Effectiveness of Brackish Water Desalination Using Reverse Osmosis System for Industrial Water Treatment at PLTU PT Bintan Alumina Indonesia

Yosia Putra Saroha Simanjuntak*(1), M. Prihadi Eko Wahyudi(2)
1,2Politeknik Negeri Batam, Batam, Indonesia

*Email address: **yosiaputra@gmail.com**

ABSTRACT — Demineralized water does not contain high minerals or chemicals and is used as feed to the boiler to produce steam. Demineralized water is essential in the PLTU (Steam Power Plant) industry because steam is produced by changing the water phase to steam. Natural water tends to be corrosive because it contains minerals such as high calcium and magnesium, which can cause scale in the boiler and reduce energy efficiency. Therefore, these minerals must be removed from the water for boiler feed. To produce denim water, PT. BAI uses a Water Treatment Plant (WTP) system, which consists of several stages, such as a clarifier, a three-layer filter, an automatic cleaning filter, ultra-filtration, and reverse osmosis. After going through these processes, demin water is stored in tanks and then flowed to the main plant. Several factors can interfere with the denim water production process at PT. BAI, including changes in water quality, problems with WTP equipment, and disturbances in the water distribution system. This study aims to maintain the reliability and efficiency of the demin water production process by carrying out routine maintenance on equipment and monitoring water quality by checking conductivity, pH levels, and produced water. Then, from the data obtained, it can be seen that the efficiency of demin water has met the operating standards and procedures set by PT.BAI, namely desalination levels above 90%. The division must also always be ready to deal with problems and take preventive actions to prevent disruption to the production process.

Keywords — Demineralized water, boiler feed, PLTU, Water Treatment Plant, reverse osmosis

I. INTRODUCTION

In the PLTU industry, demineral water is a basic need. This type of water feeds the boiler to produce steam to drive the turbine pump. Demineralized water plays a vital role because steam is produced by changing the water phase to vapor or water vapor. Reverse osmosis is a filtering method that can filter large molecules and ions from a solution by applying pressure when the answer is on one side of the selection membrane (filter layer). Osmosis is the process of moving water from a solution with a low concentration to a solution with a high concentration due to osmotic pressure.[6] This transfer process is through a semi-permeable membrane, where the water transfer process will stop after the attention of the two solutions is equal. RO requires a hydrostatic pressure greater than the difference in osmotic pressure so that water can flow from a solution with a higher concentration through a semipermeable membrane [1].

II. METHODS

This research was designed according to the theoretical basis that has been stated, where these leading theories have become a guide in conducting this research. This research design must be distinct from PT Bintan Alumina Indonesia's regulations as the study's location. This flowchart describes the steps that need to be taken to complete this research.

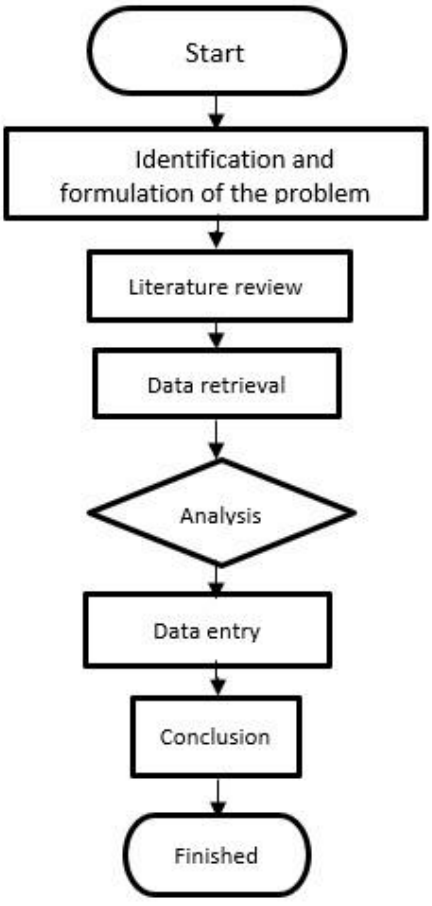

Fig 1. Research Flow Chart

https://jurnal.polines.ac.id/index.php/eksergi

ISSN 0216-8685 (print); 2528-6889 (online)

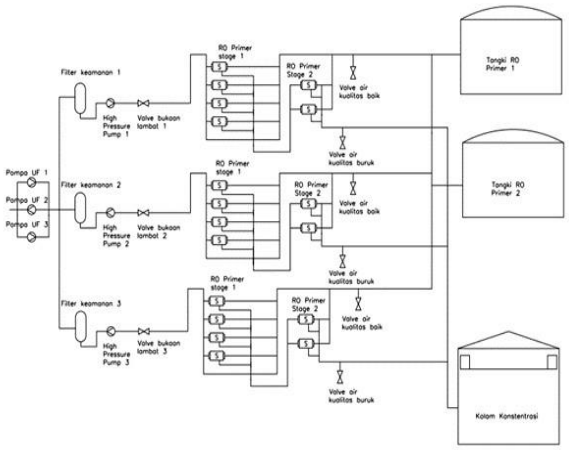

Fig 2. Primary RO Production System

From the Primary Reverse Osmosis pump, it flows into the security filter and then flows again to the High-Pressure Pump; after from the High-Pressure Pump, water through a slow opening Valve is then poured to the first stage Secondary RO. Water that meets the standards will enter the Secondary RO tank, and water with poor quality will be sent back to the Primary RO tank.

Fig 3. Reverse Osmosis at PLTU PT BAI

III. Results and Discussion

The results obtained in this study include several stages, starting from the steps of data collection, data processing, and data analysis. These results can be seen as follows:

Absolute error = $\sqrt{\frac{0{,}009}{6-1}} = 0{,}0018$

Relative error = $\frac{0{,}0018}{0{,}75}\ x\ 100\% = 0{,}24\%$

The measurement results of the conductivity of RO inlet water are obtained:

$$x = \ddot{x} + S_x$$

x = (0,75 ± 0,0018) $atau\ x$ = (0,75±0,24%)

Based on the data above, the average High Pressure Pump is 0.75 MPa the maximum pressure is on the 3rd day with a value of 0.8 MPa, and the minimum pressure value is on the 2nd day, which is 0.67 MPa. The data above is still within the minimum pressure limit of 1.03 Mpa.

TABLE 1. AVERAGE OF HIGH-PRESSURE PUMP

Variable	Research date	*The mean* of one week	Deviation	Squared Deviation
High Pressure Pump	1	0,79	0,04	0,0016
	2	0,67	-0,07	0,0049
	3	0,80	0,05	0,0025
	4	0,73	-0,01	0,0001
	5	0,76	0,008	0,000064
	6	0,74	-0,007	0,000049
K=6		4,52	0,011	0,009
Xbar		0,75		

TABLE 2. AVERAGE OF RO INLET WATER CONDUCTIVITY

Variable	Research date	Mean of one week of research	Deviation	Squared Deviation
RO inlet water conductivity	1	36,34	4,66	21,74
	2	30,03	-1,64	2,71
	3	34,34	2,66	7,09
	4	30,05	-1,62	2,64
	5	29,7	-1,97	3,90
	6	29,6	-2,07	4,31
K=6		190,1	0,02	42,41
Xbar		31,68		

Absolute error = $\sqrt{\frac{42{,}41}{6-1}} = 8{,}48$

Relative error = $\frac{8{,}488}{31{,}68}\ x\ 100\% = 26{,}76\%$

The measurement results of the conductivity of RO inlet water are obtained:

$$x = \ddot{x} + S_x$$

x = (31,68 ± 8,48) $atau\ x$ = (31,68±26,76%)

The average RO inlet water conductivity above shows that the highest RO inlet water conductivity is on the 1st production day, and on the 4th – 6th production day, the RO inlet water conductivity is average. On days 1-2, there was a

https://jurnal.polines.ac.id/index.php/eksergi

ISSN 0216-8685 (print); 2528-6889 (online)

significant decrease; on days 2-3, there was an increase; on days 3-4, there was a decrease. This decrease occurs because the pressure from the high-pressure pump is not stable.

TABLE 3. AVERAGE OF CONDUCTIVITY OF RO EXIT WATER

Variable	Research date	*The mean of one week of*	Deviation	Squared Deviation
Conductivity of RO exit	1	1,84	-0,27	0,073
	2	2,32	0,20	0,043
	3	2,14	0,02	0,00080
	4	2,09	-0,02	0,00046
	5	2,09	-0,02	0,00046
	6	2,19	0,07	0,0061
K=6		12,67	-0,02	0,12
Xbar		2,11		

Absolute error = $\sqrt{\frac{0,12}{6-1}} = 0,024$

Relative error = $\frac{0,024}{2,11}\ x\ 100\% = 1,13\%$

The measurement results of the conductivity of RO inlet water are obtained:

$$x = \ddot{x} + S_x$$

$$x = (2,11 \pm 0,024)\ atau\ x = (2,11 \pm 1,13\%)$$

The average RO water conductivity above shows that the highest RO water conductivity is on the 2nd production day, and on the 1st – 2nd production day, the RO water conductivity increases. On days 2-5, there was a significant decrease, and on days 5-6 there was an increase. This decrease occurs because the pressure from the high-pressure pump is not stable.

From the data above, in October, the Primary RO unit and Secondary RO unit operated well or produced an average of 91% for Primary RO and 90.85% for Secondary RO from design capacity. In non-October primary and secondary ROs do not operate daily because not all boilers use so sometimes the RO system is only in a standby state.

In Table 5 the actual efficiency value is obtained, and the average matter of 6 days of production achieves a desalination rate above 90% with a real efficiency value 3% higher. So, it can be concluded that the reverse osmosis system has increased efficiency. Based on the research that has been done, the increase in efficiency occurs because several factors are maintained by the rate of water entering, the rate of water leaving, and the addition of anti-scale drugs. Anti-scale is dispersive, which increases the Langelier index LST index in raw water from 0 to 2.6; controlling the input of 3mg/L anti-scale is sufficient to ensure that scale does not occur.

TABLE 4. RO MONITORING RESULTS IN OCTOBER

RO	**Parameter**	**Limitation**	**Average**	**information**
Air *input* RO Primer	FRC *Feed* (ppm)	<0,1	0,02	within limits
	Kekeruhan (NTU)	<0,5	0,38	within limits
	SDI µ	<4 µ	0,98	within limits
	Feed Flow (m^3/h)	-	267,18	within limits
	Air hasil Produksi (m^3/h)	196	179	91% of maximum capacity
	Recovery%	40	45,2	within limits
	TDS Feed (ppm)	1000	789	within limits
	TDS Permeate (ppm)	500	344,64	within limits
	Salt rejection%	98	98,81	within limits
	Differential Pressure (bar)	2,07	1,91	within limits
	FRC Feed (ppm)	<0,1	0,03	within limits
Air input RO sekunder	Kekeruhan (NTU)	<0,5	0,18	within limits
	SDI	<4	0,88	within limits
	Feed Flow (m^3/h)	-	267,18	within limits
	Air hasil Produksi (m^3/h)	175	159	90,85% from maximum capacity
	Recovery %	40	51,2	within limits
	TDS Feed (ppm)	1000	859	within limits
	TDS Permeate (ppm)	500	316,84	within limits
	Salt rejection%	98	98,11	within limits
	Differential Pressure (bar)	2,07	1,41	within limits

Based on the Permeate Flow chart above, it can be explained that the minimum production water value is on the On the 7th day with a production water value of 131 m3/h, the maximum production water value is on the 19th day with a production water value of 189 m3/h. So, based on the

https://jurnal.polines.ac.id/index.php/eksergi

ISSN 0216-8685 (print); 2528-6889 (online)

minimum and maximum values that can be seen in the graph above, the value of water produced by PT Bintan Alumina Indonesia has met the specification standards set by the company with a predetermined standard weight of 196 m3/h.

TABLE 5. COMPARISON OF EFFICIENCY VALUES OF CONDUCTIVITY

Incoming water conductivity	Water conductivity out	Actual Efficiency	theoretical
36,34	1,84	95%	90%
30,03	2,32	92%	90%
34,34	2,14	93%	90%
30,05	2,09	93%	90%
29,7	2,09	93%	90%
29,6	2,19	93%	90%

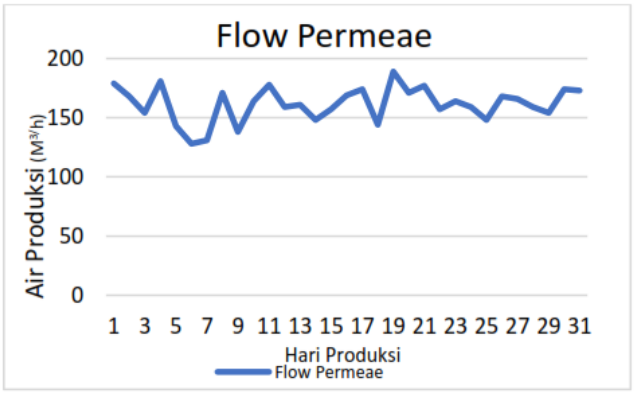

Fig 4. Permeate Flow Chart

IV. CONCLUSION

1. The actual efficiency value is obtained, and the average value of 6 days of production reaches a desalination rate above 90%, with an actual efficiency value higher by 3%. So, it can be concluded that the reverse osmosis system has increased efficiency.
2. The influence of the high-pressure pump, conductivity, and pH are by PT.BAI operational standards.
3. If the conductivity is terrible or below the standard PT Bintan Alumina Indonesia desired, it must be backwashed.

REFERENCES

[1] Malik Maulana, Abdul and Widodo, Ariyanto S (2009) Pengolahan Air Produk Reverse Osmosis Sebagai Umpan Boiler Dengan Menggunakan Ion exchange.
[2] M. Ivan Mahdi, " Kualitas air Indonesia memburuk pada 2021"
[3] Rositayanti Hadisoebroto, "KAJIAN POLA PEMAKAIAN AIR BERSIH DI TIGA APARTEMEN DI JAKARTA" Trisakti, Jakarta Barat, 2009.
[4] ELSYA ARILY YUNANDA," DESALINASI AIR PAYAU MENJADI AIR BERSIH DENGAN MENGGUNAKAN METODE REVERSE OSMOSIS"ITS, Surabaya, 2017.
[5] Suryadi, "Analisa Teknis Ekonomis Perencanaan Sistem Reverse Osmosis Untuk Kebutuhan," ITS, Surabaya, 2011.
[6] Lanxess, principle of reverse osmosis membrane separation, Deutschland, 2013.
[7] I. n. w. Linda A.Yoshi, "Sistem Desalinasi Membran Reverse Osmosis (RO) untuk Penyediaan air bersih," 2016.
[8] Horas Tiopan Sanjaya "PERANCANGAN SISTEM DESALINASI MENGGUNAKAN METODE REVERSE OSMOSIS PADA KAPAL RO-RO FERRY 5000 GT" ITS, 2018.
[9] Aan Sefentry, Rully Masriatini "PEMANFAATAN TEKNOLOGI MEMBRAN REVERSE OSMOSIS (RO) PADA PROSES PENGOLAHAN AIR LAUT MENJADI AIR BERSIH" , Universitas PGRI Palembang, 2020.
[10] Muhammad Ali Irfan, Djoko Wahyudi, Indro Wicaksono "Analisis Pengaruh Tekanan Membran Terhadap Kinerja Reverse Osmosis PLTU Paiton Unit 9",Universitas Panca Marga, 2017.
[11] Suardi, Rudi.2001. Sistem Manajemen Mutu ISO 9000:2000 , PPM, Jakarta.
[12] Iqbal, Farid. 2014. Reverse Osmosis. Water treatment plant, Jakarta.e Limited.
[13] C.B. Rasendra & Hanggara Sukandar, 2002, Desalinasi dengan Reverse Osmosis Tekanan Rendah, Departemen Teknik Kimia, Institut Teknologi Bandung.

https://jurnal.polines.ac.id/index.php/eksergi

ISSN 0216-8685 (print); 2528-6889 (online)