near the shaft of each motor 118A, 118B. Each encoder 128A, 128B generates an encoder signal that is communicated to a controller 130. The encoder signal corresponds to the rotational (angular) position of each shaft and therefore the rotational position of each rotary valve plate 116A, 116B. The encoders 128A, 128B may also be located on the rotary valve plates 116A, 116B or rotors 126A, 126B. The controller 130 may be a programmable logic controller. The controller 130, based on the encoder signals from the encoders 128A, 128B, controls the rotation speed of the motors 118A, 118B. The motors 118A, 118B, together with the movement detection of the rotors, allows precise control of the position. Although continuous movement may be used, stepped movement may also be used.

[0068] In the example set forth in FIG. 5, size and capacity restraints are minimized. That is, the flow channels 114A-114D may be as large as desired. The stator 112, as illustrated below, does not need a housing or massive high precision bearings. By allowing the stator to be as long as desired, a greater pumping volume in each channel is achieved. The motors 118A, 118B can overcome the drag torque that may be induced by debris in the process stream which could stall the rotor in prior configurations. It should be noted that the internal valve plate configuration is illustrated in FIG. 5 with no housing.

[0069] Referring now to FIG. 6, more specific details of the fluid to fluid 20 pressurizer 110 is set forth. In this example, a common shaft 138 is rotatably coupled to the rotary valve plates 116A, 116B. The common shaft 138 is supported by a first rotor housing 140A and a second rotor housing 140B disposed around the rotary valve plates 116A, 116B. A pair of bearings 142A, 142B allow the shaft 138 to rotate relative to the rotor housings 140A, 140B. The rotor housings 140A, 140B remain stationary 25 during operation while the rotary valve plates 116A, 116B rotate therein.

[0070] Referring now also to FIGS. 6A and 6B, details of the rotor housing 140A is set forth. However, the details for rotor housing 140B are similarly configured. The rotor housing 140A has a fluid inlet 150A. Rotor housing 140B has a fluid inlet 150B. Rotor housing 140B has a fluid inlet 150B and a fluid outlet 152B. The flow inlets 150A, 150B and fluid outlets 152A, 152B are radial or perpendicular to a longitudinal axis 153 and the fluid to fluid pressurizer 110. In FIG. 6A, the fluid inlet 150A and the fluid outlet 152B are linearly aligned through the flow channel 114A. Also, in this example, the fluid inlet 150A and the fluid outlet 152B are located toward

[00109] As is best illustrated in FIG. 13E, bars 1340, 1342 are used to prevent the partition 1310 from completely extending from the flow channel 214. In this example, two perpendicularly disposed bars are used. The fins 1332, 1334 allow fluid to pass as shown in the upper position of FIG. 13E. By allowing fluid to pass around the partition 1310, fluid flow is not completely stopped. In certain industrial processes such as reverse osmosis systems, it is desirable to not stop fluid flow. In particular, during the high-pressure fill cycle of a reverse osmosis system, high pressure brine pushing feed to the membrane should not be fully interrupted. The bars 1340, 1342 may be positioned on the left side of FIG. 13A closer to the flow channels 214 so that the partition does not extend outward therefrom. This allows low pressure feed to be used to positively position the partition at one end of the channel to ensure that there will be ample length of travel during the high-pressure cycle yet the flow is blocked at the low pressure channel to ensure no fluid is unnecessarily lost during the purge cycle. Blocking the low-pressure flow does not cause undue flow disruption nor stress on any of the components therein. The feed pressure during the purge cycle is high enough to allow the partition to be driven all the way to the end of the channel before the high pressure fill cycle begins. One way to perform this is to for the feed pressure being maintained at least one bar higher than the brine discharge pressure. However, more optimal designs may require a lower pressure difference.

[00110] The face plates 1320A, 1320B may be made reversible and replaceable. That is, the face plates 1320A, 1320B may be removable attached to the stator 112. Each face of the face plates may be highly precision machined to allow the face plates to be reversed.

[00111] Referring now to FIG. 13F, flow channels 214" are illustrated. The flow channels 204" are modified with end stops 1330A and 1330B located near each end. A partition 1310' moves within the flow channel 214" as illustrated above in FIGS. 13A-13E. However, in this example, the partition 1310' is retained within the flow channels 214". To allow fluid to pass through the partition, a fluid passage 1350 is provided therethrough. A valve 1376 opens when enough fluid pressure builds up within the flow channel 214". That is, the valve 1336 may only open upon a significant differential pressure between the flow channel 214" and the pipes beyond the flow channel 214". In dashed lines, the partition 1332 is shown at the other end with the

valve 1376 opened. It should be noted that the valve may open in either direction or set to be opened at one end and remain close at the flow channel 214"

[00112] Referring now to FIGS. 14A and 14B, the system is also suitable for very large commercial installations. In this example, the flow channels are replaced by pipes 1410. The pipes 1410 are coupled to manifolds 1412A and 1412B. Pipe joints 1414A and 1414B couple the pipes 1410 to the respective manifolds 1412A, 1412B. Such a configuration allows the pipes 1410 to be replaced when damaged or worn. Longer pipes and larger diameter pipes 1410 may be used in such a system. Thus, a greater amount of pumping per cycle and hence a reduction in the reduction rate may take place. By reducing the rotation rate, the wear of the rotary valve plates may be reduced. Lowering the cycle rate extends the fatigue life of all the components exposed to the varying pressures.

[00113] The manifolds 1412A, 1412B are coupled to the rotor housings 140A, 140B at pipe joints 1414A and 1414B.

[00114] The control of the system is to approximately have an equal amount of low pressure feed fluid and high pressure brine entering the unit. The low pressure feed must be equal or slightly greater than the high pressure brine flow and the high pressure brine flow must not be impeded or otherwise changed. The lower pressure feed flow may be varied. In FIG. 15, a reverse osmosis system 10' having similar components as that set forth in FIG. 1 is provided. The same elements are labeled the same. In this example, a fluid to fluid pressurizer 110 according to the present disclosure is provided. In this example, a fluid to fluid pressurizer 110 according to the present disclosure is incorporated therein. Also in this example, the controller 130 may be coupled to a salinity sensor 151 such as a total dissolved solid sensor. The speed of the motor 118 may be changed based upon the brine flow rate as measured by the flow meter 36. By this control, the high pressure brine port rotates away from a given pumping channel for the brine interface or the physical partition can reach the end of the channel. The rotation rate may be calculated based on the dimensions of the pumping channels and the brine flow rate. The motor speed calculation may be performed by the controller 130. A salinity sensor 1510 may be also used to set the motor speed. When the salinity sensor 1510 detects a mixing of high salinity brine with the feed, then the motor speed of the motor 118 may be increased and valve 38 may be opened to increase the feed flow. The pump 44 may also have

CLAIMS

What is claimed is:

1. A fluid to fluid pressurizer comprising:

an elongated stationary portion comprising a plurality of flow channels, said stationary portion comprising a first face at a first end and a second face at a second end, said plurality of flow channels are defined by a plurality of radial walls, an inner annular wall and an outer annular wall, said radial walls defining a first width for each of the plurality of flow channels;

a first rotor housing disposed adjacent to the first end of the elongated stationary portion;

a second rotor housing disposed adjacent the second end of the elongated stationary portion, said first rotor housing and the second rotor housing being stationary;

each of the first rotor housing and the second rotor housing comprising a fluid inlet fluidically coupled to a first annular channel and a fluid outlet fluidically coupled to a second annular channel;

each of the first rotor housing and the second rotor housing comprising a first rotary valve plate and a second rotary valve plate respectively, each rotary valve plate comprising an inlet valve port fluidically coupling the fluid inlet to at least a first flow channel of the plurality of flow channels, each rotary valve plate comprising an outlet valve port fluidically coupling a second flow channel to the plurality of flow channels to the second annular channel; the first rotary valve plate comprising a first sealing surface adjacent the first face and the second rotary valve plate comprising a second sealing surface adjacent the second face, said first rotary valve plate comprises a sealing area comprising a first radial sealing edge, a second radial sealing edge having a second width therebetween, said second width equal to or greater than the first width, the first radial sealing edge comprises a first taper extending therefrom;

a first annular seal disposed radially between the first rotor housing and the first rotary valve plate, said first annular seal is further disposed longitudinally between the first annular channel and the second annular channel of the first rotor housing;

a second annular seal disposed radially between the second rotor housing and the second rotary valve plate, said second annular seal is further disposed

longitudinally between the first annular channel and the second annular channel of the second rotor housing; and

a first motor coupled to the first rotary valve plate.

2. The fluid to fluid pressurizer as recited in claim 1 wherein the first rotary valve plate simultaneously couples a first plurality of flow channels to the fluid inlet and the second rotary valve plate simultaneously couples a second plurality of flow channels to the fluid outlet.

3. The fluid to fluid pressurizer as recited in claim 2 wherein the first plurality of flow channels and the second plurality of flow channels are symmetrically opposite about a longitudinal axis of the first rotary valve plate.

4. The fluid to fluid pressurizer as recited in claim 1 further comprising a motor shaft wherein the first motor is coupled to the first rotary valve plate and the second rotary valve plate with the motor shaft.

5. The fluid to fluid pressurizer as recited in claim 1 further comprising a first motor shaft coupling the first motor and the first rotary valve plate and a second motor shaft coupling a second motor to the second rotary valve plate.

6. The fluid to fluid pressurizer as recited in claim 5 wherein the first motor shaft comprises a first encoder generating a first encoder signal and the second motor shaft comprises a second encoder generating a second encoder signal and a motor controller synchronously controlling the first motor and the second motor based on the first encoder signal and the second encoder signal.

7. The fluid to fluid pressurizer as recited in claim 1 wherein the first radial sealing edge comprising an insert formed of a wear resistant material different than a port plate material.

8. The fluid to fluid pressurizer as recited in claim 7 wherein the first taper is linear.

9. The fluid to fluid pressurizer as recited in claim 7 wherein the first taper is curved.

10. The fluid to fluid pressurizer as recited in claim 7 wherein the insert is removable.

11. The fluid to fluid pressurizer as recited in claim 1 wherein the first radial sealing edge comprises a trailing edge and the second radial sealing edge comprises a leading edge, wherein the second radial sealing edge comprises a second taper.

12. The fluid to fluid pressurizer as recited in claim 1 wherein the first rotary valve plate comprises a pair of oppositely disposed sealing areas comprising a first area.

13. The fluid to fluid pressurizer as recited in claim 1 wherein the sealing area comprises four diametrically opposite and evenly spaced apart sealing areas.

14. The fluid to fluid pressurizer as recited in claim 1 wherein the sealing area comprises a plurality of groups of four diametrically opposite and evenly spaced apart sealing areas.

15. The fluid to fluid pressurizer as recited in claim 1 wherein the first rotary valve plate comprises a first annular sealing portion, a second annular sealing portion spaced apart from the first annular sealing portion, said first radial sealing edge and said second radial sealing edge extending between the first annular sealing portion and the second annular sealing portion.

16. The fluid to fluid pressurizer as recited in claim 15 wherein the first annular sealing portion comprises a plurality of radially overlapping grooves.

17. The fluid to fluid pressurizer as recited in claim 16 wherein the plurality of radially overlapping grooves are radially extending.

18. The fluid to fluid pressurizer as recited in claim 16 wherein the plurality of radially overlapping grooves are disposed at angles relative to a radius.

19. The fluid to fluid pressurizer as recited in claim 16 wherein the plurality of radially overlapping grooves are one millimeter deep or less.

20. The fluid to fluid pressurizer as recited in claim 1 wherein the sealing area comprises a plurality of grooves disposed thereon.

21. The fluid to fluid pressurizer as recited in claim 20 wherein the sealing area comprises a first set of grooves extending from the first radial sealing edge toward the second radial sealing edge and a second set of grooves extending from second radial sealing edge toward the first radial sealing edge.

22. The fluid to fluid pressurizer as recited in claim 1 wherein the first rotor housing further comprises a chamber disposed adjacent to the first rotary valve plate, the chamber fluidically coupled to the fluid inlet through a first control valve and wherein the chamber is fluidically coupled to the fluid outlet through a second control valve, a controller coupled to the first control valve and the second control valve controlling a fluid pressure within the chamber.

23. The fluid to fluid pressurizer as recited in claim 22 wherein the fluid pressure within the chamber provides an axial force on the first rotary valve plate toward the elongated stationary portion.

24. The fluid to fluid pressurizer as recited in claim 1 wherein the plurality of flow channels comprises a first flow channel end portion having a first cross sectional area a second flow channel end portion having a second cross sectional area and a middle flow channel portion having a third cross sectional area, said middle cross sectional area less than the first cross sectional area and the second cross sectional area.

25. The fluid to fluid pressurizer as recited in claim 24 wherein the middle flow channel portion comprises a movable partition disposed therein.

26. The fluid to fluid pressurizer as recited in claim 25 wherein the first flow channel end portion comprises a partition stop spaced apart from the middle flow channel portion allowing the movable partition to partially extend therefrom.

27. The fluid to fluid pressurizer as recited in claim 24 wherein the first flow channel end portion comprises a first partition stop disposed in the first flow channel end portion and a second partition stop disposed in the second flow channel end portion.

28. The fluid to fluid pressurizer as recited in claim 27 wherein the first partition stop is disposed closer to the middle flow channel portion than the second partition stop.

29. The fluid to fluid pressurizer as recited in claim 27 wherein the middle flow channel portion comprises a movable partition having a first end position adjacent to the first partition stop and a second end position adjacent to the second partition stop, wherein in the first end position, fluid flow through the flow channel is blocked and, in the second end position, fluid flow through the flow channel is partially blocked.

30. The fluid to fluid pressurizer as recited in claim 24 wherein the elongated stationary portion comprises a first removable faceplate and a second removable faceplate.

31. The fluid to fluid pressurizer as recited in claim 24 wherein the first flow channel end portion is disposed in a first removable faceplate and the second flow channel end portion is disposed in a second removable faceplate.

32. The fluid to fluid pressurizer as recited in claim 25 wherein the moveable partition comprises a guide fin.

33. The fluid to fluid pressurizer as recited in claim 1 wherein the plurality of flow channels comprises a plurality of pipes coupled to a first pipe manifold and a second pipe manifold.

34. The fluid to fluid pressurizer as recited in claim 33 wherein the plurality of pipes are coupled to the first pipe manifold at a plurality of pipe joints.

35. The fluid to fluid pressurizer as recited in claim 33 wherein the first rotor housing is coupled to the first pipe manifold.

36. A reverse osmosis system comprising:

a membrane chamber having a feed fluid inlet, a permeate outlet and brine outlet;

a fluid to fluid pressurizer as recited to claim 1 wherein the first rotor housing is fluidically coupled to the feed fluid inlet of the membrane chamber and the second rotor housing is coupled to the brine outlet;

a first flow rate sensor generating a brine flow rate signal; and

a controller coupled to the first flow rate sensor and controlling a speed of the first motor in response to the brine flow rate signal.

37. The reverse osmosis system as recited in claim 36 further comprising a salinity sensor coupled to a fluid outlet of the first rotor housing generating a salinity signal corresponding to a salinity of the fluid from the fluid outlet;

the controller coupled to the first motor and the salinity sensor, said controller controlling a motor speed of the first motor in response to the salinity signal.

38. A method of operating a fluid to fluid pressurizer having

an elongated stationary portion comprising a plurality of flow channels, a first face at a first end and a second face at a second end, said plurality of flow channels are defined by a plurality of radial walls, an inner annular wall and an outer annular wall, said radial walls defining a first width for each of the plurality of flow channels,

a first stationary rotor housing disposed adjacent to the first end of the elongated stationary portion and comprising a first rotary valve plate therein, said first rotary valve plate comprises a sealing area comprising a first radial sealing edge, a second radial sealing edge having a second width therebetween, said second width equal to or greater than the first width, the first radial sealing edge comprises a first taper extending therefrom.

a second stationary rotor housing disposed adjacent the second end of the elongated stationary portion comprising a second rotary valve plate therein, said method comprising:

communicating low pressure feed fluid to the fluid to fluid pressurizer,

communicating high pressure process fluid to the fluid to fluid pressurizer,

rotating the first rotary valve plate and the second rotary valve plate within the first stationary rotor housing and the second stationary rotor housing synchronously so that low pressure feed fluid is pressurized by the high pressure process fluid within the plurality of flow channels to form high pressure feed fluid; and

controlling a speed of rotating in response to a sensed condition in the high pressure feed fluid or a high pressure process fluid.

39. The method of claim 38 wherein controlling the speed of rotating comprises controlling the speed of rotating in response to a salinity of the high pressure feed fluid.

40. The method of claim 38 wherein controlling the speed of rotating comprises controlling the speed of rotating in response to a flow rate of the high pressure process fluid.

41. The method of claim 38 wherein rotating the first rotary valve plate and the second rotary valve plate within the first stationary rotor housing and the second stationary rotor housing synchronously comprising rotating the first rotary valve plate and the second rotary valve plate within the first stationary rotor housing and the second stationary rotor housing synchronously based on a signal from a first encoder and a second encoder.