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# SUBMERGED REVERSE OSMOSIS PLANT (SROP)

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**SUMMARY –** The availability of Potable water on the land is depended on the natural cycle of evaporation, condensation and precipitation of sea water. This is dependent on various factors and in large areas there is scarcity of potable water. In this article a Submerged Reverse Osmosis Plant is described which has been worked out that provides a cheap source of potable water from sea water. Due to development of Reverse Osmosis membranes that can filter out salt molecules it is possible to have potable water from sea water. However, this process requires high pressure sea water. In this plant the high pressure sea water is derived from deep sea that makes the potable water cheap. An innovative mechanism is used to develop the high pressure sea water. The scaled model is under construction and working plant is planned in near future.

**Key words:** Potable water, Reverse Osmosis

## INTRODUCTION

The potable water availability on the land is diminishing. Efforts are made to convert abundant sea water into potable water for drinking & industrial use. To obtain potable water from Sea water Reverse Osmosis (RO) is one of the processes that has been used and proven to be an economical and environmental friendly process as it consumes lower energy per cubic meter of potable water produced as compared to other process like distillation etc.

However, in RO of Sea Water (SW) major part of the energy is consumed in following activities:

- In bringing sea water to the RO Plant on the shore by pumping: Large quantity of SW has to be pumped from depth of sea to long distance (4-10 km) to the RO Plant on the suitable coastal site. As the RO efficiency decreases a lot with the increase in concentration of salt in the SW, only about $1/10^{th}$ volume of potable water can be produced from a volume of sea water. That is to say about 1000 liters of SW has to be used to produce 100 liters of potable water. This requires large quantity of SW to be pumped and transported to the RO plant.

- In maintaining high pressure of SW across the RO membrane: Pumps have to run continuously to maintain high pressure of the order of 60 to 70 bar of SW across the RO membrane. This is a large energy consuming process involved in RO plants.

- The capital cost and running cost of RO plants is due to the following:

    i) Large length of piping and pumping system required for pumping SW to RO plant at shore.

    ii) High pressure pump sets to maintain high pressure SW as described above.

    iii) Land cost of the area occupied by RO plant.

    iv) Operation and maintenance cost of RO plant as high pressures are involved.

In the SROP the above referred costs are eliminated/ reduced so that the cost of potable water produced is lesser than the cost of potable water produced by conventional RO plant as explained below:

- The SROP is submerged in the sea below a level of about 60 meters. This allows availability of SW in abundance to the SROP eliminating the cost of transporting sea water to RO plant.

- The high pressure SW required for RO process is developed with the help of an innovative mechanism from the pressure of the sea at the depth of sea. This eliminates high pressure pumping system required to maintain high pressure across RO membrane.

- Only a small pump is required to fetch potable water from SROP to the shore or to the point of use. Since, the amount of potable water is much less than the sea water used to produce it, the piping and pump requirements are reduced to only 10%.

- The land requirement on shore is totally eliminated, since SROP does not require any land for installation being installed submerged in sea.

- The SROP is designed to operate in fully automatic mode that eliminates operation cost to large extent.

- The components and mechanism of SROP have been designed to be with minimum requirements for maintenance. Also, the material of construction of the plant has been selected to give protection from corrosion of sea water with minimum cost.

**CONCEPT AND WORKING**

The high pressure SW required for RO process would be at a depth of 600 to 700 meters. To locate a sea shores near which such depths of sea is available would be difficult and limited to only few places. Also such depths (600 to 700 m) of sea would be far away from sea shore. However, if the RO plant is located just 60 to 70 meters below sea level the quality of SW required for RO would be suitable and such depth of sea would be available near most of the sea shores. But at this depth the pressure of SW will not be enough for RO process. Therefore, to enhance SW pressure to the required level of 60 to 70 bar an innovative mechanism consisting of levers, pistons and cylinders in used.

Please refer to the schematic of SROP attached herewith. In the pressure developing cylinder a piston is moving which is connected to Force multiplying lever. On one side of the piston, the side facing the cylinder atmospheric pressure is acting since a pipe above the sea level vents this side of the cylinder. On the other side of the piston the sea water pressure of depth of 60 meters is acting. This creates a force equal to difference of these pressures multiplied by the area of the piston and makes it to move inside the cylinder. This force is levered 10 times to act on the high pressure exerting piston in the pressure chamber A. which in turn acts on the sea water in the chamber. Thus the pressure developed in the chamber would be 10 times the pressure of SW at depth of 60 meters.

The high pressure SW in the chamber A passes through RO membrane till an impasse concentration is reached i.e. about $1/10^{th}$ volume of Chamber A.

The passed SW through RO membrane is free of salt and other suspended particles and is potable for use, which collects in the potable water chamber. From here it is pumped above sea level and taken to the point of use on the shore.

After the high pressure exerting piston has moved by $1/10^{th}$ of its stroke the outlet solenoid valve is opened that allows the balance concentrated SW to go out to the surface of sea during the remaining stroke of high pressure exerting piston. The concentrated SW at sea level is collected for making salt.

When the high pressure exerting cylinder makes full stroke, the outlet solenoid valve is closed and pump for SW is started. This pumps in fresh SW in high pressure chamber A till the piston reaches

fully outward and the pump is stopped closing solenoid inlet valve. At this position the above cycle repeats.

The cycle is controlled by position switches and is fully automatic.

**PROBLEMS AND SOLUTIONS**

The problems envisaged in SROP are as under and their solutions are also arrived at as explained below.

i) Filtration/ pre treatment of feed Water: At a depth in sea to provide filtration/ pre treatment of feed water appeared to be a problem. But using the similar arrangement as described for RO the sea water can be filtered and the filtered water is fed to inlet of pump for SW which pumps in filtered SW into the high pressure chamber A for RO.

ii) Enhancement of SW pressure to required level for RO: the innovative piston solves this problem, cylinder and lever mechanism described earlier.

iii) To maintain low pressure on the filtered side of RO membrane: A vent to the atmosphere is provided from the filtered side of RO membrane by this low pressure is maintained. Also this vent acts as air inlet when the potable water is pumped out to the sea level.

iv) Pumping of potable water above sea level: With the suitable small submersible pump of capacity 1 cu.m/hr the potable water is pumped above sea level to be collected there for transporting to the point of use.

v) Replenishment of SW in the pressurized RO chamber is achieved by a high pressure submersible pump that has a capacity about 1 cu.m/Min and can stand the sea water environment around at 60-70 bar pressure. This pump would be working only one minutes in every 6 minutes.

vi) Maintenance of SROP under deep sea water: The platform on which SROP is mounted is placed on the sea bed about 60 meters below sea level. For periodic maintenance once in 6 months or as per need it can be pulled up above sea level from floating Barges and placed on them for maintenance and component replacement. After maintenance it can be lowered and placed back in position.

vii) Corrosion due to SW at higher pressure: Stainless steel of suitable quality is used for structural and load carrying members and cylinders etc. The pistons are fabricated out of non corrosive material with piston rings made out of Teflon that gives protection against corrosive atmosphere. The material of pressure pump is also selected that avoids its corrosion.

**SCHEMATIC OF SRPO**

The schematic of SRPO is enclosed as Annexure. The working of the SRPO is explained above. The brief bill of material for SRPO is as under:

- Mounting platform
- Prefilter vessel
- Pressure developing cylinder
- Link L1
- Pressure developing piston
- Force multiplying lever
- Pump for Potable Water
- Piping for inter connection and vents etc
- Limit Switches
- Solenoid Valve/ NRV
- Outlet Solenoid Valve Contactors
- Cables/ bushing
- Sealant
- Fulcrum/ Pivot
- Link L2
- High Pressure Chamber A
- High pressure exerting piston
- RO Membrane with mounting arrangement
- Potable water chamber
- Pump for Sea Water
- Power supply

## PROJECT IMPLEMENTATION

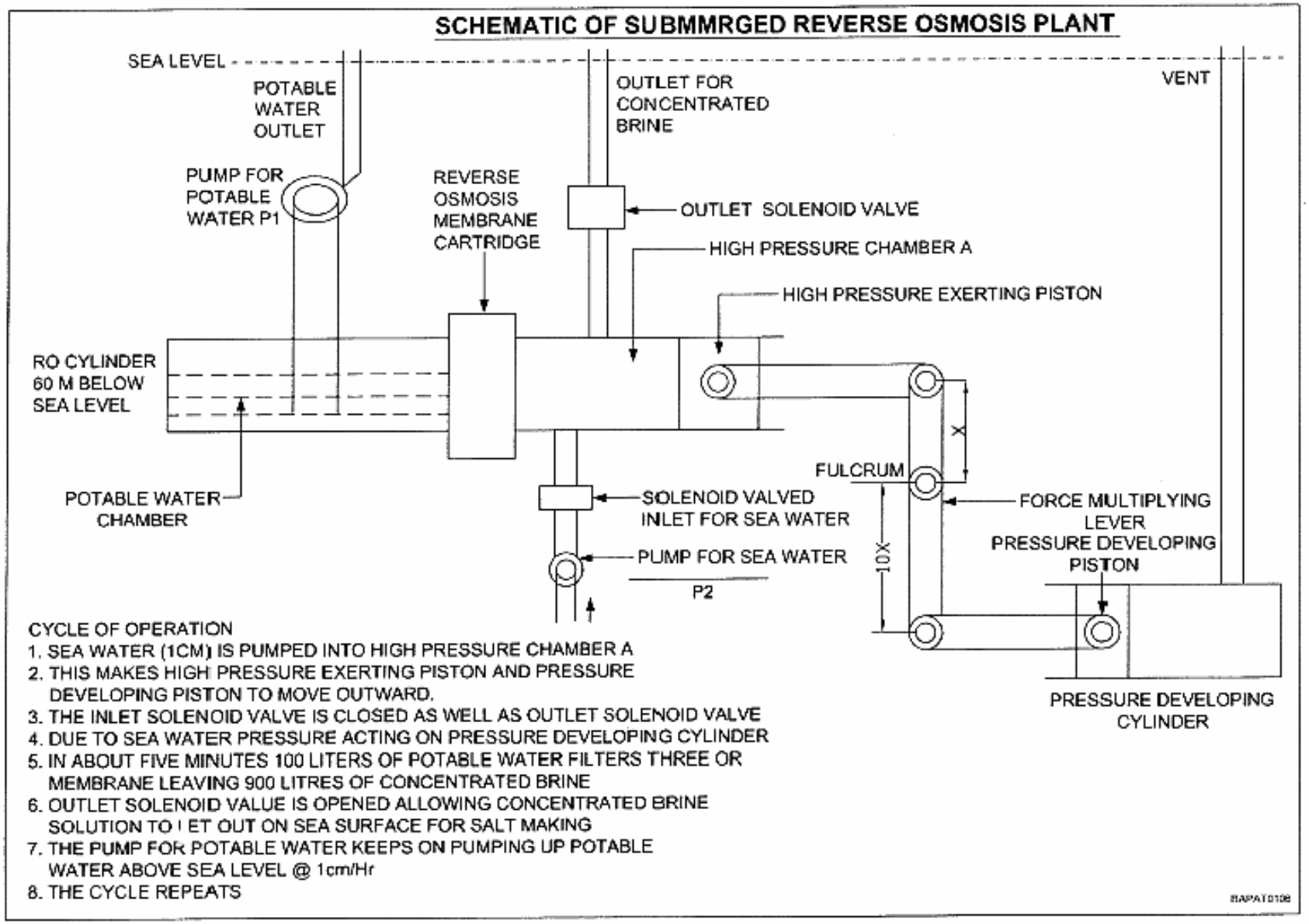
The detailed design of SROP has been made. The design has been checked with calculations for technical feasibility. Component drawings and assembly drawings have been completed. A scaled model is under preparation. After trials on the model the drawings will be modified for production of SROP. Few sites along the Western Coast of India where depth of sea is adequate and the quality of water is suitable have been identified. Permissions from authorities to conduct the trials of SROP have been initiated. Efforts are made to find the funding agency for the project and further communication is in progress with them.

## COST ESTIMATES

The cost for making model and its trials are estimated at Rs.0.5 million (US $ 11 thousand). The estimated capital cost of SROP of 1 Cu.M /hr capacity is Rs.2.00 million (US $ 44 thousand) at present level of prices. The cost of 1 Cu.M of potable water produced by the plant works out to be Rs.27 (US $ 0.6) The cost estimates are being revised on receiving the quotations for components and material which are being obtained at present.

## PLAN

To complete the model its trials, manufacturing SROP and its commissioning, it is estimated to take two years. Low cost funding is sought from World Bank and other eco friendly institutes, which will speed up the activities and make it economical. There are some innovative processes in SROP for which actions for IPR have been initiated. The plan for commercialization of SROP has been made. The commercial version of SRPO will be a boon for settlements, installation, projects on sea shore and in the sea where potable water is needed by the mankind.


SCHEMATIC OF SUBMMRGED REVERSE OSMOSIS PLANT
SEA LEVEL
POTABLE WATER OUTLET
OUTLET FOR CONCENTRATED BRINE
VENT
PUMP FOR POTABLE WATER P1
REVERSE OSMOSIS MEMBRANE CARTRIDGE
OUTLET SOLENOID VALVE
HIGH PRESSURE CHAMBER A
HIGH PRESSURE EXERTING PISTON
RO CYLINDER 60 M BELOW SEA LEVEL
X
FULCRUM
POTABLE WATER CHAMBER
SOLENOID VALVED INLET FOR SEA WATER
FORCE MULTIPLYING LEVER
PRESSURE DEVELOPING PISTON
10X
PUMP FOR SEA WATER
P2
PRESSURE DEVELOPING CYLINDER
CYCLE OF OPERATION
1. SEA WATER (1CM) IS PUMPED INTO HIGH PRESSURE CHAMBER A
2. THIS MAKES HIGH PRESSURE EXERTING PISTON AND PRESSURE DEVELOPING PISTON TO MOVE OUTWARD.
3. THE INLET SOLENOID VALVE IS CLOSED AS WELL AS OUTLET SOLENOID VALVE
4. DUE TO SEA WATER PRESSURE ACTING ON PRESSURE DEVELOPING CYLINDER
5. IN ABOUT FIVE MINUTES 100 LITERS OF POTABLE WATER FILTERS THREE OR MEMBRANE LEAVING 900 LITRES OF CONCENTRATED BRINE
6. OUTLET SOLENOID VALUE IS OPENED ALLOWING CONCENTRATED BRINE SOLUTION TO I ET OUT ON SEA SURFACE FOR SALT MAKING
7. THE PUMP FOR POTABLE WATER KEEPS ON PUMPING UP POTABLE WATER ABOVE SEA LEVEL @ 1cm/Hr
8. THE CYCLE REPEATS
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