RECIRCULATION PROCESS OF DEMINERALIZATION WATER TREATMENT PLANT TO REDUCE CONDUCTIVITY LEVEL OF WATER

Kukuh Pambudi[1], Widi Nurcahyo[2], K. Adi Dharma[3]andW. Tantrawan[4]

[1]Indonesia Chemistry of Power Generation Association (ICEMPO),
E-mail:kukuh.pambudi@indonesiapower.co.id ;
[2]Indonesia Chemistry of Power Generation Association (ICEMPO),
E-mail:widi.nurcahyo@indonesiapower.co.id ;
[3]Indonesia Chemistry of Power Generation Association (ICEMPO),
E-mail: adi.darma@indonesiapower.co.id ;
[4]Indonesia Chemistry of Power Generation Association (ICEMPO),
E-mail:wayan.tantrawan@indonesiapower.co.id

ABSTRACT

Demineralization Water Treatment Plant serves to treat water that has been filtered at the Water Treatment Plant to be "good quality water" with the process of reverse osmosis. The initial design of Demineralization Water Treatment Plant in Pemaron – Bali Gas Turbine is to produce water that have conductivity level in 15 microsimens / cm, which is used for gas turbine cooling water system. At the moment we are planning to install Hydrogen Plant, it turns out this equipment takes raw water with a maximum conductivity of 5 microsimens / cm. So the product of Demineralization Water Treatment Plant is unable. Do a little innovation in production process of Demineralization Water Treatment Plant, namely recirculation, so that it can reduce the value conductivity to below 5 microsimens / cm. From result of laboratory test, it can be concluded that conductivity water after recirculation process is 2 microsimens / cm, thus meet requirement and can be used as raw water for Hydrogen Plant

Keywords: Conductivity Level, Recirculation, DWT Plant

1. INTRODUCTION

In Pemaron – Bali Power Plant have two unit of gas turbine in General Electric MS 7000 type. In this type of gas turbine , there were two cooling systems, consist of cooling water system and hydrogen cooling system. Cooling water system used for cooling lubricants, atomizing air, and heat exchanger in generator, the conductivity level of water in cooling water system maximum is 15 microsimens/cm. Water for gas turbine cooling water is produced by Demineralization Water Treatment Plant BWRO type 200. However, the principle of the hydrogen cooling system is the use of hydrogen gas for cooling generator winding. Hydrogen gas is used as a medium for heat exchanger process between the generator winding and cooling water systems. Hydrogen gas obtained from vendors in the bottle package.

In 2008, the company planned to install a Hydrogen Plant as a tool to generate hydrogen gas. Raw water that is used to the hydrogen plant has a maximum conductivity limit of 5 microsimens / cm, it is far below the production capability of Demineralization Water Treatment Plant. Solutions taken to overcome these problems, is made of small innovations in the production process of Demineralization Water Treatment Plant, called recirculation. Innovation in production process of Demineralization Water Treatment Plant capable of lowering the value of water conductivity below 5 microsimens / cm so that it can be used as raw water for Hydrogen Plant

2. REVERSE OSMOSIS [1]

2.1. Definition of Reverse Osmosis

Osmosis is a natural phenomenon in which a solvent (usually water) passes through a semipermeable barrier from the side with lower solute concentration to the higher solute concentration side. As shown in Figure 1a, water flow continues until chemical potential equilibrium of the solvent is established. At equilibrium, the pressure difference between the two sides of the membrane is equal to the osmotic pressure of the solution. To reverse the flow of water (solvent), a pressure difference greater than the osmotic pressure difference is applied (see Figure 1b); as a result, separation of water from the solution occurs as pure water flows from the high concentration side to the low concentration side. This phenomenon is termed reverse osmosis (it has also been referred to as hyperfiltration).

A reverse osmosis membrane acts as the semipermeable barrier to flow in the RO process, allowing selective passage of a particular species (solvent, usually water) while partially or completely retaining other species (solutes). Chemical potential gradients across the membrane provide the driving forces for solute and solvent transport across the membrane: $-\Delta \mu_s$, the solute chemical potential gradient, is usually expressed in terms of concentration; and $-\Delta \mu_w$, the water (solvent) chemical potential gradient, is usually expressed in terms of pressure difference across the membrane (Bhattacharyya and Williams, 1992b).

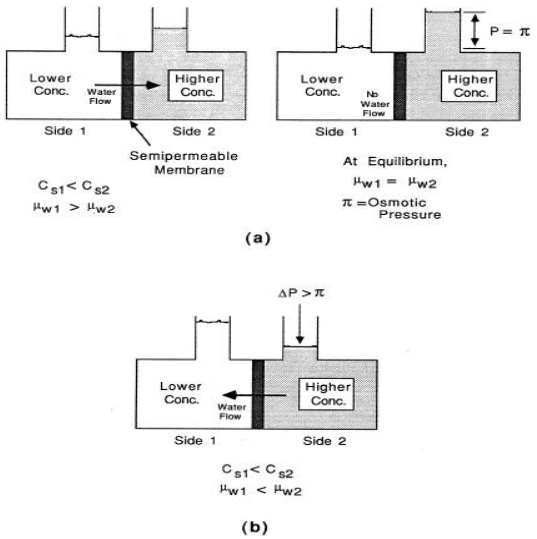

Figure 1. Schematic of Osmosis and Reverse Osmosis Phenomena.

2.2. RO Process Description and Terminology

The RO process is relatively simple in design. It consists of a feed water source, feed pretreatment, high pressure pump, RO membrane modules, and, in some cases, posttreatment steps. A schematic of the RO process is shown in Figure 2a. The three streams (and associated variables) of the RO membrane process are shown in Figure 2b: the feed; the product stream called the permeate; and the concentrated feed stream, called the concentrate or retentate. The water flow through the membrane is reported in terms of water flux, J_w, where

$$J_w = \frac{volumetric\ or\ mass\ permeate\ rate}{membrane\ area} \quad (1)$$

Solute passage is defined in terms of solute flux, J_s:

$$J_s = \frac{mass\ permeation\ rate}{membrane\ area} \quad (2)$$

Solute separation is measured in terms of rejection, R, defined as

$$R = 1 - \frac{C_P}{C_F} \quad (3)$$

The quantity of feed water that passes through the membrane (the permeate) is measured in terms of water recovery, r, defined for a batch RO system as

$$r = \frac{\sum J_w A_m \Delta t}{V_F} = \frac{V_P}{V_F} \quad (4)$$

and for a continuous system as

$$r = \frac{J_w A_m}{F_F} = \frac{F_P}{F_F} \quad (5)$$

In a batch membrane system, water is recovered from the system as the concentrate is recycled to the feed tank; as a result, if the solute is rejected the feed concentration (C_F) continuously increases over time. For a continuous membrane system, fresh feed is continuously supplied to the membrane.

Water flux is sometimes normalized relative to the initial or pure water flux (J_{wo}) as $\frac{J_w}{J_{wo}}$ as flux drop, defined by

$$Flux\ Drop = 1 - \frac{J_w}{J_{wo}} \quad (6)$$

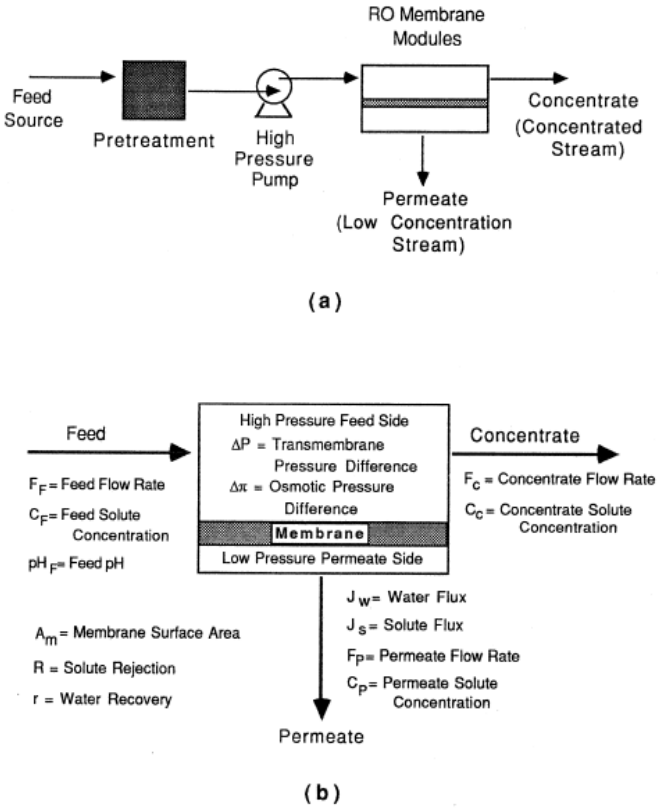

Figure 2. Schematic of (a) RO Membrane Process and (b) RO Process Streams.

The pressure difference between the high and low pressure sides of the membrane is denoted as ΔP while the osmotic pressure difference across the membrane is defined as $\Delta\pi$; the net driving force for water transport across the membrane is $(\Delta P - \sigma\Delta\pi)$, where σ is the Staverman reflection coefficient. Gekas (1988) has reviewed the standardized terminology recommended for use to describe pressure-driven membrane processes, including for reverse osmosis.

3. WATER DEMINERALIZATION PLANT[4]

Demineralization Water Treatment Plant in Pemaron – Bali Power Plant is set up to treat the filtered water (outlet from Activated Carbon Filter), convert into good quality water that will be used as cooling water purpose. The Demineralization Water Treatment Plant is designed to operate on filtered deep well water with a fess TDS of 2700 mg/l. The plant is capable of producing 0,2 m^3/hr permeate water with a maximum TDS content of 10 mg/l when treating feed water at a temperature range of 30 to 35 ^oC. The Demineralization Water Treatment Plant can operate at different temperature ranges and feed TDS. However, variations is the permeate water quality are anticipated. The water for the pretreatment is taken directly from the Water Tank (T103) using transfer pump. Based on the process philosophi, the whole Demineralization Water Treatment Plant can be divided into two major sections, for easy familiarization with the various unit : Pretreatment Section and Reverse Osmosis Section

3.1. Pretreatment Section

Raw water for pretreatment section is taken directly from the Water Tank and pumped by the Transfer Pump to the Cartridge Carbon and Cartridge Filter in series. The Cartridge Carbon removes, by adsorption, soluble organics and residual chlorine if any and the Cartidge Filter with 5 micron rating system for removal of particles greater than 5 microns.

3.2. Reverse Osmosis Section

The outlet water of the Cartridge Filter is then boosted to a approximately by a high pressure pump and is divided inside the Reverse Osmosis pressure vessels into permeated and rejected stream by reverse osmosis pressure. The kind of arrangement that has been provided in the plant is "Brine Staging" where the product from the 1st stage becomes the feed for the 2nd stage. This arrangement help to achieve approximately 10 ppm TDS in product water.

25% of the feed water and some dissolved solids are transported across the membrans to the product stream. The remaining water, 75%, flows out through the system as final reject. Product water from the reverse osmosis unit is then collected into the Product Water Storage Tank (Water Tank 1), called Product Water RO1. This water will be used for cooling water system. Antiscalan is added to water line downstream of the Cartridge Filter to remove any remaining free chlorine from the water and prevent the scaling of the membrane.

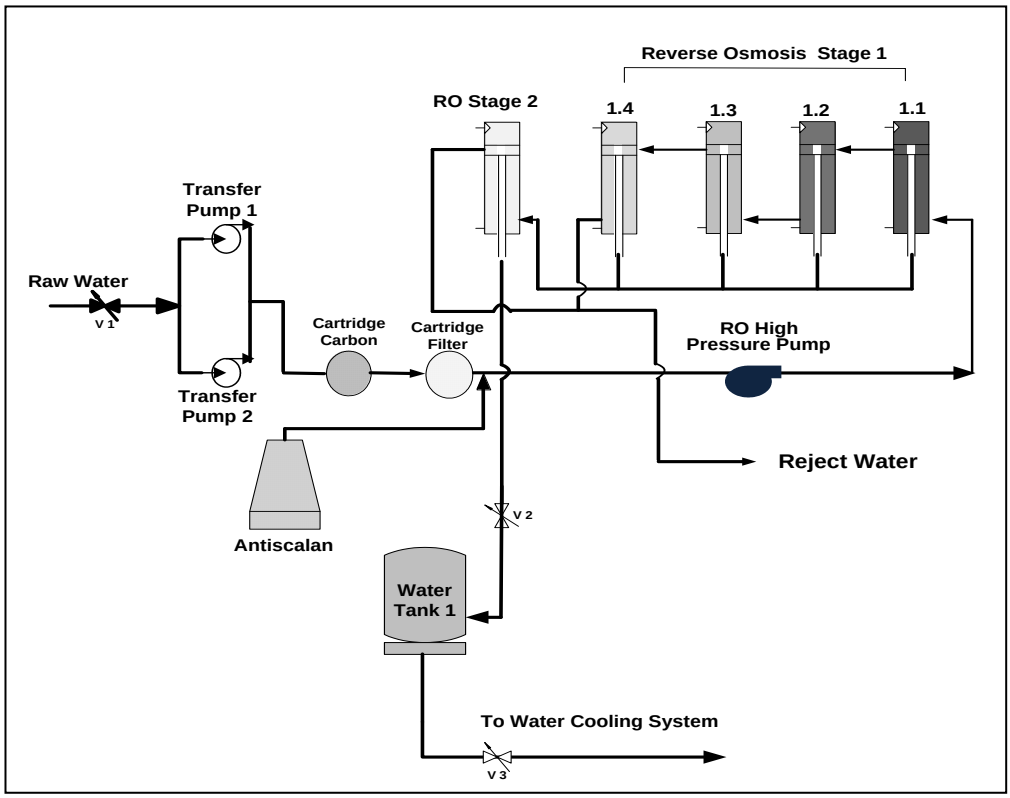

Figure 3. Initial Design Of Demineralization Water Treatment Pl

3.3. Product Analysis

Table 1 describes the water quality before and after treated by the Demineralization Water Treatment Plant. Based on data in table 1 the value of conductivity 14 microsimens / cm, is still far above the standard required by the hydrogen plant

Table 1. Parameter Raw Water And Product Water RO1

No	Parameters	Unit	Raw Water	Product Water RO1
1	Conductivity	micro S/cm	1400	14,5
2	Silika	mg/L SiO_2	27,8	8,9
3	Ca Hardness	mg/L Ca as CaCO3	81,4	0,28
4	Mg Hardness	mg/L Mg as $CaCO_3$	56,96	0,46
5	Total Hardness	mg/L Ca & Mg as $CaCO_3$	203,5	0,74
6	TDS	Ppm	980	10,2

4. DISCUSSION

4.1. Recirculation Process

As explained in introduction, the initial design of the Demineralization Water Treatment Plant in Pemaron - Bali Power Plant dedicated only to produce water for the cooling water system with conductivity values between 10-15 μS / cm. Based on table 1, the value of product water conductivity is 14 microsimens / cm, well above the required standard hydrogen plants. However, the new Hydrogen Plant require raw water with a maximum conductivity value of 5 microsimens / cm.

To overcome these problems, performed modifications to the production process of Demineralization Water Treatment Plant. Demineralization Water Treatment Plant product water that stored in the Product Water Storage Tank (Water Tank 1) flowed back into the inlet of the Demineralization Water Treatment Plant (as raw water). In this modification, the addition of a pipe from the water tank to the inlet Demineralization Water Treatment Plant, the addition of valves to maneuver the direction of flow and the addition of Product Water Storage Tank (Water Tank 2) to accommodate the product water from the recirculation process. Product Water RO 1 (10-15 μS / cm) entered back into the inlet Demin Water Treatment Plant to reprocessing of reverse osmosis that will produce Product Water RO 2 which has conductivity values below 5 μS / cm (Table 2)

Sequence of the production process at this stage of recirculation, is similar as the production process in chapter 3 above. Outcome of the process of recirculation stored at Product Water Storage Tank (Water Tank 2)

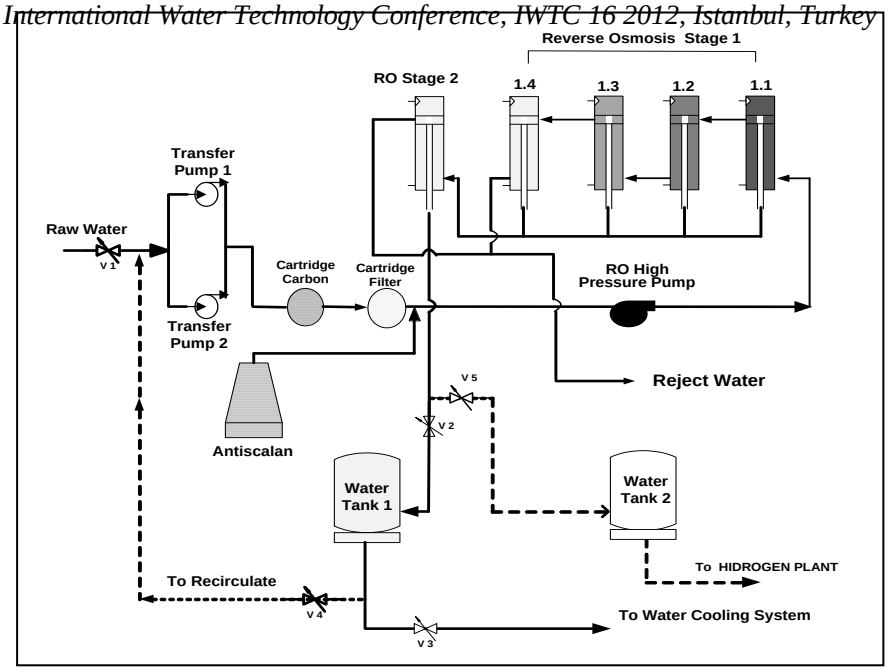

Figure 4 Recirculation Design Of Demineralization Water Treatment Plant

Noteworthy here is the maneuvering valve procedure at the time of the operation of Demineralization Water Treatment Plant. Make sure that Product Water RO1 was up before the valve leading to the Product Water Storage Tank (Water Tank 2) is opened, so Product Water RO1 not mixed with Product Water RO 2.

4.2. Product Analysis

Table 2 describes the water quality before and after recirculated by the Demineralization Water Treatment Plant. Based on data in table 2 the value of conductivity 2,13 microsimens / cm, This value meets the standard requirements of the hydrogen plant

Table 2. Parameter Product Water RO1 and Product Water RO1

No	Parameters	Unit	Product Water RO1	Product Water RO2
1	Conductivity	micro S/cm	14,5	2,13
2	Silika	mg/L SiO_2	8,9	0,13
3	Ca Hardness	mg/L Ca as CaCO3	0,28	0,18
4	Mg Hardness	mg/L Mg as $CaCO_3$	0,46	0,13
5	Total Hardness	mg/L Ca & Mg as $CaCO_3$	0,74	0,31
6	TDS	Ppm	10,2	1,41

5. CONCLUSION

Through the process of recirculation, can be derived product water conductivity values. Modifications are made simple and require only a little additional material. The production process is also similar to the previous production process. Noteworthy here is the maneuvering valve procedure at the time of the operation of demineralization

Water Treatment Plant. Make sure RO1 not That Product Water Product Water mixed with RO 2.

Based on data table 1 and table 2, it can be concluded that conductivity water after recirculation process is 2 microsimens / cm, thus meet requirement and can be used as raw water for Hydrogen Plant.

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