

A METHOD OF CHANGING OPERATING MODES IN AUTOMATIC WATER FILTERING APPARATUS USING TUBULAR MEMBRANES

The invention relates to a method of changing operating modes in automatic water filtering apparatus using tubular membranes.

In installations that treat small to medium flow rates of water for distribution in the public drinking water mains network, it is particularly advantageous to treat the water by means of tubular membrane filters. Such installations must be capable of operating automatically and of providing filtered water in constant quantity and quality, regardless of variations in the quality of the source, and in spite of being made available to local authorities that do not have sufficient financial means to have qualified personnel in continuous attendance on such installations.

At present, three different filtering modes are known and in use with inside-skin tubular membranes:

(1) dead-end filtering where all of the water fed to the membranes passes through the membranes and is collected as a permeate (filtered water) from the periphery of the bundle of membranes. The flow rate at the axial outlet from the membranes is zero, and the membranes are cleaned periodically by backwashing whenever the thickness of the layer of matter in suspension as stopped by the membrane and as deposited thereon gives rise to a headloss which would increase pressure at constant flow rate to above an admissible threshold. The periodic backwashing has the purpose of removing this layer of deposited matter, and backwashing operations are triggered by automatic control means.

(2) cross-flow filtering, where only a portion of the water fed to the membranes passes through the membranes and is collected as a permeate, while the remainder is collected at the axial outlet from the membranes and is recirculated in a loop. Membrane cleaning is provided: firstly on a continuous basis by

the water circulating over the membranes, thereby enabling a portion of the matter in suspension to be kept in suspension instead of being deposited on the membranes, and thus limiting cake thickness; and secondly
5 by periodic backwashing.

(3) cross-flow filtering accompanied by continuous purging, using the above-described cross-flow filtering technique, where a portion of the feed water is purged so as to limit the concentration of matter in suspension in
10 the circuit.

Dead-end filtering is the most economic from the energy point of view since the flow rate of its single feed pump needs to be no greater than the flow rate of filtered water production. Cross-flow filtering requires
15 an additional pump for recirculation; adding a continuous purge where water is returned to its source or to the drainage system is naturally even less economical.

In the event of the turbidity or the organic matter content of the feed water rising above the threshold at which good dead-end mode operation is possible, it must
20 be possible to switch over to cross-flow mode filtering, and if the quality of the water becomes even worse, it will be necessary to be able to proceed with continuous purging. Conversely, if the quality of the water to be
25 filtered is restored, then it is advantageous to be able to return to a more economical mode of operation.

At present, all three of these operating modes can be implemented in a single installation, with switching from dead-end mode to cross-flow mode being performed by
30 switching on a recirculation pump, and with the addition of a purge being provided by opening an appropriate valve. The decision to change configuration is then taken by the person responsible for supervision and as a function of the quality of the filtered water.

35 It would thus be advantageous to provide automatic switching from one mode to another without requiring human intervention.

The invention thus provides a method of changing operating modes in water filtering apparatus comprising inside-skin tubular membrane modules for filtering water, the possible filtering modes being: dead-end filtering; 5 cross-flow filtering accompanied by recirculation in a loop; and cross-flow filtering accompanied by continuous purging; the method being characterized in that two types of triggering are provided for filter membrane backwashes, the first type being related to time periods 10 between two backwashes, which time periods are predetermined for each mode of filtering, and the second type being related to reference values of an operating parameter of the automatic apparatus, the parameter being related to the quality of water to be treated; and 15 switching from one mode of filtering to another after at least one backwash has been triggered by reaching one of the reference values instead of at the end of a predetermined time period, with switching taking place in the following order: dead-end filtering, cross-flow 20 filtering, cross-flow filtering with continuous purging, or vice versa if two or more consecutive backwashes have been triggered at the end of a predetermined time period instead of being triggered by reaching.

When at least one backwash is triggered in dead-end 25 mode because an operating parameter of the apparatus has reached a first reference value rather than because a first predetermined time period has expired, operation switches automatically to cross-flow mode by switching on the recirculation loop, and when at least one backwash is 30 triggered in cross-flow mode because a second reference value is reached rather than because a second predetermined time period has expired, operation switches automatically to cross-flow mode with purging by opening a purge valve on the recirculation loop.

35 It is advantageous, at least when passing to continuous purging, to omit switching over after the first backwash related to a reference value, and to

switch over only after two backwashes related to the reference value have been triggered in a third predetermined time period which is less than the second predetermined time period. Conversely, in the event of the automatic control means observing that two or more consecutive backwashes are triggered during cross-flow filtering with continuous purging because the second predetermined time period has expired rather than because the reference value has been reached, then the system returns to cross-flow filtering mode without purging by closing the purge valve.

Such a return to the preceding operating mode may be provided between cross-flow mode and dead-end mode, for example in the event of the automatic control means observing that two or more consecutive backwashes have been triggered by the second predetermined time period expiring, when said second time period is not less than the first predetermined time period.

The operating parameter used by the automatic control means in conjunction with reference values must be related to the quality of the water to be treated. Examples include turbidity due to the quantity of matter in suspension, and transmembrane pressure which increases as the quantities of matter in suspension and of organic matter increase.

Using turbidity requires two experimental values to be determined for subsequent use as the reference values by testing the installation when it is put into service.

However, the parameter is advantageously the inlet pressure to the filter modules. This inlet pressure is related to the transmembrane pressure by the equation:

$$P_{tm} = \frac{1}{2}(P_e + P_s) - P_p$$

where:

P_{tm} = transmembrane pressure
 P_e = inlet pressure to the module
 P_s = outlet pressure from the module
 P_p = permeate pressure (filtered water pressure)

For a given membrane, the maximum transmembrane pressure is the maximum pressure at which the membrane operates properly, and it is higher for cross-flow filtering than it is for dead-end filtering. Since the maximum inlet pressure to the module is related to the maximum transmembrane pressure by the equation:

$$P_{\text{max}} = P_{\text{tmmax}} + \frac{1}{2}\Delta P + P_p$$

where $\Delta P = P_e - P_s$ (longitudinal head loss), two reference values are available, with the lower one being associated with dead-end mode operation and with possible switching to cross-flow mode, and with the higher one being associated with cross-flow mode operation and with possible switching to cross-flow mode with purging.

Water filtering devices operate discontinuously depending on the demand for filtered water. Each time the water level in the reservoirs or tanks feeding the public network is high they are stopped, and they are started again only when the water level drops below a given value. Thus, when using membrane filtering, each time the filters are put into operation, filtering begins with dead-end filtering, and switching to the other two modes of filtering takes place only if the quality of the water deteriorates during filtering, e.g. due to thunderstorms or high levels of rainfall. Filter apparatus is generally dimensioned as a function of the most frequent quality of water to be treated so as to operate in the considerably cheaper dead-end mode.

The control method is described in greater detail below by means of an illustrative and non-limiting example.

The method is implemented using a set of inside-skin filter membrane modules including a recirculation loop and a backwashing circuit, and also a continuous purge valve, all connected to enable the three above-described operating modes to be performed. Such dispositions are known to the person skilled in the art and include several variants whereby the modules may be fed with

water to be filtered from the top and/or from the bottom. Until now, switching from one operating mode to another has been under manual control when it is observed that the quality of filtered water is not adequate.

5 The description starts from the apparatus being switched on again after production has been switched off for a period due to a lack of demand for water (full tank).

10 The membranes are then fed by means of a feed pump, and the recirculation loop may optionally be used for allowing raw water to pass, but the recirculation pump is not switched on. Backwashes are triggered in conventional manner and automatically after a first predetermined time period which generally lies in the range 20 minutes to 24
15 hours depending on the quality of the water to be treated. This first time period t_1 is determined experimentally when the filter installation is initially put into operation. However, and in accordance with a preferred embodiment of the invention, apparatus is
20 provided for measuring the inlet pressure to the membranes. This apparatus is connected to automatic control means for the automatic apparatus.

 If the inlet pressure reaches a maximum value p_1 corresponding to a maximum transmembrane pressure for
25 dead-end mode (the first reference value) before the time period t_1 has expired since the previous backwash, then the control means triggers backwashing, and at the end of backwashing it puts the recirculation loop into operation by switching on the recirculation pump. Filtering then
30 continues in cross-flow mode. It may be advantageous to provide for the recirculation pump to be switched on only after two consecutive backwashes have been triggered by the first reference value within a period of time less than time period t_1 .

35 In cross-flow mode, backwashes are normally triggered at the end of a second predetermined time period t_2 which is generally less than or equal to t_1 .

Further, in accordance with the invention, when the maximum inlet pressure p_2 corresponding to the maximum transmembrane pressure in cross-flow mode is reached (i.e. the second reference value), the control means
 5 triggers backwashing and, when the backwashing is completed, it optionally opens the purge valve. Here again it is advantageous for the control means to open the purge valve only after two backwashes have been triggered by the second reference value in a time period
 10 t_3 which is less than t_2 . This prevents purging being switched on in the event of a deterioration in water quality of very short duration.

Since using the purge is particularly disadvantageous economically speaking, it is desirable to
 15 attempt to return to cross-flow filtering mode without purging. To do this, if the control means observes that n consecutive backwashes have been triggered at the expiry of a filter time period equal to t_2 , then it closes the purge valve to return to cross-flow mode
 20 without purging. The value of n is chosen, e.g. empirically, as a function of the installation. If the quality of the water does not enable cross-flow mode on its own to be maintained, then backwashes are again triggered by reaching the second reference value and the
 25 control means will return to filtering with a purge.

If backwashes continue to be triggered by the time period t_2 , then filtering continues in cross-flow mode.

It may then be appropriate to attempt to return to dead-end mode, e.g. after m consecutive backwashes have
 30 been triggered at the expiry of time period t_2 (where $m > n$).

The possibilities of returning to the preceding operating mode are determined on a case-by-case basis depending on expected variations in the quality of the
 35 water to be treated, on the production capacity of the installation, on the volume of the reservoir tank, etc. ..., and also taking account of the fact that when

production is stopped and after a backwash, the control means will restart the apparatus in dead-end filter mode.

The preferred operating cycle is summarized in the table below.

5	Backwashing triggered by	Filter mode
	t ₁	dead-end
	p ₁	dead-end
	p ₁ (twice running)	switch to cross-flow mode
	t ₂	cross-flow
10	p ₂	cross-flow
	p ₂ (twice in < t ₃)	switch to cross-flow mode with purging
	p ₂	cross-flow mode with purging
15	t ₂ (<u>n</u> times)	return to cross-flow mode without purging
	t ₂	cross-flow
	t ₂ (<u>m</u> times)	return to dead-end mode (optional)
20	t ₁	dead-end

where: $m > n$

$t_3 < t_2 \leq t_1$

CLAIMS

- 1/ A method of changing operating modes in water filtering apparatus comprising inside-skin tubular membrane modules for filtering water, the possible
5 filtering modes being: dead-end filtering; cross-flow filtering accompanied by recirculation in a loop; and cross-flow filtering accompanied by continuous purging; the method being characterized in that two types of
10 triggering are provided for filter membrane backwashes, the first type being related to time periods between two backwashes, which time periods are predetermined for each mode of filtering, and the second type being related to reference values of an operating parameter of the automatic apparatus, the parameter being related to the
15 quality of water to be treated; and switching from one mode of filtering to another after at least one backwash has been triggered by reacting to one of the reference values instead of at the end of a predetermined time period, with switching taking place in the following
20 order: dead-end filtering, cross-flow filtering, cross-flow filtering with continuous purging, or vice versa if two or more consecutive backwashes have been triggered at the end of a predetermined time period instead of being triggered by reaching a reference value.
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- 2/ A method according to claim 1, characterized in that switching from dead-end filtering mode to cross-flow filtering mode is performed after a backwash has been triggered twice by reaching a first reference value, and
30 that switching from cross-flow filtering mode to cross-flow filtering mode with continuous purging is performed after the time interval between two backwashes triggered by reaching a second reference value has become less than a predetermined time period, which is itself less than
35 the predetermined time period for the first types of backwash triggering.



3/ A method according to claim 2, characterized in that switching from cross-flow filtering mode with purging to cross-flow filtering mode without purging takes place when n consecutive backwashes have been triggered by reaching the end of the time period predetermined for cross-flow filtering, and switching from cross-flow filtering mode to dead-end filtering mode takes place when m consecutive backwashes have been triggered by reaching the end of the time period predetermined for cross-flow filtering, with $m > n$.

4/ A method according to any one of claims 1 to 3, characterized in that the reference value(s) is/are inlet pressures to the modules corresponding to maximum transmembrane pressures in dead-end filtering and in cross-flow filtering.

5/ A method according to any one of claims 1 to 4, characterized in that after the operation of the modules has been stopped, backwashing is performed and the modules are restarted in dead-end filtering mode.

