Study of Application of Reverse Osmosis Technology in Longline Tuna Fishing Boat 120 GT

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ABSTRACT

Inboard system is one of the things that need attention, which in this shipping system is a continuation of the ship hull design before the ship is produced. One of the things to note is the planning of clean water needs as long as the ship is operating. In the shipping world Reverse Osmosis water treatment system is one of the simple water treatment process, which is processing of sea water into fresh water using a semi permiabel membrane, where the membrane used is one membrane that can do the filtration of salt components So it will get fresh water.

This process is the opposite of a naturally occurring Osmosis process, so to perform this process requires considerable pressure to resist Osmosis pressure.

RO process is a simple process so that the required area is not large in the application on the ship, so this process becomes one of the alternatives in the process of processing sea water into fresh water as a utility unit in ship operations.

One of the application of RO process in ship is on the fishing boat, where the need for fresh water will be in supply from the RO process applied in the fishing boat. Besides to supply the need for fresh water the application of sea water processing system to fresh water with RO process will streamline the use of loading space in the fishing boat so that the loading space for fish catch will be maximized and fishing operations last longer, this will help maximize Fishing operations.

Things to note is the need for the area of the RO process, the need for electric power used for the process of generating pressure from the RO system and the pre-treatment area of the RO system itself, so it needs to be done in advance, especially the needs of fresh water from fishing vessels during The operation process takes place

Keyword : design, process, osmosis, reverse osmosis, fresh water, component, fishing boat

NOMENCLATURE

Π = osmotic pressure
S = The rate of salt separation
Cp = concentration of processed salt (mg / liter)
Cf = the concentration of raw water salt (mg / liter)
R = The production rate
N_w = the steady state permeation speed of the solvent penetrates the membrane
P_w = specific permeability,
N_S = Transfer Solute
R = rata average hydroulic radius of the pore
π = membrane porosity
V_w = molar volume of solvent
a_w = solvent activity, condition 1 and 2
N_s = solute flux penetrates the membrane
D_s = coefisien local solute diffusion

INTRODUCTION

In some cases shipbuilding design needed some tech support to get good and ideal ship results. One is a fishing boat design 120 GT, which in addition to the hull which is the main form of the ship, is the process of placement (layout) in the ship itself, such as engine layouts, tanks, sanitation and so forth.

One is the tank layout in the fishing vessel, especially the catch tank catches need to be

optimized so that the catch can be transported as optimal as possible.
In addition to that, the Fish boat 120 GT is also equipped with fresh water system. Fresh Water System (Domestic Fresh Water System) is one of the existing systems in the ship serves to meet all the needs of fresh water, such as:

- Eat
- Drink
- Bath
- Wash the crew
- Cooling machine
- And other needs

Where the water used is clean and good water, so water quality becomes an important thing to be fulfilled.
The need for fresh water (Domestic Fresh Water) on board can be fulfilled with:

- Desalination technology
- Supply of fresh water (by filling the Fresh Water Tank at the time the ship landed
- Reverse Osmosis Technology

Desalination Technology
The desalination technology that is deployed on board is a complicated technology in both process and equipment, so it is highly unlikely to be done on ships (which is a very limited area of the ship)

Fresh Water Tank Filling Technique
Filling in the Fresh Water Tank is technically very simple to do, but it requires a relatively large Fresh Water Tank and the freshwater filling is so limited that it will affect the length of time the ship operates in the oceans.

Reverse Osmosis Technology
This technology is a technology to make the process behind the events Osmosis process that takes place naturally.

- **Osmosis Theory**

Seawater processing into fresh water can be done with membrane technology using a semipermiable membrane, known as the Reverse Osmosis process.

The Reverse Osmosis process is based on the event of the osmosis process, in which the event is the flowing of solvent molecules into the solution spontaneously through the semipermiabel membrane, or the flowing of solvent molecules from a more dilute solution into a more concentrated solution.
Events The process of osmosis there is a tendency to balance the concentrations between two interconnected solutions through semi-permeable membranes (so-called equilibrium conditions).
The osmotic pressure is included in the colligative properties because the magnitude depends only on the amount of solute particles. J.H. Vant Hoff found a relationship between the osmotic pressure of dilute solutions with the ideal gas equation, which is written as follows:

$\Pi V = n RT$
$\Pi = n RT / V$
$n / V = M$ (molar)
so,
$\Pi = M RT$
Information,
Π = osmotic pressure
V = volume of solution (L)
n = number of moles of solute
R = gas constant (0082L.atm mol -1 K-1)

The Reverse Osmosis system process is a water filtration process, by working to put pressure on a liquid that has high concentration to a liquid with low concentration through a semi permiable membrane.
The pressure applied in the process of this system is intended to counter the Osmosis Pressure of a liquid (solution), where in the liquid is seawater, so the operating pressure during the Reverse Osmosis system process takes varying pressure depending on the condition of the seawater during the vessel's operation.

The osmotic pressure equation can also be illustrated in the equation below:
The osmotic pressure of a solution can be expressed in the equation:

$\Pi = 1.12\ (t + 273)\ \Sigma\ mi$
Where,
Π = Osmosis Pressure (Psi)
T = temperature (^oC)
Σ mi = number of molality of non inonic ionic content

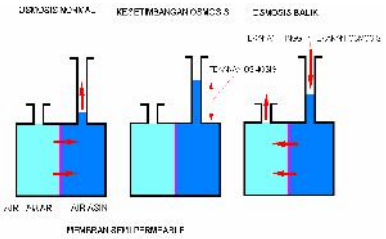

Fig. 1. Osmosis process and Reverse Osmosis process

- **Reverse Osmosis Theory**

In the process of desalination of seawater with the Reverse Osmosis (RO) system, it is not possible to separate all salt from the sea water, because it will require very high pressure. Therefore, in fact, to produce fresh water then salt water or seawater in a high-pressure pump into a reverse osmosis membrane module having two outlets ie the outlet for fresh water produced and a water-outlet outlet that has been concentrated by reject water).

Processing of sea water into fresh water using Reverse Osmosis system takes place in 4 stages:
1. Pre-Treatment
2. Pressurization
3. Membrane separation
4. Post treatment stabilization

Reverse Osmosis process system can be explained as follows:

- feed (seawater) enters into the membrane intended to Separate Suspended solids
- Adjust the pH
- Adding the inhibitor compound to control the scaling caused by certain compounds, such as CaSO4, Then the feed is pumped (where the pump works to increase the pressure) of the feed through the initial stages to the operating pressure corresponding to the membrane and feed salinity.
- The next step is the separation step between the soluble salt and the solvent, where the feed is passed through the permeable membrane, which in this membrane will block the flow of the dissolved salt, while the solvent (water product) will pass as the product water.

This membrane permeability effect will result in the presence of two streams, ie the flow of clean water products and concentrated brine flow.
The equations related to the reverse osmosis process are as follows:

- Solubility and diffusion model For homogeneous diffusion with membrane

$$N_w = P_w \frac{\Delta p - \Delta \pi}{L} \quad (1)$$

Where,
$N_w =$ the steady state permeation speed of the solvent penetrates the membrane
$P_w =$ specific permeability,
Where,

$$p_w = \frac{C_w \overline{D_w} \overline{v}_w}{RT} \quad (2)$$

$\overline{D}_w =$ mean diffusivity of solvent in membrane
$V_w =$ molar volume of solvent

$$\Delta \pi = \frac{RT}{V_w} ln \frac{a_{w1}}{a_{w2}} \quad (3)$$

Where,
a_w= solvent activity, condition 1 and 2
Transfer solute :

$$N_s = -D \frac{dC_s}{dx} + k_s \frac{C_s}{C_w} N_w \quad (4)$$

Where,
$N_s =$ solute flux penetrates the membrane
$D_s =$ coefisien local solute diffusion
$C_s =$ local solute concentration in the membrane
$k_s =$ coefficient coupling (between 0 - 1)
The efficiency of the solute rejection, defined as follows:

$$R_s = 1 - \frac{C_{S2}}{C_{S1}} \quad (5)$$

For random, isotropic, microporous membranes. Steady state solvent flux is :

$$N_w = \frac{K_w \Delta P}{\eta_w L} \quad (6)$$

Where,
Hydraulic permeability is,

$$K_w = \frac{\epsilon R^2}{20} \quad (7)$$

η_w = solvent viscosity

R = rata average hydroulic radius of the pore

π = membrane porosity

From the above equations can be illustrated, Reverse Osmosis process system depends on several things,

- Membrane characteristics used
- Solvent speed penetrates semipermiabel membrane
- Volume molar from the solvent (this depends on the condition of the marine waters traversed by the fishing vessel during operation (this will affect the characteristics of the Reverse osmosis system and equipment to be used)
- Coefficient of diffusion of the membrane (this depends on the selection of membranes to be used)
- Coefficient of diffusion of the membrane (this depends on the selection of membranes that will be used)
  Taransverse position (this relates to the design of the Reverse Osmosis process) especially the design of the piping position on the reverse osmosis equipment
- Solvent viscosity (this depends on the marine environment that the ship passes during the operation)

Membranes in the Reverse osmosis system require pretreatment on the unit to avoid the fatal damage and smoothness of the Reverse Osmosis system used.

This is also done on the use of the Reverse Osmosis system that is applied to the ship, which can be seen in the process diagram below:

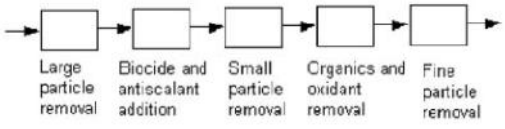

Fig. 2. RO pretreatment schematic.

Reverse osmosis process installation can be seen in the picture below :

Fig. 3. Installation Reverse Osmosis Process

The final stage of the Reverse Osmosis process system is stabilization, where at this stage the membrane-separated product water usually requires a pH adjustment before being delivered to the distribution system to be used as drinking water, one of the stabization processes is the aeration process of the product water to increase the pH to 7. *(Danial / fadjar. P, Trends Magazine August 2010 edition).*

METHODOLOGY

Fresh Water System on Tuna longline boat 120 GT

On Longline Tuna Fish boat 120 GT using conventional system of need for clean water (freshwater) is done by storage system (filling is done at the time of leaning ship). This system is a freshwater storage system in accordance with the needs as long as the ship is operating or sailing. In this system requires a large tank or in accordance with the needs of ship personnel (crew).

this system only provides fresh water tanks).

Implementation Conventional system is very simple and easy in operational process, but this system require tank and cost to purchase big Fresh Water so that for long term this system less economical.

Calculation of Fresh Water Tank Fishing Tuna Longline 120 GT (Conventional System)

Calculation of freshwater tank dimension (Fresh Water Tank)

Main Size Fish Vessel 120 GT

Loa	=	29.00 m
Lpp	=	26.18 m
B	=	7.00 m
H	=	3.10 m
T	=	2.40 m

Data of Tuna Longline Fish Ship 120 GT

1. Weignt of Fuel Oil

- HSD = M/E PowerxFOCx Endurance
- M/E : MCR = 1x600HP= 297,0 100 kw
- Endurance = 4,00 24 dayShip
- speed = 10,00 5 knnot
- D/G Power(2x80kW)=160 160 kw
- SFOC = 170,00 170 gram/kWh
- FO Consumption for M/E (HSD)= 4,85 9,792 ton
- FO Consumption forD/G(HSD)= 2,61 15,6672 ton
- Margin 10%
- Total of HSD = 36,21ton
- Minimum capacity of HSD tanks (storage) (100% Capacity, SG = 0.85 t/m3, 2% steel deduction) = 43,47 m3
- Actual Capacity of HSD = **53,10 m3**
  44,23ton

2. Weight of fresh water

- FW = Crew x FWC x Endurance (day)
- Where : Total of Crew & Visitor = 18 persons
- FWC (Fresh Water Consumption) = 25 kg/person/day
- Endurance = 28,00 days
- FWT = 12,60 ton
- Margin 10% = 1,26 ton
- Total of fresh water = 13,86ton

- Minimum capacity of fresh water tanks (storage) (SG = 1.00 t/m3, 2% steel deduction)
  = 14,14 m3
- Actual Capacity of Fresh Water
- Tank = 15,60 m3
  = 15,288 ton

Category FW - FRESH WATER (SG = 1.000 tonnes/cu.m 100 % full)

Compartment	Frames	Volume (m^3)	Weight (t)	LCG (m)	TCG (m)	VCG (m)	FSM (m^4)
FW1P	2-10	6.16	6.16	4.118	-2.304	2.521	1
FW1S	2-10	6.16	6.16	4.118	2.304	2.521	1
FW2P	-2-2	1.64	1.64	0.097	-1.709	2.789	0
FW2S	-2-2	1.64	1.64	0.097	1.709	2.789	0
Total		**15.60**	**15.60**	**3.274**	**0.000**	**2.578**	

Table 1. Calculation of Fresh Water Tank ship Fish 120 GT (conventional system)

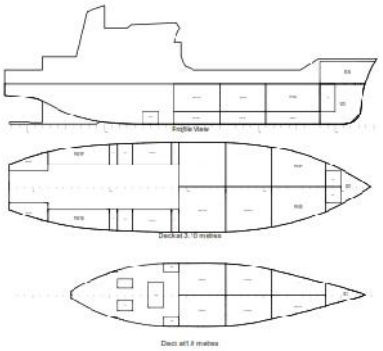

Fig. 4. Tankplan Tuna Longline 120 GT (conventional system)

Use Reverse Osmosis on Longline Tuna Fish boat 120 GT

The use of the Reverse Osmosis system on the Longline Tuna Fish boat 120 GT required several stages and design considerations before the Reverse Osmosis system was implemented.

Reverse Osmosis Design Consideration on Longline Tuna Fish 120 GT

The application of the Reverse Osmosis process system in the ship required data, such as

- Analysis of raw water quality, related to the selection of specifications of equipment components to be used.

Data on water conditions (seawater):

- TDS (total disolve solid) 35,000 ppm at 25 ºC TDS 42,000 ppm at 30 ºC
- NaCl of 35 gr
- Salt density 1.5 gr / ml *(Source: Sanitary Engineering Laboratory)*
  Volume NaCl = 35 / 1.5 ml = 23.3 ml
  Volume of solvent = 1000ml - 23.3ml = 976.67 ml = 0.97667 lt
- Calculation of osmotic pressure:
  Temperature (t) = 25 ºC, then
  The osmotic pressure (π) = 1.12 (t + 273) Σmi = 1.12 (25 + 273) {35 gr: [(Mr Na + Mr Cl) / Vol pearut]} = 1.12 x 298 K x { 35 gr: [(23 + 35,5) / 0,9867]} = 199.68 Psi (13.96 bar)

The above calculation shows the magnitude of osmotic pressure for salt water (raw water) containing 35 g of NaCl is equal to 199.68 Psi, so that required greater pressure than 199.68 Psi to be able to filter salt molecules by membrane.

The process unit of the Reverse Osmosis process system to be used in a 120 GT Fish vessel consists of three main components:

- Pre-treatment
- Reverse Osmosis Unit
- Power Source

Pre-Treatment

Pre-treatment is done because the Reverse Osmosis process system is an ultra filtration unit. Pre-treatment is performed on sea water feeds that will go into the Reverse Osmosis unit.

This pre-treatment unit includes:

- Clarifier pump
- Feed tanks
- Dosing pump (KmnO4)
- KmnO4 Tank
- Reactor Tank
- Pressure Sand Filter
- Manganese Greensand Filter
- Activated Carbon Filter
- Filter Cartridge RO
- Dosing Pump of chemicals RO
- Chemical Tank RO
- Feed Pump

Reverse Osmosis Unit

- Reverse Osmosis Unit (RO)

This unit consists of a spiral-coiled membrane membrane with a vessel protector operating at high pressure. Selection of the membrane specification is adjusted to the condition of raw water (for the vessel adapted to the operational location of the ship).

- Product Water Tank
  Located on the right side (starboard) and left (portside) ship. To maintain the stability of the ship, both tanks are designed with the same size and volume.
- Product Pump
  As a product water pump for charging to places in need.

Power Source

Resources The power required varies greatly depending on the capacity of the water to be produced.

Fresh Water Tank Calculation by applying Reverse Osmosis system in Longline Tuna Fish boat 120 GT, can be seen the difference of Fresh Water tank volume in the table below,

Category FW-FRESH WATER (SG = 1.000 tonnes/cu.m 100% full)						
Compartment	capacity (m3)	capacity (tonne)	LCG m	TCG m	VCG m	FSM tonne m
FWT2-SB	0.775	0.775	2.047	2.042	2.829	0
FWT2-PS	0.775	0.775	2.047	-2.042	2.829	0
FWT1-SB	2.996	2.996	4.454	2.3	2.579	0
FWT1-PS	2.996	2.996	4.454	-2.3	2.579	0
total	7.542	7.542				0

Table 2. Calculation of Fresh Water Tank ship Fish 120 GT (with RO application in fishing boat 120 GT).

The use of Reverse Osmosis process system reduces Fresh Water Tank quantity, seen from ship layout of Tuna Longline 120 GT.

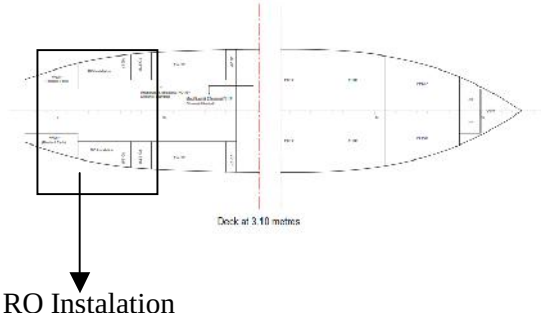

Fig. 5. Layout Fresh Water Tank Ship Fish Tuna Longline 120 GT (using Reverse Osmosis system)

DISCUSSION

Implementation of Reverse Osmosis in Longline Tuna Fish boat 120 GT to meet the needs of fresh water during the ship operates. The use of the Reverse Osmosis process system in the vessel provides several advantages,

- fresh water tank (FWT), will have smaller dimension
- The need for fresh water will be fulfilled well.
- Reverse osmosis process takes place in batch and continuous.
- The operation of the voyage takes longer, because the smaller FWT modification will add dimension of the fuel tank so that the shipping operation takes longer, so that the maximum fishing process that influences the catch.
- The larger storage space for fish (hauls)

The things that were done before implementing the Reverse Osmosis process system in the vessel are,

- Review of Revere Osmosis process system include, RO temperature and operating pressure, specification of RO components especially membrane specification to be used and layout of system placement of Reverse Osmosis process in ship.
- Survey to obtain data of freshwater demand during the operation of a fishing boat 120 GT (this relates to the capability of products produced by the Reverse Osmosis process system)
    - First of all the predicted maintenance of reverse osmosis process system, which is influential on economic calculation. Where the Reverse Osmosis system will be used with different feed media (the ship is a dynamic building), will affect the pre-treatment of the water (feed water) before entering the Reverse Osmosis unit. So it affects the maintenace frequency of the Reverse Osmosis system, especially the maintenance of the Reverse Osmosis membrane unit.
    - The position of the Reverse osmosis process system is carried out at the portion close to the fishing gear unit of the 120 GT, to efficient piping systems within the vessel.
    - Pre treatment is needed to extend the life of the membranes used in the Reverse Osmosis process system.

CONCLUSION

Some conclusions from this paper are:

- The use of Reverse Osmosis system in Fishing boat 120 GT needs to be done to get the fulfillment of clean water consumption more efficient and fulfilled well
- The use of Reverse osmosis system in fishing boat 120 GT, will increase the operating time of fishing vessels, so as to obtain maximum catch
- Reverse Osmosis process is a separation system between the solute of the solvent, which takes place physically so that the operating process takes place at room temperature with or without heating and cooling. For that process with Reverse Osmosis system is very simple and suitable to be applied to the ship.
- Reverse Osmosis process system can be done in two process, that is batch or continuous system so require Fresh Water Tank which is relatively small.
- The use of the Reverse Osmosis process system in a 120 GT fishing vessel will increase the loading space (fish) and enlarge the fuel tank so that the operation of the 120 GT Fish vessel lasts longer.

The weakness of fresh water system with RO system ie, Installation is more complex and lengthy due bait water must be processed first to remove particulates. other than that this system also needs repair and treatment periodically.

REFERENCE

1. Robert H. Perry/Cecil H. Chilton,”Chemical Engineer’s Handbook”, Fifth Edition. International Student Edition
2. Said, Nusa Idaman. 1999. ”Pengolahan Payau Menjadi Air Minum Dengan Teknologi Reverse Osmosis”. Jakarta: Badan Pengkajian dan Penerapan Teknologi.
3. Laporan Balai Teknologi Hidrodinamika –Pusat Teknologi Rekayasa Industri Maritim, “Basic Desain Kapal Ikan Tuna Longline 120 GT”, BPP Teknologi
4. Jane Kucera,” Reverse Osmosis Design, Processes, and Applications for Engineers”, John Wiley & Sons, Inc. Hoboken, New Jersey, and Scrivener Publishing LLC, Salem, Massachusetts