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STUDY OF DESALINATION SYSTEM USING REVERSE OSMOSIS TECHNIQUE

Usama A. Abdel Ghany[1] , Ramadan Y. Sakr[2] and Mohamed M. Khaled[3]

[1] Civil Engineering Department, Faculty of Engineering, Al-Azhar University
[2] Mechanical Engineering Dept., Faculty of Engineering at Shoubra, Benha University
[3] Mechanical Engineering Deptartment, Water Treatment Consulting Office (WTCO)

الملخص

توجد فجوة كبيرة فى مصر الآن بين المتاح من المياه و الاحتياج الفعلى للمياه فى الأغراض المختلفة و لذا لا بد من التفكير فى مصادر بديلة لتعويض هذه الفجوة. تحلية مياه البحر تعتبر أحد أهم المصادر البديلة لمياه الشرب فى مصر. طريقة التناضح العكسى من أهم الطرق المطبقة حاليا" و لكن ما زالت تطبق فى نطاق محدود و هى لا تفى بتغطية هذه الفجوة المائية. و فى هذا البحث يتم دراسة استخدام التناضح العكسى فى عملية تحلية المياه المالحة (المصدر هنا بئر جوفى) و قد تم اجراء عملية التناضح على مرحلتين لرفع كفاءة المياه الناتجة من عملية التحلية كما أن المحطة المدروسة تتكون من مساران بكل مسار من هذه المسارات بطاريتين للتناضح العكسى (تتم التحلية على مرحلتين) حيث تتألف البطارية الأولى من عدد خمسون غشاء للتناضح العكسى بينما البطارية الثانية تحتوى على 25 غشاء فقط . و قد تم دراسة عدة عوامل مؤثرة على كفاءة عملية التحلية من أهمها درجة الحرارة و مقدارها 20-25-30 درجة مئوية و كذلك تغيير مقدار ملوحة المياه المراد تحليتها و كانت قيم الملوحة 3000-6000-8000-10000 جزء فى المليون و كذلك استخدام نظام ال (تربو تشارجر) كأحد الوسائل الهامة لاسترداد الطاقة المستهلكة. و قد تم اجراء الحسابات باستخدام برنامج الاكسل و قد دلت النتائج على أنه بزيادة درجة الحرارة تزداد كفاءة عملية التحلية و كذلك باستخدام ال (تربو تشارجر) فان الكفاءة تزيد و كذلك يتم توفير جزء من الطاقة المستنفذة. بالاضافة الى أن الكفاءة تزيد عندما تكون درجة الملوحة مقبولة و تقل عند درجات الملوحة العالية.

ABSTRACT

There is a large gap between the available water resources in Egypt and the total water demand assessed by 30 billion cubic meter. Reverse Osmosis (RO) has been a major source of additional potable water in many parts of the world. Reverse Osmosis is a membrane-based demineralization technique used to separate dissolved solids, such as ions, from solution (most applications involve water-based solutions, which is the focus of this work). Energy recovery systems such as the turbocharger has been studied to convert the energy present in the brine of RO systems back to the high pressure pumps used in treating the water. Two stage membrane modules were checked in this study. Three different variables were studied, the first one was the ambient temperature the second was the salinity consequently the osmotic pressure and the third was using turbocharger. The applied temperatures were varied from 20ºC to 25ºC and 30ºC. Different values of salinity were investigated the values are, 6004.4 ppm, 3000 ppm, 8000 ppm and 10000 ppm respectively.

KEYWORDS: Water desalination**;** Reverse Osmosis; Salinity; Temperature; Exergy analysis.

1. INTRODUCTION

Water is a plentiful natural resource as approximately three quarters of the planet is covered by it. However, 97.50% of this resource is comprised by saline water and 2.5% by potable water. So, the demand for potable water for domestic, industrial and agricultural use is increasing due to population growth and social development. So, improvement on existing water processes as well as new water processes are needed to make potable water sources more efficient and economical. Desalination has been a major source of additional potable water in many parts of the world. A worldwide survey showed that during the period 1997-2015 the number of desalination plants in the world has increased from 12451 to 18426 and the quantity of potable water produce has changed from 22.7 Mm^3/d to 86.8Mm^3/d. Reverse osmosis plants are now being used for a variety of applications including semiconductors, food processing, power generation, pharmaceuticals, desalination, biotechnology, co-produced water from oil and gas production, textile, pulp and paper, mine and diary wastewater, process and boiler water.

The most common application of RO is to replace ion exchange, including sodium softening, to purify water for use as boiler makeup to low- to medium-pressure boilers, as the product quality from an RO can directly meet the boiler make-up requirements for these pressures. For higher-pressure boilers and steam generators. In a one stage RO system, the feed water enters the RO system as one stream and exits the RO as either concentrate or permeated water. In a two stage system the concentrate (or reject) from the first stage then becomes the feed water to the second stage. The permeate water is collected from the first stage is combined with permeate water from the second stage. Additional stages increase the recovery from the system.

A. Al-Zahrani, et al [1] stated that, the specific energy consumption behavior depends on the feed salinity. It increases with the applied pressure almost linearly when the feed salinity is low. Three novel multi-generation energy systems are considered, analyzed and optimized by Pouria Ahmadi [2]. It was observed that, the exergy efficiency of RO integrated system is 37%, which is higher than single generation systems and, in addition, this integrated system has no emissions as it uses ocean energy instead of fuel. Jon Johnson, et al [3] stated that, the development of thin film composite membranes and spiral wound element configurations helped achieving larger rejection and higher productivity which resulted in better water quality significantly lower energy consumption, and improved system operation (lower fouling, higher recovery). Jane Kucera [4] stated that, Spiral wound membrane modules are the most common type of module used for RO today The major advantage of a spiral wound module is that the packing density is fairly high, about 150 - 380 ft^2/ft^3, higher then for plate and frame or tubular modules. M Abou Rayan, et al [5] calculated the final cost for RO plant of total capacity =2000 m^3/day in Dahab = 6.57 L.E/m^3. It was concluded that, The RO system is sensible to change in feed water temperature and the product quality is sensitive to the working pressure. Aihua Zhu, et al [6] found that, the specific energy consumption can be substantially reduced, providing the same permeate flow. Even though in some cases there is only marginal energy savings, it is still worthwhile to adopt the proposed operating strategy.

A brackish water desalination plant that incorporates reverse osmosis (RO), nanofiltration (NF)., and electro-dialysis (EDR) units was analyzed by Nafiz Kahraman, et al [7] thermodynamically using actual plant operation data The analysis shows that, the fraction of exergy destruction in the pump–motor units is 39.7% for the RO unit, 23.6% for the NF unit and 54.1% for the EDR unit. A new simple model for seawater latent heat of vaporization was developed by Mostafa H. Sharqawy, et al [8] from first principles, which is presented as a function of salinity and pure water latent heat. It was discovered that, temperature and salinity are the independent properties of Existing correlations for the thermophysical properties of seawater, most of the properties examined are given in the temperature range of (0 to 120 ºC) and salinity range of (0 to 120 g/kg); however, the surface tension data and correlations are limited to oceanographic range (0 - 40 ºC and 0 - 40 g/kg salinity). ˙Ibrahim Dinc¸er, et al [9] stated that, for thermal energy storage systems, exergy analysis allows one to determine the maximum potential associated with the incoming thermal energy. This maximum is retained and recovered only if the thermal energy undergoes processes in a reversible manner.

The thermal energy storage (TES) in the Friedrichshafen DE system has been analyzed by Behnaz Rezaie, et al [10]. It was found that, the overall energy and exergy efficiencies of the stratified TES in the DE system are 60% and 19%, respectively, When accounting for thermal stratification. Edo Bar-Zeev [11] studied the usage of Rapid sand filtration (RSF) as an effective pretreatment procedure prior to reverse osmosis (RO) membranes in desalination plants. It was stated that, RSF in newly operated desalination facilities required a maturation period of about three months before the feed water may be filtered efficiently. To date the desalination industry RSF has regarded RSF mainly as a physical barrier effectively retaining particles larger than 0.35 mm. Vincenete, et al [12] stated that, 80% of the exergy destruction is placed on core processes, 29% extra exergy is necessary to obtain the unit of feed exergy from previous stages and extra exergy of 1.06 kJ is needed to generate 1.0 kJ of final product exergy. P.S.Kelkar, et al [13] concluded that, water from reverse osmosis plants is costly 2.20 U.S dollars per cubic meter and not affordable by local population and state governments. It has to be fully supported by the central government. It was found that by Mostafa H. Sharkawy, et al [14] the reverse osmosis desalination plant considered has a very law second law efficiency less than 2% even when using the available energy recovery systems. It was concluded that, the second law efficiency is increased to 20% and input power is reduced by 38%.

It was reported that by Jung-Hoon Song, et al [15] the production of high purity water was carried out using the RO-CEDI hybrid process. The CEDI system showed good performance in producing high purity water showing a respictivety greater than 15MΩ.cm. Y.Cerci [16] stated that, The largest exergy destruction occurred in the membrane modules, and this amounted to 74.07% of the total exergy input. The smallest exergy destruction occurred in the mixing chamber. The mixing accounted for 0.67% of the total exergy input and presents a relatively small fraction. The second law of efficiency of the plant was calculated to be 4.3%, which seems to be low. Baltasar Penate et al, [17] concluded that, obtaining the required alternative energy for sea water desalination processes is necessary instead of using fossil fuel. The availability of efficient and reliable designs of RO plants driven by renewable energies for medium to large capacity desalination is essential for the sustainable development.

2. EXPERIMENTAL SETUP

Reverse osmosis is a membrane –based demineralization technique used to separate dissolved solids, such as ions, from solution (most applications involve water – based solutions, which is the focus of this work). Three different variables were studied, the first one was the ambient temperature the second was the salinity consequently the osmotic pressure and the third was using turbocharger for energy recovery. The applied temperatures were varied from 20 ºC to 25 ºC and 30 ºC. Different values of salinity were investigated the values are, 6004.4 ppm, 3000 ppm, 8000 ppm and 10000 ppm respectively.

2.1Plant Description

This is a case study for Cement Plant stage 3&4 with Annual Capacity of 2 X 1.6 million tons in Egypt. Water supply demineralization treatment system In Al-Ariesh – Sinai. The product water quality of the water supply treatment system is designed according to "Sanitary standard for domestic drinking water"; the product water data is not actually the product water from RO system. Two stages of RO membrane were checked in this study. The whole system consists of raw water purifying system, pretreatment system, primary RO demineralization system, secondary RO demineralization system and demineralized water supply system etc. The feed water was withdrawn from a ground water well (Deep well).

Fifteen points were distributed along the whole route of desalination process as depicted clearly in fig .1 and fig .2.

2.2 Processes Description

2.2.1 Pre-treatment Process

The source of raw water is underground water at a salinity of about 6000 ppm is withdrawn by two low pressure pumps from the water tank of 150 m^3 with a total flow rate of 210 m^3/h. The saline water exits the pumps with an absolute pressure of 600 KPa, then the water passes through six multimedia filters followed by six iron removal filters, and finally two cartridge filter and chemical dosing system. The pressure drop through these filters is about 300 KPa.

2.2.2 Reverse Osmosis Process

The plant consists of two racks; each rack is served by a high pressure pump. In each rack, there are two stage membrane modules. The first stage module contains 50 membranes and the second module contains 25 membranes. The membrane modules require that, the process water be pressurized to overcome the osmotic pressure and the fluid friction that occurs across the membranes. The process water enters into the high pressure pumps in which its pressure is raised to 1710 KPa. Next, the process water is then routed into the membrane modules where it is separated into the permeate with a flow rate of 46.9 m^3/h and brine flow rate of 53.1m^3/h in first stage and permeate with a flow rate of 28.1 m^3/h and brine flow rate of 25 m^3/h in second stage. There is an energy recovery turbocharger between the two stages membrane modules.

2.2.3 Post Treatment Process

The permeated water of the first stage is mixed with that of the second stage and by using dosing system the water properties are adjusted to desired values.

2.3 Components of the Plant

The detailed components of the concerned plant were illustrated clearly in fig. 1. and fig.2.

The concerned components are as follows:

1- Feed pump.
2 - Pre-treatment chemicals.
3- Multi-media filter.
4 - Iron removal filter.
5- Post treatment chemical.
6- Cartridge filter.
7- Reverse osmosis units.
8- Chemical cleaning system.
9- Back wash system.
10- Control room.

Table.1. Plant Data

- Average power input= 154.7 KW	- Raw water TDS = 6004.4 PPM
- Raw water flow rate = 210 m^3/h	- Brine TDS = 23569.2 PPM
- Brine flow rate = 50 m^3/h	- Permeate TDS = 149.5 PPM
- Permeate flow rate = 150 m^3/h	- Pressure drop across MMF = 1 bar
- First-stage pressure = 17.10 bar	- Pressure drop across IRF = 1 bar
- Second-stage pressure = 21.40 bar	- Pressure drop across CF = 1 bar

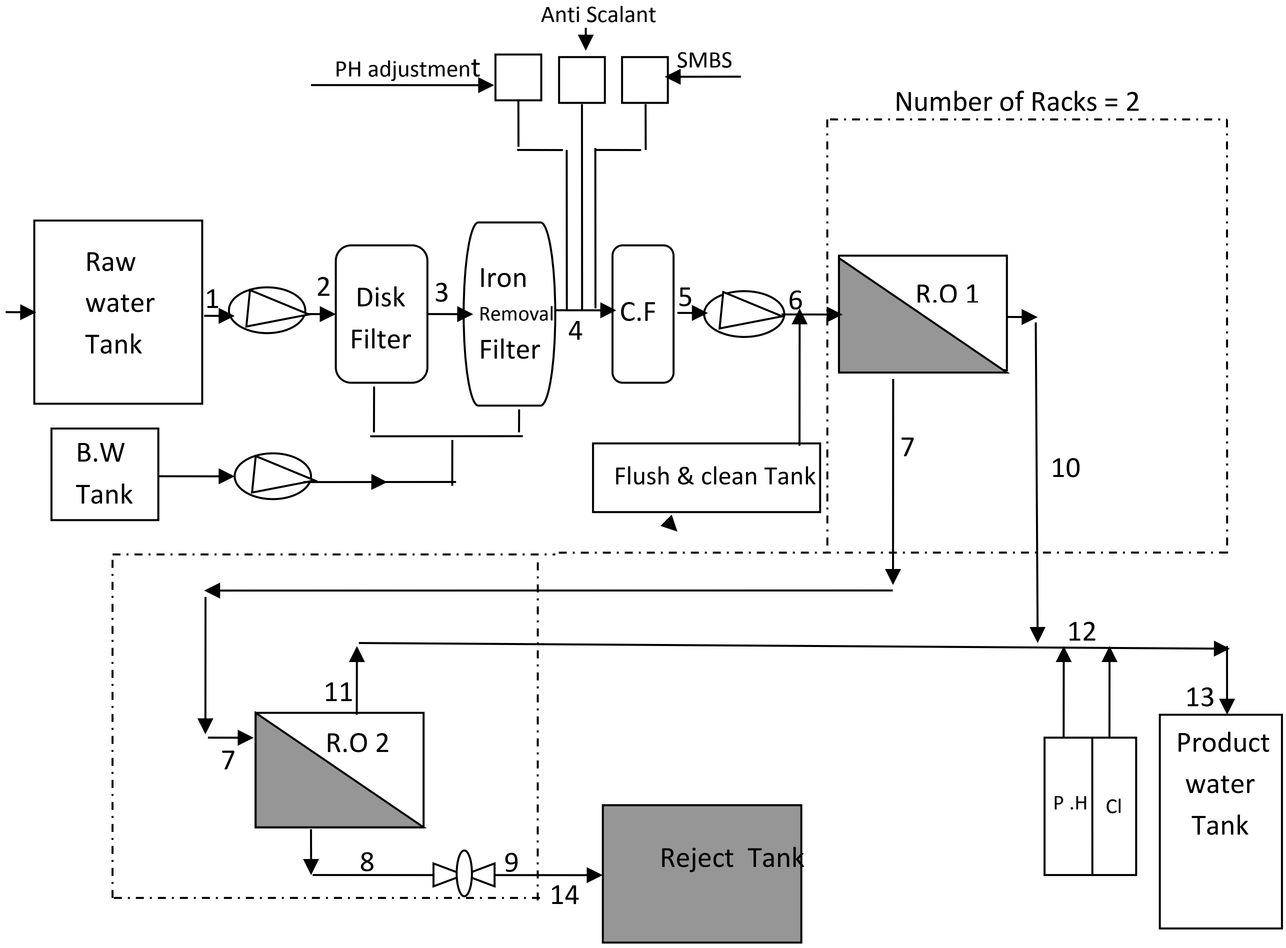

Fig. 1. Process flow diagram for double stage R.O system

2.4 Osmotic Pressure Calculations

- The required number of membranes in the first stage = 50 membrane.
 But, in the second stage = 25 membrane.
- Salt rejection (SR) = 1- X_p/X_f=1-149.5/600.4
So, SR = 0.9751 = 97.51 %.
 - The recovery ratio (R) for one module = Q_p / Q_f = 75/100 = 0.75
- So, R = 0.75 = 75%.
- π_f = 45.54 KPa , - π_b = 850.91 KPa and - π_p = 7.55 KPa
- $\pi_{average} = 0.5 * (\pi_f + \pi_b) = 0.5* (45.54 +850.91)$
So, $\pi_{average}$ = 448.23 KPa
Therefore, the net osmotic pressure across the membrane (**$\Delta\pi$**)
- $\Delta\pi = \pi_{average} - \pi_p = 448.23 - 7.55$
So, $\Delta\pi$ = 440.68 KPa.

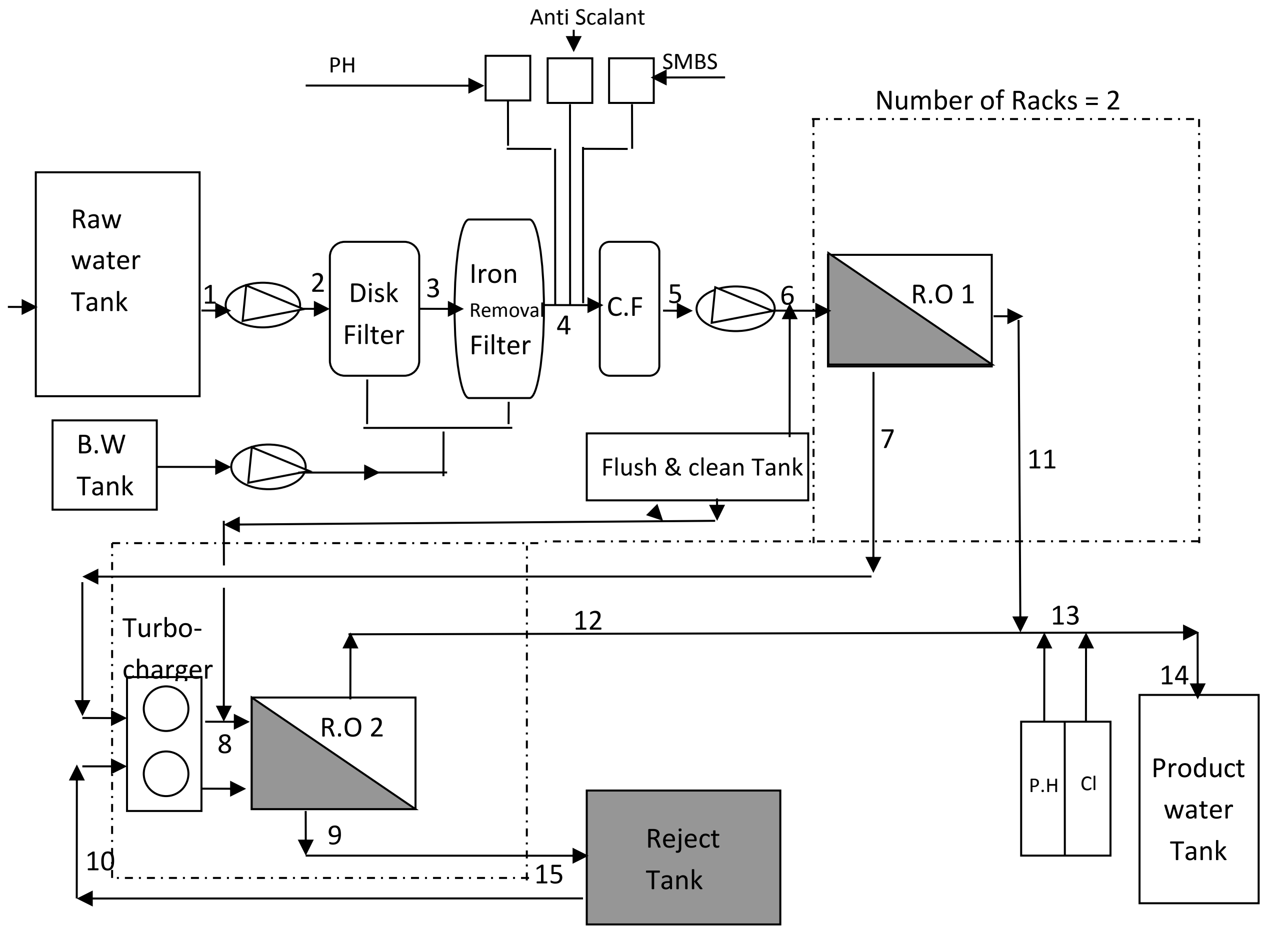

Fig.2. Process flow diagram for double stage R.O with turbocharger

3. RESULTS

The results of analysis are obtained using the EES software and M.S.Excel spread sheet.

This desalination plant is analyzed under the following assumptions:

1. The rates of discharged brine and outgoing product water are taken from plant data. The discharge and salinity of incoming raw water are determined by the mass balance.
2. In all calculations, the raw water temperature = 30°C as the ambient temperature.
3. All components of the system operate steadily.
4. The salinity of the incoming raw water is constant.
5. The kinetic and potential energies of fluid streams are negligible.
6. The saline water is an ideal solution.
7. Salt, water, and saline water are incompressible substances.
8. The electric power supplied is consumed by the pumps.

The obtained results are presented in the following tables as follows:

3.1 Effect of Using Turbocharger on R.O Efficiency

Table.2. The calculated values of different R.O parameters (without turbocharger)

point	Discharge m^3/h	Abs Pressure (bar)	TDS (ppm)	Osmotic pressure (Kpa)
1	210	1	6004.4	455.38
2	210	6	6004.4	455.38
3	210	5	6004.4	455.38
4	210	4	6004.4	455.38
5	200	3	6004.4	455.37
6	100	17.1	6004.4	455.37
7	53.1	16.5	11219.8	850.91
8	30.62	15.1	23569.2	850.91
9	30.62	1	23569.2	1787.49
10	46.90	1	99.6	1787.49
11	22.48	1	232.8	7.55
12	69.38	1	149.5	17.66
13	138.76	1	149.5	11.34
14	61.24	1	23569.2	11.34

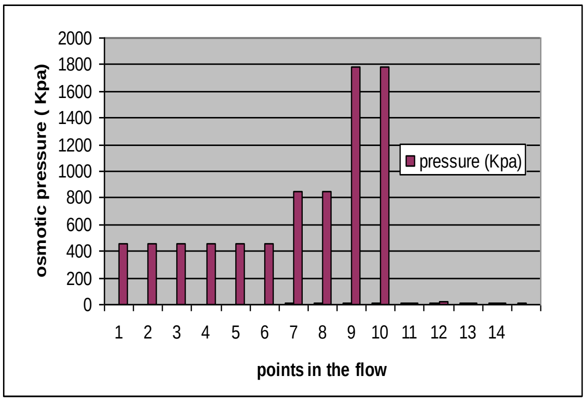

Fig.3.The different osmotic pressure values

Table.3. The calculated values of different R.O parameters with Turbocharger

point	Discharge m^3/h	Abs Pressure (bar)	TDS (ppm)	Osmotic pressure (Kpa)
1	210	1	6004.4	455.37
2	210	6	6004.4	455.37
3	210	5	6004.4	455.37
4	210	4	6004.4	455.37
5	200	3	6004.4	455.37
6	100	17.1	6001.4	455.37
7	53.1	16.5	11219.8	850.91
8	53.1	21.4	11219.8	850.91
9	25	20	23569.2	1787.49
10	25	1	23569.2	1787.49
11	46.9	1	99.6	7.55
12	28.1	1	232.8	17.66
13	75	1	149.5	11.34
14	150	1	149.5	11.34
15	50	1	23569.2	1787.49

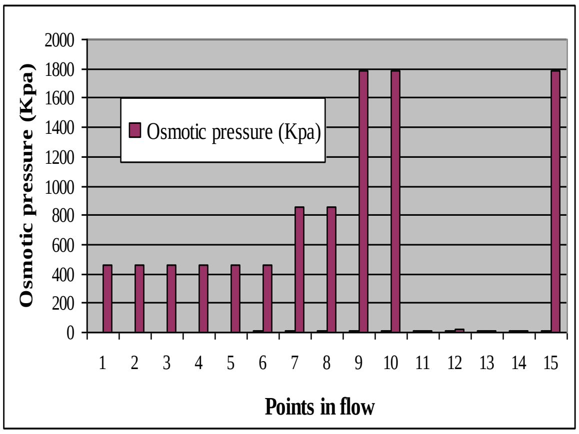

Fig.4.The different osmotic pressure values

It was noticed that, the efficiency of RO process was improved by using turbocharger.

3.2 Effect of Salinity Change on R.O Efficiencies

Different values of salinities were investigated at temperature = 30°C and by using turbocharger between the two modules. The calculated results were as follows:
Raw water TDS =3000 ppm and Brine TDS = 11775.96 ppm and Permeate TDS= 74.96 ppm

Table 4. Raw water TDS = 3000 ppm and Temperature = 30°C –With Turbo charger

Location	Pressure (p) bar	Salinity (ppm)	Mass flow rate Kg/sec	Specific exergy	Exergy flow rate KW
1	1.00	3000	58.33	0.00	0.00
2	6.00	3000	58.33	0.41	23.68
3	5.00	3000	58.33	0.31	18.02
4	4.00	3000	58.33	0.20	11.84
5	3.00	3000	55.55	0.10	5.72
6	17.10	3000	55.55	1.42	78.61
7	16.50	5605.79	29.50	0.94	27.82
8	21.40	5605.79	29.50	1.32	38.93
9	20.00	11775.96	13.88	0.31	4.37
10	1.00	11775.96	13.88	-1.40	-19.49
11	1.00	49.764	26.05	0.48	12.61
12	1.00	116.31	15.61	0.47	7.38
13	1.00	74.69	41.66	0.48	19.99
14	1.00	74.69	41.66	0.48	19.99
15	1.00	11775.96	13.88	-1.40	-19.49

Raw water TDS =6004.4 ppm and Brine TDS = 23569.2 ppm and Permeate TDS= 149.5 ppm

Table 5. Raw water TDS = 6000 ppm and Temperature = 30°C –With Turbocharger

Location	Pressure (p) bar	Salinity (ppm)	Mass flow rate Kg/sec	Specific exergy	Exergy flow rate KW
1	1.00	6004.4	58.33	0.00	0.00
2	6.00	6004.4	58.33	0.406	23.68
3	5.00	6004.4	58.33	0.309	18.02
4	4.00	6004.4	58.33	0.203	11.84
5	3.00	6004.4	55.55	0.103	5.72
6	17.10	6001.4	55.55	1.415	78.61
7	16.50	11219.8	29.50	0.535	15.79
8	21.40	11219.8	29.50	0.912	26.91
9	20.00	23569.2	13.88	-1.014	-14.09
10	1.00	23569.2	13.88	-2.732	-37.95
11	1.00	99.6	26.05	0.961	25.06
12	1.00	232.8	15.61	0.939	14.67
13	1.00	149.5	41.66	0.953	39.74
14	1.00	149.5	41.66	0.953	39.74
15	1.00	23569.2	13.88	-2.732	-37.95

Raw water TDS = 8000 ppm and Brine TDS = 31402.57 ppm and Permeate TDS= 199.19 ppm

Table 6. Raw water TDS = 8000 ppm and Temperature = 30°C –With Turbocharger

Location	Pressure (p) bar	Salinity (ppm)	Mass flow rate Kg/sec	Specific exergy	Exergy flow rate KW
1	1.00	8000.0	58.33	0.00	0.00
2	6.00	8000.0	58.33	0.41	23.68
3	5.00	8000.0	58.33	0.31	18.02
4	4.00	8000.0	58.33	0.20	11.84
5	3.00	8000.0	55.55	0.10	5.72
6	17.10	8000.0	55.55	1.42	78.61
7	16.50	14948.77	29.50	0.27	8.02
8	21.40	14948.77	29.50	0.65	19.13
9	20.00	31402.57	13.88	-1.87	-25.91
10	1.00	31402.57	13.88	-3.58	-49.77
11	1.00	132.70	26.05	1.28	33.25
12	1.00	310.17	15.61	1.25	19.46
13	1.00	199.19	41.66	1.26	52.71
14	1.00	199.19	41.66	1.26	52.71
15	1.00	31402.57	13.88	-3.58	-49.77

Raw water TDS = 10000 ppm and Brine TDS = 39253.21 ppm and Permeate TDS= 248.99 ppm

Table 7. Raw water TDS = 10000 ppm and Temperature = 30°C –With Turbocharger

Location	Pressure (p) bar	Salinity Ppm	Mass flow rate Kg/sec	Specific exergy	Exergy flow rate KW
1	1.00	10000.0	58.33	0.00	0.00
2	6.00	10000.0	58.33	0.41	23.68
3	5.00	10000.0	58.33	0.31	18.02
4	4.00	10000.0	58.33	0.20	11.84
5	3.00	10000.0	55.55	0.10	5.72
6	17.10	10000.0	55.55	1.42	78.61
7	16.50	18685.96	29.50	0.01	0.38
8	21.40	18685.96	29.50	0.39	11.49
9	20.00	39253.21	13.88	-2.70	-37.49
10	1.00	39253.21	13.88	-4.42	-61.35
11	1.00	165.88	26.05	1.59	41.38
12	1.00	387.72	15.61	1.55	24.22
13	1.00	248.98	41.66	1.57	65.60
14	1.00	248.98	41.66	1.57	65.60
15	1.00	39253.21	13.88	-4.42	-61.35

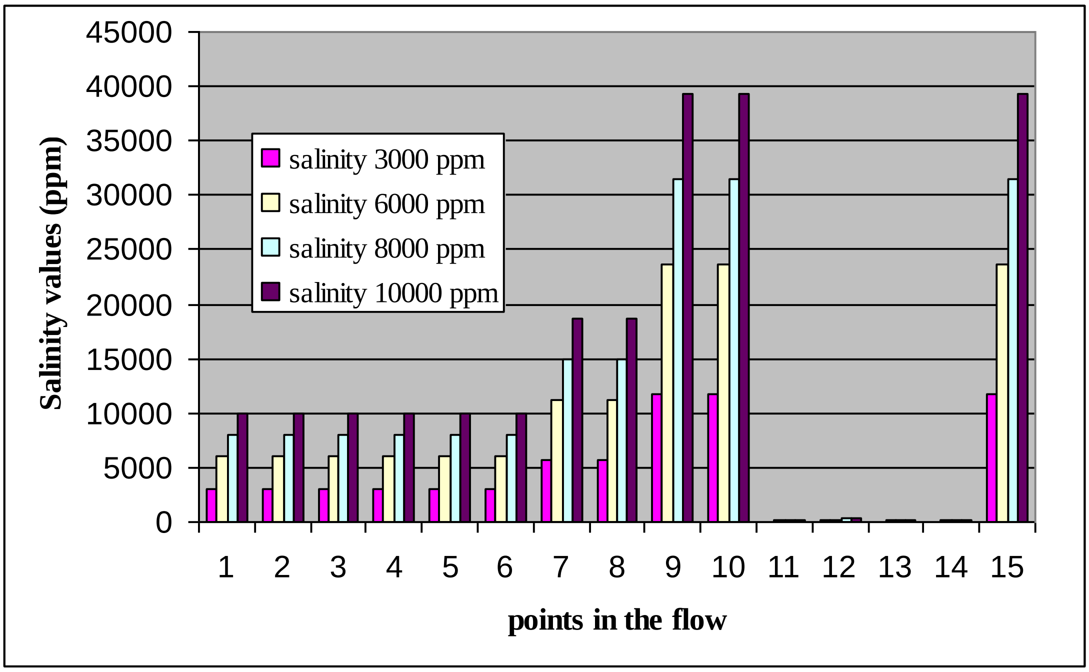

Fig. 5. The different values of water salinities

Table 8. Effect of Changing Salinities on Different Efficiencies

TDS (ppm)	3000	6004.4	8000	10000
Pump Eff %	62.43	62.43	62.43	62.43
X des pumps%	37.70	38.01	38.30	38.63
X des RO1 %	24.76	24.69	24.61	24.49
X des RO2 %	17.62	17.21	16.86	16.46
X des MMF%	3.67	3.70	3.73	3.76
X des IRF %	4.01	4.04	4.07	4.11
X des CF %	3.97	4.00	4.03	4.07
X turbo %	8.27	8.34	8.40	8.47
Total %	100.00	100.00	100.00	100.00

3.3 Effect of Changing Temperatures

Table 9. Effect of changing of Temperature with Turbocharger on Efficiencies

Temperature	30°C	25°C	20°C
Pump Eff %	62.43	62.32	62.21
X des pumps%	37.70	38.06	38.10
X des RO1 %	24.76	24.66	24.64
X des RO2 %	17.62	17.55	17.89
X des MMF%	3.67	3.71	3.73
X des IRF %	4.01	4.00	3.95
X des CF %	3.97	3.99	3.99
X turbo %	8.27	8.02	7.71
Total %	100.00	100.00	100.00

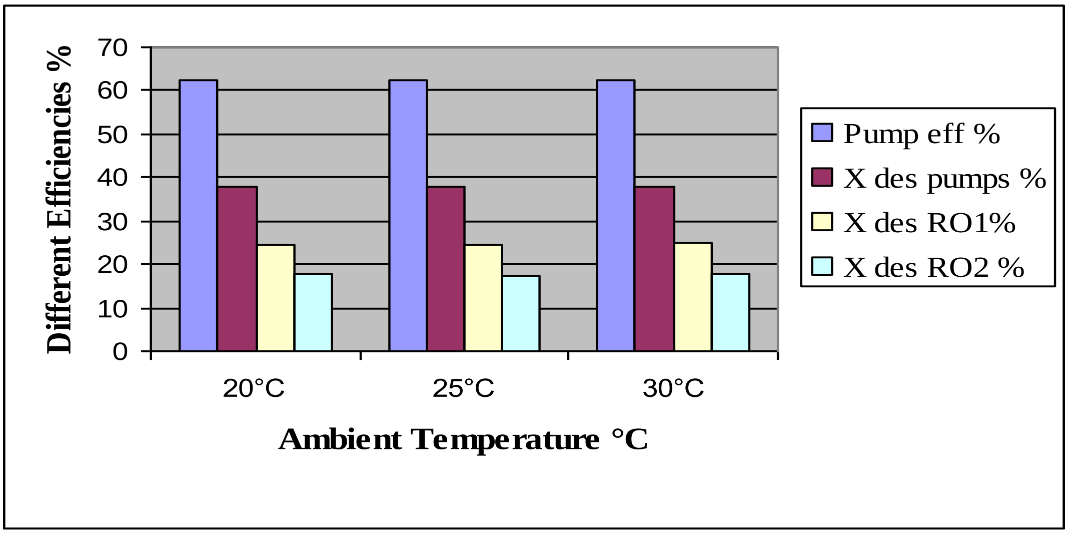

Fig. 6. The different values of the different efficiencies

Table 10. Effect of Changing Temperatures on input and output efficiencies

Temperature	30°C	25°C	20°C
X in	154.7	154.70	154.70
W min	1.79	1.52	1.24
X mechanical	0.00	0.00	0.00
X total	152.91	153.18	153.46
Delta X pump	96.57	96.40	96.23
X des pumps	58.13	58.30	58.47
X des RO1	37.76	37.78	37.81
X des RO2	26.32	26.89	27.46
X des MMF	5.66	5.69	5.72
X des IRF	6.18	6.12	6.07
X des CF	6.12	6.12	6.12
X Turbo	12.75	12.29	11.83

4. ECONOMICS

Energy cost is the major component of the operating cost of a desalination plant. Methods need to be developed for economically combining desalination with renewable energy systems. The RO plant energy consumption is approximately 6–8 kW h/m^3 without energy recovery. Installing an energy recovery device reduces the energy consumption to 4–5 kW h/m^3. The total annual amount of distilled water in the whole worldwide represent 0.60% from the total water demand, the total quantity is about = 24 billion cubic meter coming by applying this technique and the used amount of this part not exceed than 1% in the agricultural sector. The total cost of the one cubic meter of distilled water is evaluated by 0.40 U.S. dollar that means the total cost of the one cubic meter is about 8.00 Egyptian as stated by Nader Nour El-din .[18]. On the other hand, the water production cost of the world largest seawater RO desalination plant is 0.53 U.S dollar /m^3as reported by Akili, et al [19].

5. CONCLUSION

1- Water desalination using reverse osmosis RO technique is considered one of the most promising alternatives to get potable water.

2- Energy recovery systems such as the turbocharger has been studied to convert the energy present in the brine of RO systems back to the high pressure pumps used in treating the water. Installing an energy recovery system can reduce energy consumption from 6–8 kWh/m^3 to 4–5 kWh/m^3. The exergy efficiency was improved by using turbocharger.

3- The exergy efficiency was improved by increasing the ambient temperature.

4-The exergy efficiency was decreased when the salinities were increased consequently, the osmotic pressures also were increased.

5- The proposed suitable system for this study is, using turbocharger and the ambient temperature = 30 °C and the salinity = 6000 ppm.

6. FURTHER WORK

- Research on RO systems has been intensive and several innovations are being introduced. These include the use of a solar photovoltaic system to power RO desalination and new

membranes with new material types, such as the poly-etherurea and polyamide–urea barrier, which have been reported to decrease microbial adhesion and thus, fouling potential.

- Increasing the number of RO units in series and increasing the size of individual RO units were also found to be promising strategies.

- Energy recovery systems such as the Pelton wheel, turbocharger and pressure exchanger may developed to convert the energy present in the brine of RO systems back to the high pressure pumps used in treating the water.

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