from the membrane housing 54 is communicated to the turbine portion 74T of the turbocharger 74. The turbine 74T rotates the pump portion 74P to increase the pressure within the input line 78 to the membrane housing 54. The depressurized brine fluid returns to the tank 40 through the inlet port 66 and the valve 64. The high pressure pump 52 can operate at a lower pressure because of the boost provided by the turbocharger 74. By reducing the pump power, the added heat into the fluid is reduced. This also eliminates cooling equipment to maintain the fluid temperature to a desired batch temperature.

[0013] Referring now to Figure 5, a similar example to that illustrated in Figure 3 is set forth. In this example, another high pressure pump 80 is coupled between the fill reservoir 32 and the input port 38 to the tank 40. This configuration may be referred to as a "semi-batch" reverse osmosis system 30". In this example, the charge pump 34 transfers feed fluid from the reservoir 32 to entirely fill the tank 40. The valve 36 is closed. The high pressure pump 80 is used to pump feed into the fluid tank 40 from the reservoir 32. The pump 52 is engaged so that as feed is injected into the tank 40 through the feed pipe 51 and the feed fluid input pipe 53, the pressure quickly rises due to the incompressibility of the fluid. The pressure reaches the point where the permeate exits the membrane housing 54 through the permeate outlet pipe 58 into the tank 60. The permeate flow equals the rate of flow from the high pressure pump 80. As permeate is extracted, the pressure in tank 40 increase to overcome the increasing osmotic pressure in order to maintain the permeate flow into the permeate tank 60. The pump 52 circulates fluid from the tank 40 through the membrane housing 54 and back to the tank 40. Concentration sensor 72 senses the concentration of the fluid within the tank 40 and when a concentration has reached a concentration limit, the high pressure pump 80 is shut down and valve 42 is opened to allow the fluid within the tank 40 to drain into the brine tank 46. The next batch begins by opening the valve 36 and increasing the amount of fluid within the tank 40 until it is full wherein the valve 36 is closed and the high pressure pump 80 is activated to feed fluid into the tank 40 during the permeate production as described above.

SUMMARY

[0014] The present disclosure provides a method and system for batch processing feed fluid in a system that can continuously operate in an efficient manner.

In one aspect of the disclosure, a reverse osmosis system includes a membrane housing comprising a reverse osmosis membrane therein. The membrane housing has a feed fluid input, a brine outlet and a permeate outlet. The system further includes a charge pump, a plurality of valves and a tank having a first volume separated from a second volume by a

movable partition. The plurality of valves are configured, in a first mode, to selectively couple the charge pump to the first volume while the brine outlet and the feed input are connected to the second volume, and in a second mode, to selectively couple the charge pump to the second volume while the brine outlet and the feed input are connected to the first volume. The first mode and the second mode are configured for alternating operation.

In another aspect of the disclosure, a method includes filling a tank having a first volume separated from a second volume by a movable partition separating a first end from a second end, producing permeate with fluid in the second volume at a membrane housing comprising a feed fluid input, a brine outlet and a permeate outlet, and controlling a plurality of valves so that in a first mode, a charge pump is selectively coupled to the first volume while the brine outlet and the feed input are connected to the second volume, and in a second mode, to selectively couple the charge pump to the second volume while the brine outlet and the feed input are connected to the first volume. The first mode and second mode are configured for alternating operation.

[0015] Further areas of applicability will become apparent from the description provided herein. It should be understood that the description and specific examples are intended for purposes of illustration only and are not intended to limit the scope of the present disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The drawings described herein are for illustration purposes only and are not intended to limit the scope of the present disclosure in any way.

[0017] Figure 1 is a cutaway view of a membrane and fluid flow therethrough according to the prior art.

[0018] Figure 2 is a chart of feed pressure, osmotic pressure, feed total dissolved solids (TDS), permeate rate and net driving pressure (NDP) according to the prior art.

[0019] Figure 3 is a schematic view of a reverse osmosis system according to the batch-operated reverse osmosis system according to the prior art.

[0020] Figure 4 is a second schematic view of a batch operated system according to the prior art.

[0021] Figure 5 is a schematic of a third batch-operated system according to the prior art.

[0022] Figure 6 is a schematic of a batch-operated system according to the disclosure.

[0023] Figure 7 is a state chart for the operating states of the valves of Figure 6 during operation.

[0024] Figure 8A is an alternative valve configuration for a reverse osmosis system.

CLAIMS

1. A reverse osmosis system comprising:

a membrane housing comprising a reverse osmosis membrane therein, said membrane housing comprising a feed fluid input, a brine outlet and a permeate outlet;

a charge pump;

a plurality of valves; and

a tank having a first volume separated from a second volume by a movable partition;

wherein said plurality of valves are configured, in a first mode, to selectively couple the charge pump to the first volume while the brine outlet and the feed input are connected to the second volume, and in a second mode, to selectively couple the charge pump to the second volume while the brine outlet and the feed input are connected to the first volume, and

wherein the first mode and the second mode are configured for alternating operation.

2. The reverse osmosis system of claim 1 wherein the plurality of valves are disposed in a spool valve, said spool valve comprises a rod and a plurality of disks coupled to a linear actuator, said linear actuator positioning the disks in a first position and thereafter, a second position.

3. The reverse osmosis system of claim 2 wherein the spool valve comprises a low pressure end, a high pressure end and a seal between the low pressure end and the high pressure end.

4. The reverse osmosis system of claim 1 further comprising a controller and a concentration sensor generating a concentration signal corresponding to a salt concentration coupled to a drain line, said controller flushing pipes with feed fluid until the salt concentration in the drain line is below a threshold.

5. The reverse osmosis system of claim 1 wherein the movable partition comprises a passage therethrough and a swinging plate selectively coupling the first volume to the second volume.

6. The reverse osmosis system of claim 5 wherein the swinging plate is spring activated.

7. The reverse osmosis system of claim 5 wherein the passage is aligned with a first port and a second port of the tank.

8. The reverse osmosis system of claim 7 wherein the passage is aligned with a second port and a third port of the tank.

9. The reverse osmosis system of claim 1 wherein the movable partition has a first side having a first shape corresponding to a first tank end shape and the partition comprises a second side having a second shape corresponding to a second tank end shape.

10. A method comprising:

filling a tank having a first volume separated from a second volume by a movable partition separating a first end from a second end;

producing permeate with fluid in the second volume at a membrane housing comprising a feed fluid input, a brine outlet and a permeate outlet; and

controlling a plurality of valves so that in a first mode, a charge pump is selectively coupled to the first volume while the brine outlet and the feed input are connected to the second volume, and in a second mode, to selectively couple the charge pump to the second volume while the brine outlet and the feed input are connected to the first volume,

wherein the first mode and second mode are configured for alternating operation.

11. The method of claim 10 wherein filling the tank comprises filling the first volume with feed fluid in response to producing permeate to cause a partition to move toward the second end until a concentration of fluid in the second volume exceeds a threshold.

12. The method of claim 11 further comprising, when the concentration of fluid in the second volume exceeds the threshold, producing permeate with the first volume, recirculating brine to the second volume.

13. The method of claim 12 further comprising moving the movable partition toward the first end in response to producing permeate with the first volume.

14. The method of claim 10 further comprising, when the partition is at the second end, opening a swinging plate in a passage through the movable partition so that piping associated

with the second end receives fluid from the first volume.

15. The method of claim 14 further comprising maintaining the opening of the swinging plate until a drain concentration of fluid in a drain line is below a drain concentration threshold.

16. The method of claim 15 further comprising filling the first volume with feed fluid after the drain concentration of fluid in the drain line is below the drain concentration threshold and further comprising closing the swinging plate in response to filling.

17. The method of claim 10 further comprising producing permeate in batches from the first volume and the second volume.

18. The method of claim 10 further comprising controlling a plurality of valves in response to a first volume concentration and a second volume concentration.

19. The method of claim 10 further comprising a spool valve in response to a first volume concentration and a second volume concentration.

20. The method of claim 10 further comprising maintaining a constant permeate production rate until the concentration of fluid in the second volume reaches the threshold.

21. The method of claim 10 further comprising maintaining net driving pressure until the concentration of fluid in the second volume reaches the threshold.