

Membrane filter housing and method of using the same

The present invention relates to a membrane filter housing, comprising a housing with a feed inlet, a permeate outlet and at least two membrane filters provided in the housing, wherein a fluid to be filtered is fed via the feed inlet to the membrane filters, and a permeate stream is discharged via the permeate outlet. The invention also relates to a method using such a membrane filter housing.

A membrane filter housing as mentioned above is generally known in practice. In such prior art membrane filter housings a plurality of membrane modules is placed in a housing such that in the direction of flow, they lie substantially in each others extended direction. A housing of this kind is shown in Figure 1. It can be clearly seen that the connections for the inlet of fluid to be filtered and for the outlet of permeate of said known filter housings are located at the ends of the housing.

However, these known housings have several drawbacks. The first is that the membrane flux through the various membrane modules in the housing is not the same. At reference numeral 2 the feed is let into the housing 1 and at reference numeral 3 the permeate is discharged. For filtration, the feed will therefore be conducted through the membrane modules 4, 4', 4'', 4''' to the central permeate conduit 5. Consequently, the pressure at the feed side is the highest near I and the lowest near II. Correspondingly, the pressure is the lowest at the permeate side near I and the highest near II. The membrane flux is driven by the local pressure difference over the membrane (transmembrane pressure difference, TMD) and equals the feed pressure minus the permeate counterpressure. Due to pressure losses, this TMD will clearly be greater near I than near II. These pressure differences are caused by the counter-oriented pressure reductions occurring at the feed

side and permeate side in the membrane filter modules. Due to the irregular membrane flux, the terminal modules will foul more heavily and will therefore be subjected to a greater mechanical load. The more centrally placed membranes will initially contribute less to the filtration. Moreover, such an irregular membrane flux will lead to the problem that during cleaning not all the membrane modules will be cleaned equally well. This has a negative effect on the entire productivity of the membrane filtering installation.

The object of the invention is to provide an improved membrane filter housing that does not exhibit the aforementioned drawbacks. A particular object of the invention is to provide an improved membrane filter housing having a regular membrane flux. The object of the invention is finally to provide a membrane filter housing that simplifies the construction and the continued operation of a filter installation using such membrane filter housings.

In order to realise the above mentioned objectives, the invention provides a membrane filter housing of the kind mentioned in the preamble and which is characterised in that one of the permeate outlet and the feed inlet is located at least at one end of the membrane filter housing and the other one is located at a position substantially in the middle of the membrane filter housing. The housing according to the invention has a number of advantages. The most important advantage is an even pressure difference of the feed side relative to the permeate side, irrespective of the position in the housing. Another advantage is the spatial separation between the feed conduits and the permeate conduits.

The membrane filter housing according to the invention can be applied very well with "dead end" filtration. If, as may in practice be taken as starting point, all the membrane modules have an equal pressure drop, then all the modules will have a same transmembrane pressure and consequently a same membrane flux. This provides a very even load throughout the entire installation. Also in

this case, all the membrane modules will exhibit substantially the same degree of fouling. This means that the membrane modules can be cleaned more reliably. An extra advantage of the invention is that because the pressure difference of the feed side compared with that of the permeate side is the same, the pressure losses no longer contribute to an uneven distribution of the membrane flux over the individual modules. Consequently it is not necessary to minimise the pressure losses of individual modules.

If the feed inlet is located in the middle of the housing and the permeate outlet at the ends, it is also very simple to provide the ends of the membrane filter housings with an extra connection for the discharge of the concentrate stream. In this way the apparatus can very simply be applied as "cross flow" filter. This allows the transmembrane pressure to be adjusted very accurately. At the feed side, the pressure gradient from feed inlet to concentrate outlet can be adjusted by controlling the flow rate at the feed side. At the permeate side the pressure gradient will be caused by a locally occurring loss of flow. Suitable adjustment of the flow rate now allows the pressure gradient at the feed side to be matched with the pressure gradient at the permeate side. This will result in a substantial equilibration of the transmembrane pressure over the entire membrane filter housing. According to another embodiment, the flow rate is adjusted at the permeate side. This provides the same advantage.

It is of course also possible to adjust both flow rates.

In accordance to a first further preferred embodiment, the housing according to the invention is characterised in that the feed inlet is located at a position in the middle of the membrane filter housing and the permeate outlets are located at the two ends of the membrane filter housing. This is a simple manner of realising the aforementioned embodiments.

Another embodiment entails the provision of feed inlets at both ends of the membrane filter housing, and of a permeate outlet at a position substantially in the middle of the membrane filter housing. According to a further embodiment, it is also an option to provide a concentrate outlet at a position substantially in the middle of the membrane filter housing.

The invention also provides a filter system in which at least one membrane filter housing according to the invention is applied. Preferably a filter system is used of the kind in which several membrane filter housings according to the invention are used. The respective feed inlets may then be coupled to a common feed conduit such that the flow approaches the respective membrane filter housings successively.

Herein below the invention will be further explained with reference to the appended drawings. The figures represent preferred embodiments of the invention without limiting the invention thereto.

Figure 1 shows a membrane filter housing according to the prior art.

Figures 2 to 2D show a membrane filter housing according to a first embodiment.

Figures 3 and 3A show a membrane filter housing according to a second embodiment of the invention.

Figure 4 shows a membrane filter housing according to the invention during cleaning.

Figure 1 shows a membrane filter housing 1 according to the prior art. Provided are feed connections 2 and permeate outlet connections 3. The fluid to be filtered streams through the membrane modules 4, 4', 4'', 4''' and is discharged via the permeate conduit 5.

In accordance with the invention, a first embodiment provides a membrane filter housing as shown in Figure 2. The housing 1 comprises a plurality of modules 4, 4', 4'' and 4''', and a central permeate conduit 5. The feed is supplied via the feed connection 2 and permeate is discharged via permeate outlet 3. Although the permeate con-

duit 5 is embodied continuous, it may optionally be omitted at position II. When fluid to be filtered is supplied at the inlet 2, it will penetrate through the membrane modules 4' and 4, and 4'' and 4''', respectively, reach the permeate conduit 5 and will subsequently exit the housing via 3. Filtration is effected as a result of the transmembrane pressure difference between the feed side and the permeate side. The pressure difference is the driving force. Because of pressure losses in the membrane modules, the pressure will be higher at the feed side near II than near I. Accordingly, the pressure will be higher in the permeate conduit near II than near I. This results in the pressure difference being substantially constant over the entire membrane filter housing. This provides a very constant membrane flux over the entire membrane filter housing.

Figure 2A shows a filter system wherein two of the membrane filter housings shown in Figure 2 are linked together. Feed is supplied via the central feed conduit 6. The arrow A indicates the direction of flow of the feed through the central feed conduit 6. Initially feed will reach the membrane filter housing 1 and subsequently the membrane filter housing 1'. As the feed rate near position 7 will be greater than near position 8, the diameter of the feed conduit 6 is preferably designed to be larger at position 7. If the membrane filter housings 1 and 1' are identical, the flow rate near position 7 will generally be twice as large as near position 8. Therefore, near position 7 the diameter of the feed conduit 6 will preferably be so much larger than near position 8, that the velocity of the flow of the feed is constant.

Since in general it is construction-technically awkward to provide the central feed conduit 6 with a diameter different to that of the membrane filter housing 1 if the latter is directly connected thereto, as shown in Figure 2A, the connection of the membrane filter housing to the common feed conduit 6 is preferably embodied as shown in Figure 2B. In this way it is simple to adjust the

diameter as desired. For example, it is possible to embody the feed conduit near position 9, as shown in Figure 2B, conical (not shown) for a gradual transition from the larger diameter (not shown) near 7' to the smaller diameter (not shown) near 8'.

Of course, the invention is not limited to the filter system combining only two membrane filter housings 1, 1' into one filter system. It is also possible to combine more membrane filter housings to obtain a filter system with many membrane filter housings. Figure 2C shows an embodiment wherein four membrane filter housings are combined into one filter system. However, in such a case it will be particularly preferred to adapt the diameter of the common feed conduit 6 to the amount of feed to be conducted therethrough, as is shown in Figure 2B.

Figure 2D shows a further embodiment of the filter system as shown in Figure 2C, wherein "cross flow" filtration is possible. To this end extra connections 10 are provided, which are located at the ends of the membrane filter housings 1, 1', 1'', 1'''. At the feed inlet 2 feed is supplied, which is introduced into the central permeate conduit 5, 5', 5'', 5''' via the membrane modules 4, 4', 4'', 4''' comprised in each of the membrane filter housings 1, 1', 1'', 1'''. The permeate subsequently flows to the permeate outlets 3. The feed flows through the membrane modules 4' and 4, and 4'' and 4''', respectively, and is discharged as concentrate near 11, 11', and 12, 12', respectively. The flow rate of the feed through the membrane modules can be varied. For this purpose, for example, valves may be provided at the feed side 2, or at the concentrate discharge side. Alternatively, the permeate stream may be controlled, for example, by valves at the permeate discharge side 3. Correct control of the various streams makes it possible to control the pressure gradient over the apparatus. By controlling the flow rates of feed and/or permeate in the correct manner, the pressure drop over the entire apparatus can be kept constant.

In this way a very even transmembrane flux can be obtained.

Figure 3 shows another embodiment of the membrane filter housing according to the invention, wherein feed inlet connections 2 are provided at the ends of a membrane filter housing 1, and a permeate outlet 3 in the middle of the filter housing 1. The principle of operation of a membrane filter housing according to Figure 3 is substantially the same as that of Figure 2. But the direction of flow through the membrane modules is reversed.

A further embodiment of the membrane filter housing according to Figure 3 is shown in Figure 3A. The embodiment shown in Figure 3A is suitable for cross flow. The feed is supplied to the filter housing 1 via the feed inlets 2 and flows through the various membrane modules 4, 4', 4'' and 4''', of the various housings 1, 1', 1'', 1''' and is discharged as concentrate via a central concentrate discharge pipe 13. As shown in Figure 3A, the central concentrate discharge pipe 13 also comprises a central permeate discharge pipe 14. This provides a very compact construction for cross flow filtration. The advantage gained herewith is that the pressure drop can be regulated to a constant value.

Figure 4 shows an embodiment in which the filtering apparatus according to Figure 2 is being rinsed. To this end rinse water is supplied near the permeate outlet 3, flows via the permeate conduit 5 through the membrane modules 4 and exits the apparatus via the feed inlet 2. The system as shown in Figure 3 can be cleaned similarly by back-flushing permeate.

To a person skilled in the art it is, moreover, obvious that the direction of filtration can be reversed. In the Figures 1-3 filtration takes place from the inside to the outside. This means that the feed is at the inside of the membrane while the permeate is at the outside. When the filtering apparatus is reversed, feed will be at the outside and the permeate at the inside (see Figure 4).

Rinsing of the installation will then take place in reversed direction.

The invention is not limited to the embodiments shown in the figures. After reading the foregoing description, further modifications will become clear to a person skilled in the art, and these fall under the protective scope of the present invention. For maintenance purposes it is, for example, possible to drain the housing by opening the connections 14 shown in the figures (see for example Figure 2C). The entire apparatus can be emptied very easily, for example, by also opening the remaining connections, or by using locally applied pressure, which may be realised, for example, with the aid of liquid or gas such as compressed air.

CLAIMS

1. A membrane filter housing, comprising a housing with a feed inlet, a permeate outlet and at least two membrane filters provided in the housing, wherein a fluid to be filtered is fed via the feed inlet to the membrane filters, and a permeate stream is discharged via the permeate outlet, **characterised** in that one of the permeate outlet and the feed inlet is located at least at one end of the membrane filter housing and the other one is located at a position substantially in the middle of the membrane filter housing.

2. A membrane filter housing according to claim 1, **characterised** in that the feed inlet is located at a position in the middle of the membrane filter housing and the permeate outlets are located at the two ends of the membrane filter housing.

3. A membrane filter housing according to claim 2, **characterised** in that the concentrate outlets are provided near the ends of the membrane filter housing.

4. A filter system, **characterised** in that it comprises at least one membrane filter housing according to one of the preceding claims.

5. A filter system according to claim 4, **characterised** in that it comprises membrane filter housings according to claim 2 or 3, each of which being coupled with the respective feed inlet to a common feed conduit, such that the flow approaches the respective membrane filter housings successively.

6. A filter system according to claim 5, **characterised** in that the diameter of the common feed conduit decreases in the direction of flow.

7. A filter system according to claim 6, **characterised** in that the diameter decreases such that the velocity of the flow of the liquid to be filtered is substantially constant in the entire common feed conduit.

8. A membrane filter housing according to claim 1, **characterised** in that feed inlets are provided at both ends of the membrane filter housing and a permeate outlet is located at a position substantially in the middle of the membrane filter housing.

9. A membrane filter housing according to claim 8, **characterised** in that a concentrate outlet is located at a position substantially in the middle of the membrane filter housing.

10. A filter system, **characterised** in that the same comprises at least one membrane filter housing according to one of the claims 8 or 9.

11. A method of filtering a liquid, **characterised** in that the same uses a membrane filter housing according to one of the preceding claims.