CERAMIC MEMBRANE MODULE

FIELD OF THE INVENTION

The present invention relates in general to membrane modules. In particular, this invention relates to a membrane module for multiple single tube ceramic membranes.

BACKGROUND OF THE INVENTION

The use of membrane technology in industrial applications require the utilization of large membrane areas. A membrane module is the smallest unit which houses membranes. Membrane modules are commonly used in the separation of liquids, solids or gases. Presently, there are two common membrane module designs namely: plate and frame and tubular. For ceramic membrane applications, a tubular module is preferred. Typically, a ceramic membrane module comprises a number of tubular ceramic membrane elements arranged parallel to one another and grouped inside a single housing. Such an arrangement allows for a higher throughput of filtration compared to when using a single membrane element. This arrangement also allow better utilization of space.

However, the use of ceramic membranes in such membrane modules creates a concern with regards to the integrity and structural strength of the ceramic membranes. Ceramic membranes are typically made of porous ceramic based materials. Such ceramic materials inherently do not possess high tensile strength. They are prone to fracture and crack when exposed to high mechanical stress.

When membranes modules are installed and in operation, they are frequently exposed to mechanical and thermal stresses from vibrations and movements caused by pump motors as well as expansion and contraction due to temperature changes arising from processed fluids in the membrane module. These mechanical and thermal stresses are transmitted into the membrane modules and can easily damage the ceramic membranes installed within.

This concern has been partially addressed simply by ensuring that the walls of such ceramic membranes are sufficiently thick to provide structural strength and support. However, thickening the walls also decreases the efficiency and permeability of the membrane element. A better method would be to use multi-channel ceramic membrane elements.

Multi-channel membrane elements comprises of a large single membrane element having a number of channels through the single membrane element. This can further be grouped into several multi-channel membranes and installed into a membrane module as disclosed in US Patent Application Publication No. 2001/0013272A1. Such multi-channel membranes are large and thick enough to provide inherent mechanical support to the multi-channel membrane.

However, using multi-channel membrane elements is merely a compromise in performance as compared to using a plurality of single-tube ceramic membranes within a membrane module. Single-tube ceramic membranes have advantages over multi-channel ceramic membranes in terms of both costs and performance. Single-tube ceramic membranes are cheaper. They are suitable for high viscosity and corrosive fluid separation. Multiple single-tube ceramic membranes have a high surface area to volume ratio, thus increasing throughput. Generally, multiple single-tube ceramic membranes far outperform multi-channel ceramic membranes. However, single-tube ceramic membranes generally have thin walls and are thus

structurally weak and susceptible to damage when exposed to mechanical and thermal stresses.

There is therefore a clear need for providing a novel apparatus for installing multiple single-tube ceramic membranes in a membrane module.

SUMMARY OF THE INVENTION

A ceramic membrane module comprising: a tubular housing for housing a plurality of single-tube ceramic membranes each having opposing end portions, the tubular housing comprising two cover plates respectively coupled to opposing ends of the tubular housing; two sealing discs for sealing the tubular housing, each of the sealing discs being respectively secured to each of the cover plates at the opposing ends of the tubular housing; two housing covers for respectively closing off respectively the opposing ends of the tubular housing, each of the housing covers respectively secured to each of the sealing discs at opposing ends of the tubular housing; and at least one support bar for supporting the ceramic membrane module, and the at least one support bar comprising a main shaft and two opposing position keys.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a cross sectional view of a ceramic membrane module in accordance with the present invention;

FIG. 2 shows a support bar of the ceramic membrane module of Fig. 1;

FIG. 3 shows an enlarged view of region A of the ceramic membrane module of Fig. 1; and

FIG. 4 shows an enlarged view of region B of the ceramic membrane module of Fig. 1.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to Fig. 1, a ceramic membrane module 5 in accordance with the present invention comprises a tubular housing 11, a first housing cover 13 and a second housing cover 15, a support bar 17, sealing discs 19, a plurality of single-tube ceramic membranes 23 and a variety of seals and sealing means such as o-rings 24a, 24b.

The tubular housing 11 has cover plates 25 respectively coupled to opposing ends 11a of the tubular housing 11. Typically, the cover plates 25 are permanently attached to the tubular housing 11. The plurality of single-tube ceramic membranes 23 are housed inside the tubular housing 11 and are held securely and substantially parallel to the tubular housing 11 by the cover plates 25 and sealing discs 19. The first housing cover 13 further comprises an inlet 32 for fluid to be filtered to be pumped into the membrane module 5. The fluid is forced into the plurality of single-tube ceramic membranes 23 under pressure. Filtered fluid from the single-tube ceramic membranes 23 is known as permeate and exits the walls of the single-tube ceramic membranes 23 into the tubular housing 11. This is commonly referred to as cross-flow filtration. The tubular housing 11 further comprises two permeate outlets 34, 36 for the outflow of the permeate. The retentate which is the fluid left after filtering then exits the single-tube ceramic membranes 23 and enters the second housing cover 15 of the membrane module and exits the membrane module via an outlet 38. The second housing cover 15 can further be provided with at least one other outlet 40 for drainage purposes.

Referring to Fig. 3, the sealing discs 19 are superposed on of the cover plates 25 and the housing covers 13, 15 are further superposed on the sealing discs 19. The three sandwiched components are then clamped together securely by securing means such as bolts and nuts 41. The cover plates 25 and sealing discs 19 are provided with a plurality of tube openings for receiving end portions 23a of the single-tube ceramic membranes 23. The tube openings of the cover plates 25 and sealing discs 19 are aligned such that the single-tube ceramic membranes 23 are substantially parallel when the opposing end portions 23a are received into the tube openings. The single-tube ceramic membranes 23 are slightly longer than the tubular housing 11 and the coupled opposing cover plates 25. As such, the opposing end portions 23a of the single-tube ceramic membranes 23 jut out slightly from the cover plates 25. O-rings 24a are disposed on both opposing end portions 23a of each single-tube ceramic membrane 23. The opposing end portions 23a of each single-tube ceramic membrane 23 are disposed in the tube openings of the opposing cover plates 25 and sealing discs 19. The o-rings 24a disposed on the end portions 23a of the single-tube ceramic membranes 23 are sandwiched between the cover plates 25 and sealing discs 19. The cover plates 25 and sealing discs 19 are clamped onto the o-rings 24a disposed on the end portions 23a of the single-tube ceramic membranes 23 which secures the single-tube membranes 23 inside the housing 11. At the same time, these o-rings 24a also prevent the leakage of fluids from the cover 13 into the tubular housing 11 without passing through the single-tube ceramic membranes 23. Further, the o-rings 24a also serve to act as damping means to dissipate any vibrations or mechanical stress that might be transmitted to the single-tube ceramic membranes 23.

Referring to Fig. 2 and Fig. 4, the support bar 17 is housed inside the tubular housing 11 together with and substantially parallel to the plurality of single-tube ceramic membranes 23. The support bar 17 comprises a main shaft 18 with opposing end portions referred to as position keys 17a. The

position keys 17a have a lower cross sectional thickness than the main shaft 18. Due to this difference in thickness, a shoulder 18a is present on the support bar 17 at the position keys 17a. The main shaft 18 is substantially circular in cross-section, while the position keys 17a are polygonal in cross-section.

The support bar 17 is held in place at its position keys 17a by the cover plates 25 and the sealing discs 19. The cover plates 25 and sealing discs 19 each further provided with a bar opening for receiving the position keys 17a of the support bar 17. The length of the main shaft 18 is similar to the length of the tubular housing 11. The shoulder 18a of the support bar 17 is thus in complete contact with the cover plate 25. To further enhance the rigidity of the support bar 17and cover plates 25, the support bar 17 is welded to the cover plates 25 at the shoulder 18a. This also further ensures that there are no leakages of fluids from the covers 13,15 into the tubular housing 11 at the bar opening.

The bar opening is shaped in a polygon corresponding to the polygonal cross-section of the position keys 17a of the support bar 17. The main shaft 18 is disposed inside the tubular housing 11 with the position keys 17a protruding through the bar openings of the cover plates 25 and the sealing discs 19. The length of the main shaft 18 is such that the opposing shoulders 18a are in direct contact with the cover plates 25.

The position keys 17a of the support bar 17 functions as a guide to ensure accurate positioning of the sealing discs 19 onto the cover plates 25 to prevent the end portions 23a of the single-tube ceramic membrane from being damaged by the cover plates 25 during installation. Furthermore, once installed, the polygonal shape of the position key 17a also aids in providing support and rigidity to the entire structure. The polygonal shape of the position keys 17a prevents any slippage of the support bar 17 due to mechanical or thermal stresses as compared to a cylindrical position key.

The tubular housing 11 together with the support bar 17 coupled to the cover plates 25 and the sealing discs 19 form a supporting structure for providing rigidity and structural strength to the plurality of single-tube ceramic membranes 23. The o-rings 24a used for securing and sealing the single-tube ceramic membranes 23 also serves to dampen the vibrations and mechanical stresses that might be transmitted to the single-tube ceramic membranes. Further, when the ceramic membrane module 5 is subjected to high variation of temperatures i.e. heating up and cooling down, the tubular housing 11 as well as the plurality of single-tube ceramic membranes 23 would experience thermal expansion or contraction. In view of large differences in thermal extension factors between the tubular housing 11 and membrane materials, this temperature variation will cause thermal stress on the single-tube ceramic membranes 23. The o-rings 24a disposed on the opposing end portions 23a of the single-tube ceramic membranes 23 allows for such extension and contraction allowing the relieving of thermal stress and preventing any damage to the single-tube ceramic membranes 23.

The ceramic membrane module 5 may be provided with more than one support bar 17 depending on the size of the tubular housing, the number of single-tube ceramic membranes 23, the operating conditions and operating parameters such as temperature and pressure. The structural rigidity and integrity of the ceramic membrane module 5 may further be enhanced by the addition of a threaded extension on the position key 17a. This threaded extension can be adapted for receiving a threaded nut. By mounting and tightening the nut onto the extension, pressure may be exerted to tighten the sealing discs 19 onto the cover plates 25.

During normal operation, a ceramic membrane module 5 in accordance with the present invention will be generally operated in a cross-flow mode. It will be suitable for various process operating in a variety of

configurations, such as: open and closed systems, feed and bleed operations, batch and continuous operations.

The present invention further allows the ceramic membrane module 5 to undergo on-line regeneration of the single-tube ceramic membranes 23 as well as easy replacement of individual damaged single-tube ceramic membranes 23.

When used for treatment of high viscosity fluid such as: waste engine oils, oil slops, organic effluent, and bio or food effluent, the single-tube ceramic membranes are easily fouled by residual particulates or biomass found in these high viscosity fluids. Surface washing of the single-tube ceramic membranes 23 using permeates do not yield satisfactory results and some of the pores in the single-tube ceramic membranes will still be blocked. A more effective method would be to implement an on-line back flush of the single-tube ceramic membranes 23.

During the back flush operation, the feed stream is cut off and any remaining process fluids and permeate drained away. A selected solvent solution is pumped into the module from the permeate outlet so that the solvent solution will enter the membrane wall from shell side and pass through the membrane surface into the tube side. The system is maintained at a certain predetermined pressure. The fine particles and viscous materials blocking membrane pores of the single-tube ceramic membranes will eventually be dissolved and washed out as a washed solution. The washed solution will be then transferred to a container for recycling. A Blanket gas such as nitrogen will be used to strip off any remaining solvent in the ceramic membrane module 5. The normal operation of the ceramic membrane module 5 may now be continued.

During normal operation, individual single-tube ceramic membrane 23 may be damaged or exposed to wear and tear and may require replacement. In accordance with the present invention, damaged single-tube ceramic

membranes 23 may easily be replaced without affecting other single-tube ceramic membranes 23.

The above descriptions do not in any way limit the scope of the invention. It would be apparent to one skilled in the art that the present invention may be modified without departing from the scope of the invention.

CLAIMS

1. A ceramic membrane module comprising:

a tubular housing for housing a plurality of single-tube ceramic membranes each having opposing end portions, said tubular housing comprising two cover plates respectively coupled to opposing ends of said tubular housing;

two sealing discs for sealing said tubular housing, each of said sealing discs being respectively secured to each of said cover plates at said opposing ends of said tubular housing;

two housing covers for respectively closing off respectively said opposing ends of said tubular housing, each of said housing covers respectively secured to each of said sealing discs at opposing ends of said tubular housing; and

at least one support bar for supporting said ceramic membrane module, and said at least one support bar comprising a main shaft and two opposing position keys.

2. A ceramic membrane module according to claim 1, wherein said sealing discs and said cover plates further comprises a plurality of openings for receiving said plurality of single-tube ceramic membranes.

3. A ceramic membrane module according to claim 2, wherein said plurality of single-tube ceramic membranes are secured by their end portions to said sealing discs and said cover plates.

4. A ceramic membrane module according to claim 2, wherein said end portions of said plurality of single-tube ceramic membranes are disposed within said plurality of openings of said sealing discs and said cover plates.

5. A ceramic membrane module according to claim 2, wherein said sealing discs and said cover plates further comprises at least one bar opening for respectively receiving one of said opposing position keys of said at least one support bar.

6. A ceramic membrane module according to claim 5, wherein said at least one support bar is secured to said opposing cover plates to provide rigidity and support to said plurality of single-tube ceramic membranes.

7. A ceramic membrane module according to claim 1, wherein at least one seal is disposed on each of said opposing end portions of each of said plurality of single-tube ceramic membranes.

8. A ceramic membrane module according to claim 7, wherein said at least one seal is disposed between said sealing discs and said cover plates.

9. A ceramic membrane module according to claim 1, wherein cross-sectional thickness of said opposing position keys of said at least one support bar is lower than a cross-sectional thickness of said main shaft.

10. A ceramic membrane module according to claim 1, wherein cross-section of said main shaft is substantially circular.

11. A ceramic membrane module according to claim 1, wherein cross-section of opposing position keys are substantially polygonal.

12. A ceramic membrane module according to claim 1, wherein said main shaft having a length substantially equal to distance between said two cover plates coupled to opposing ends of said tubular housing;