixed with the floc-containing water to be treated by flotation, the result of flotation is very reliable. The flotation process will be definitely successful if preprecipitation is successfully performed and if small particles are gathered into flocs by means of polymers that affect the static (electricity) of the particles. The liquids to be purified must be examined for their ability of flocculation in each flotation plant. It is difficult to know in advance as to which precipitation method would be generally applicable, and therefore local flocculation tests should be made in order to ensure the result of flotation.

Wiser wants to continuously develop technical improvements and new additional operations for its flotation units. Wiser also wants to provide more efficient flotation units, reduce their construction and equipment costs and minimise the use of chemicals and energy. Moreover, the reliability of operation and automatic operation are also important considerations to Wiser.

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