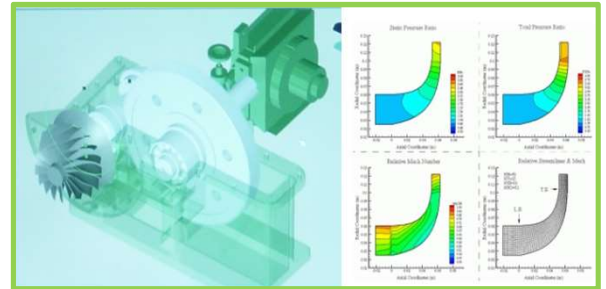


Turbomachinery

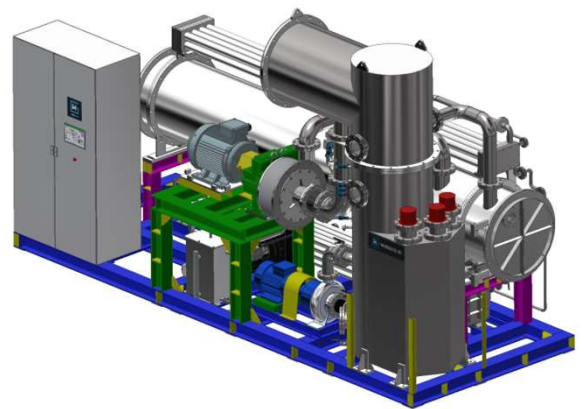
Engineering
Aerodynamic Designing
Manufacturing
& Consulting



World wants water !
We can make good water !

Turbo MVR Distiller

For Making Clean Drinking Water
& Waste Water Treatment



Turbo Blower

With Variable Speed Driver &
Inlet Guide Vane Controller



[주] 워터젠
WATERGEN Co.Ltd



[MEANING of WATERGEN]

Generating World Aqua Technology with very efficient Energy Recovery system using a high speed turbomachinery.

[CEO's WELCOME]

Recently, water usage per capita is decreasing due to increasing population in the world, so the specific areas around the middle east Asia, southeast Asia, India and Africa are at risk of water deficiency.

Currently, extreme water deficiency is occurring in almost one-fifth of the world's population. In a few years, that will rise to almost 50%.

To make matters worse, rapid industrialization is also causing serious water pollution on the ground and in underground drinking water sources, and 5 million people are dying because of waterborne diseases.

The time has come to realize the need and necessity of an efficient distiller machine that is not too big, and can easily generate clean water anywhere.

"WATERGEN Co." has developed the technology that can retrieve energy using a high speed turbo machinery, and grafted our skills into improving drinking water technology. As a result, we succeeded in developing a highly efficient distiller system, named the "Turbo Mechanical Vapor Recompression Distiller" after 10 years of practical experiments using governmental funds.

From now on, we are steadily following our vision to pursue "Contribution to Human Society" by providing plenty of clean drinking water for well-being of people around the world with the highly efficient "Turbo-MVR" distiller system.



Doctor & Master's Degree
from Kyushu University
(Japan)
Senior Researcher of Korea
Aerospace Research
Institute
Head of R&D Center,
Turbomachinery
Companies

Thank you

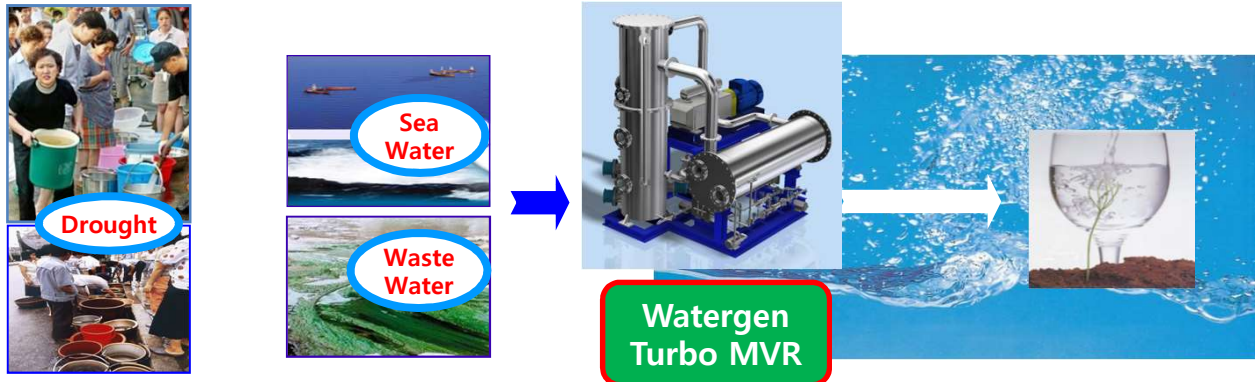
CEO / Ph.D

Yong ik, Hyun





Turbo Mechanical Vapor Recompression Distiller (Desalination and Distiller System)



MVR Distiller Application :

- Distillation of sea water, brackish water, infected underground water, malignant waste water through a very effective heat pump system using turbo mechanical vapor recompression method for production of high purity water for drinking and industrial reuse.
- Appropriate for island region with drinking water insufficiency, inland region with underground water contamination and facilities creating malignant waste water.

Features of Turbo Mechanical Vapor Recompression System :

- Simple design and constituents, only electric power source needed for operation - no heat sources
- World Best Efficiency (Low specific energy consumption, C.O.P > 20)
- Easy maintenance due to a compact MVR system with high speed turbo steam compressor
- Simple and reliable automation system without special crew training for operation
- Easy full access to heat transfer surfaces and steam compressor for after service
- Simple raw water pre-treatment, selectable H/X materials (sea water : Titanium, muddy river & underground water : STS316L, STS304)

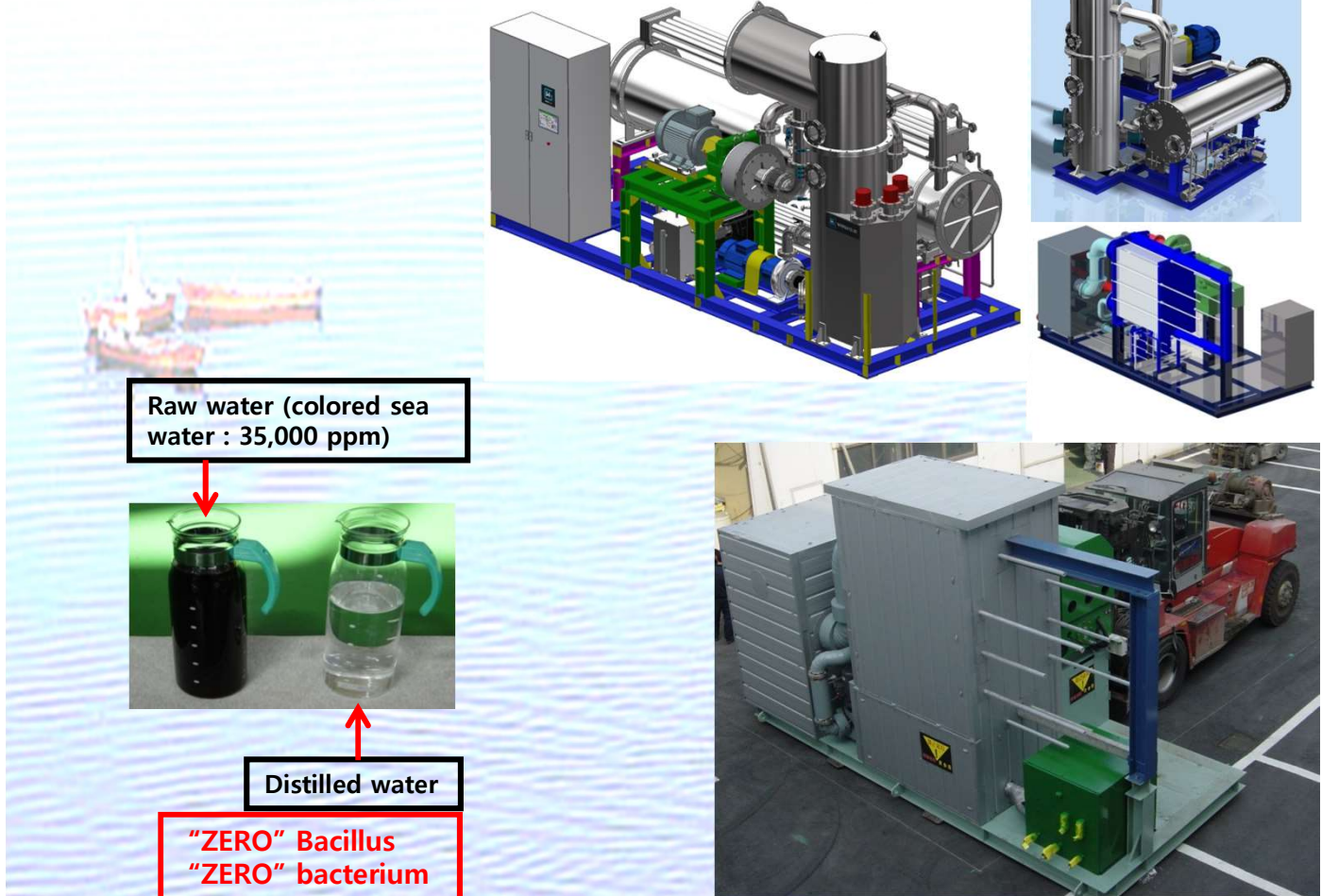




Drinking Water Distiller System

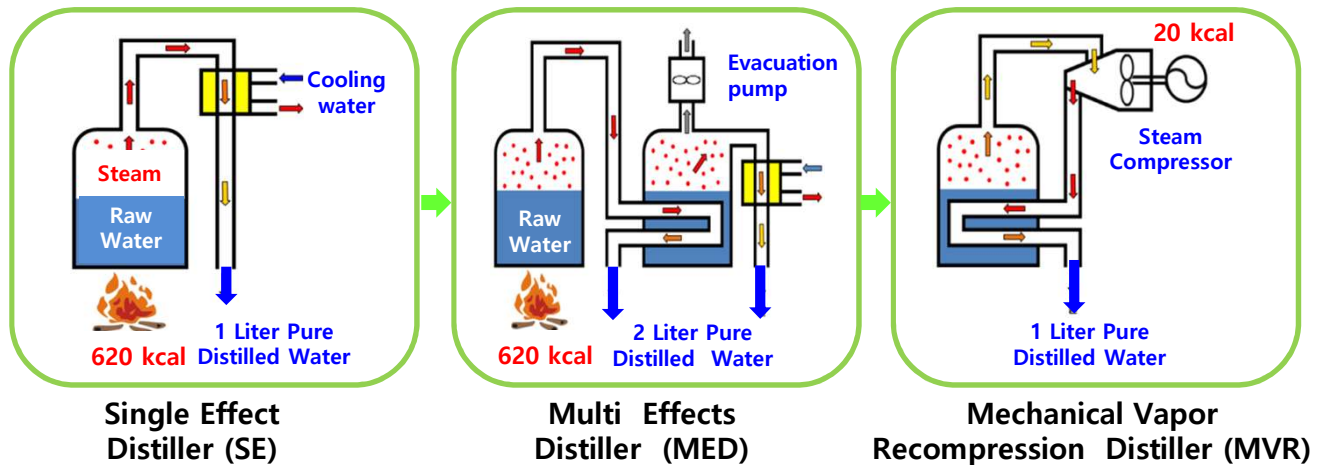
Turbo-MVR Distiller system converting sea /dirty/infected/muddy water into clean drinking water...

- **Can be applied to any type of water** : sea water, saline water, contaminated & infected ground/underground water, muddy water, etc.
- No level of cleanliness of raw water required
- No need for pre & post treatment
- 100% sterilization with high temperature : **Naturally getting "ZERO" Virus water !**
- Available for small size/integrated and fixed type/transportable type : **Can be installed in any location (suitable size within 20 feet standard high cubic container)**
- No Need for Periodic Parts Replacement
- **No Chemicals Dosing**
- Automated Operation : **No need for special operator**





Principle of Energy Recovery for Evaporation Distiller System



Methods	1 Effect	2 Effects	~	10 Effects	1 MVR
Input Energy (Kcal/Liter)	620	310	~	62	20
Input Energy (kWh/ton)	720	360	~	72	23

➤ Research & Development Goal : Energy Recovery & Saving =>Low Operation Cost !

Using the evaporation method to get clean water or salt is very common. Nowadays, reducing the energy needed to run the evaporation method based machines is a hot issue.

First, the simple SE(Single Effect) method takes about 620 kcal to make 1L of distilled water. We boil the water and collect the steam. Finally, we cool it down to get pure water from the steam. But, this means that we are throwing away all the heat energy into air through cooling water. The water manufacturing cost increases as we waste more energy.

To prevent the energy loss, people put the machines in serial lines, which is called MED or MSF method. But these were not quite satisfactory for us.

So, we thought to compress the low pressure steam with a compressor (which works with 20kcal of electric energy). We then used this compressed steam to boil the original water where the steam came from via heat exchangers. This became an ideal machine, MVR, which can recycle up to 90% of the original input energy shown in the SE method.

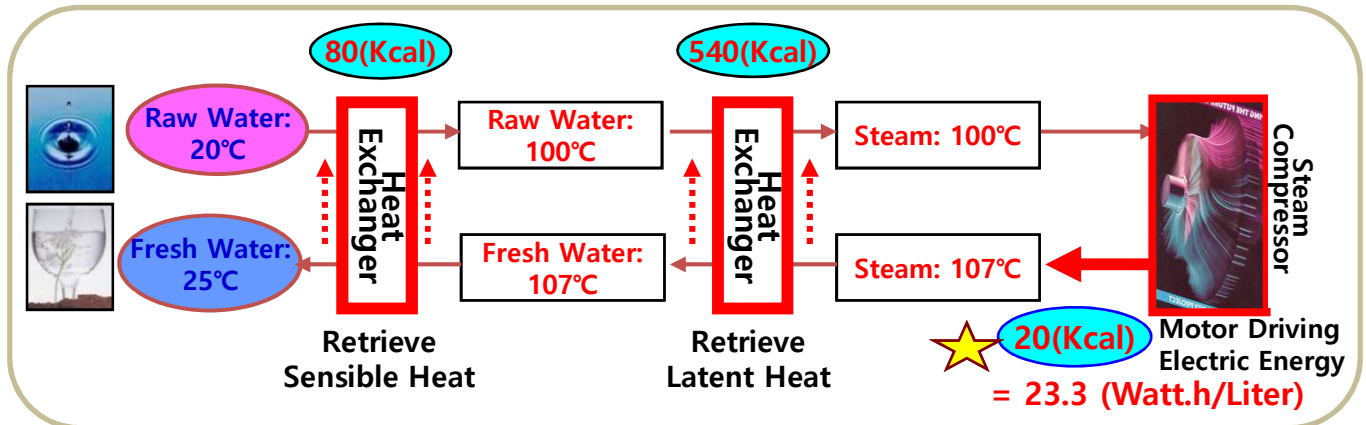
However, to build and operate MVR, we need a turbo type steam compressor which require a high level of technology. Only the technologically advanced countries can make it, so those countries that do not possess this technology have great problems to research and develop.

The existing machines using the SE(Single Effect) method need 720 kWh of energy to get 1 ton of water. But MVR needs only 23 kWh, which is just 5% of that required in SE. This is why they call the MVR machine "highly efficient machine".

We evaluate the energy reuse with COP(Coefficient of Performance). Our MVR has a COP of 31.



How does the Turbo MVR distiller system work in more detail ?



When 1 liter of 20°C raw water receives 620 kcal of energy, saturated steam is made through 100°C saturated liquid.

As this low pressure steam is compressed with a turbo compressor, using approximately 20 kcal of electric energy, the temperature rises up to 107°C.

Thermal energy of this high pressure 107°C steam is transferred to 100°C raw water through a large latent heat exchanger and the energy of the 107°C condensed water is transferred to 20 °C raw water through small sensible heat exchangers, finally condensed water of 25°C is made.

For an efficiently energy utilization, the variety of operational temperature difference is achieved by variable speed operation of steam compressor (3~10°C).

By inputting 20 kcal of electric energy, 620 kcal of thermal energy is recovered and recycled.



High Speed Turbo Steam Compressor
(ADR 100 Model)



Turbo MVR Distiller (ADR 75 Model)

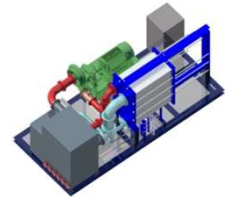




Watergen Co.

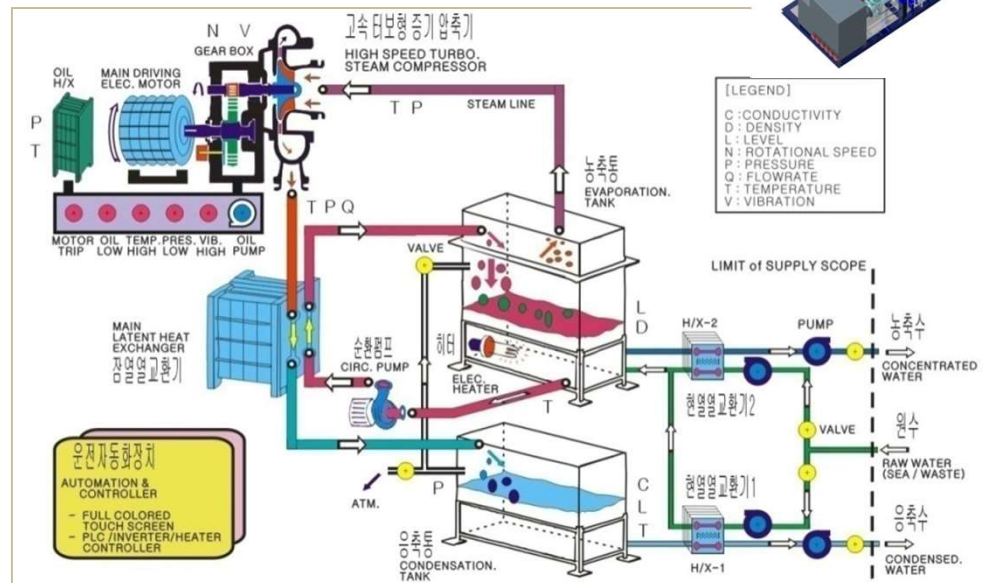
Original technologies required for developing Turbo-MVR :

- High speed turbo-blower, steam compressor, plate & pipe type heat exchanger : designing/manufacturing/operating technologies
- Automation/control and system integration technologies
- Watergen Co., secured with 100% self-developed technologies



[Main Components]

Evaporation tank,
Condensation tank,
Plate type(or pipe type)
latent heat exchanger,
Turbo steam
compressor,
Circulation pump,
Sensible heat
exchangers, Electric
heater, Condensed /
Concentrated / Raw
water pump,
Equipment controller
& automatic operation
panel.



Water Recovery Rate and Power Consumption

Type	TDS(ppm)	Recovery Rate(%)	Power consumption (kWh/ton)	Remark
Sea Water	15,000~50,000	50 ~ 85%	30.3 ~ 63.3	* TDS : Total Dissolved Solid
Brackish Water	1,500~15,000	85 ~ 98%	27.0 ~ 30.3	
Underground Water		More than 90%		It depends on the amount of TDS

The input raw water can be concentrated until max. 100,000ppm(=10% density) by MVR Distiller

☞ Water recovery rate = $\{1 - \text{TDS} / (100,000\text{ppm})\} \times 100$

※ Example : in case of TDS 15,000 of input raw water

Water recovery rate = $\{1 - 15,000 / 100,000\} \times 100 = 85\%$, Rejected water rate : 15%

It means we are able to extract pure drinking water of 85% from input raw water.

Power consumption calculation formula, based on our experiences :

☞ Power consumption(kWh/ton) = $145 / 100 \times (\text{concentration})^2 + 27$

※ Example : in case of TDS 15,000 of input raw water, concentration may be 1.5, expressed by percentage of density of impurity dissolved in water.

Power consumption = $145 / 100 \times 1.5^2 + 27 = 30.3(\text{kWh/ton})$

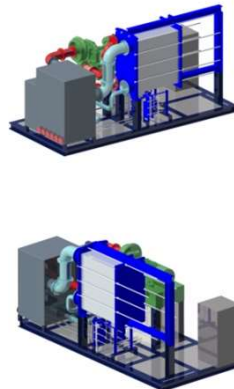
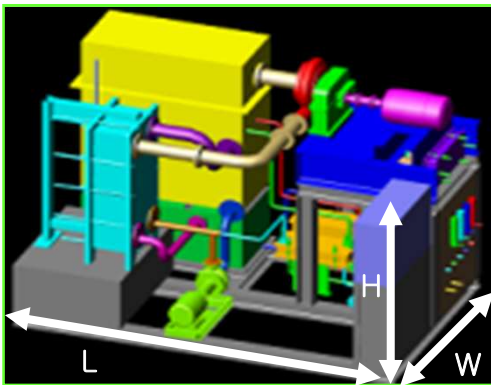




Turbo_MVR Distiller Model & Dimension

❖ Basic Model

Model	Capacity (m3/day) (ton/day)	Dimension (meter)			Weight (ton)	Delivery (months) On FOB	Test before delivery
		L	W	H			
ADR 25	25	6.0	2.5	2.9	10	4 – 6	Witness test at factory
ADR 50	50	6.0	2.5	2.9	13		
ADR 75	75	6.0	3.5	3.6	15		
ADR 100	100	6,5	3.5	3.6	17		
ADR 200	200	7.5	4.0	4.0	20		



❖ Tiling-Up Model

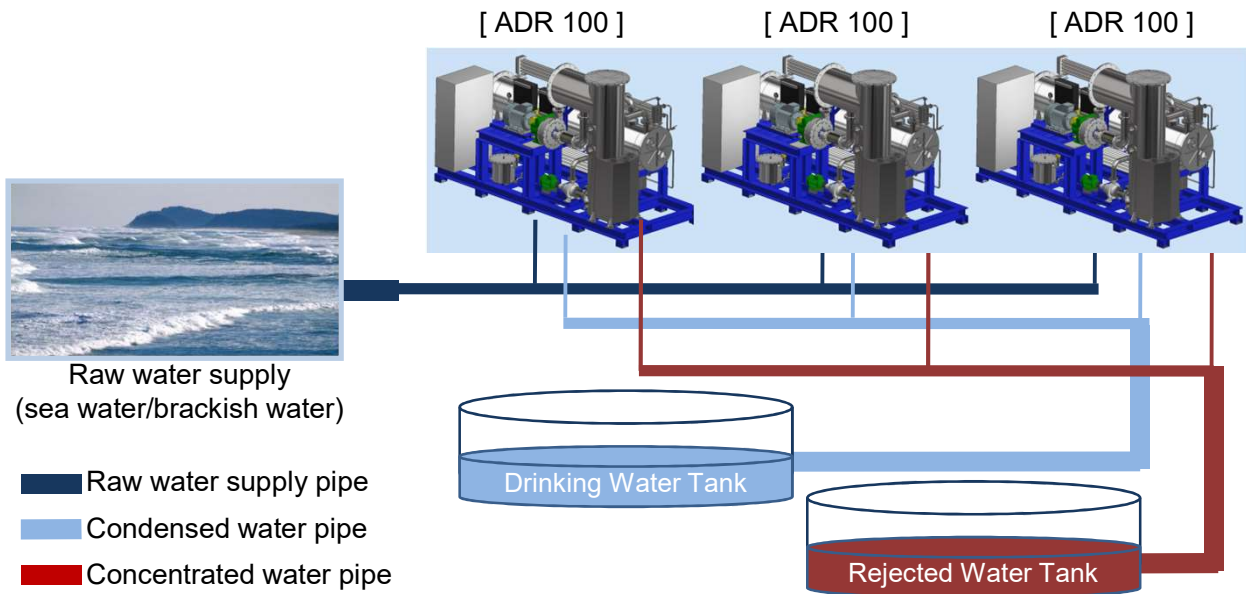
Model	Capacity (m3/day) (ton/day)	Dimension (meter)			Weight (ton)	Delivery (months) On FOB	Test before delivery
		L	W	H			
ADR 300	300	6.5	3.5*3	2.9	17*3	6 - 9	Witness test at factory per set
ADR 500	500	6.5	3.5*5	2.9	17*5		
ADR 1,000	1,000	6.5	3.5*10	2.9	17*10		

- ☞ According to user's requirement, we can meet the requested capacity by tiling-up model thru combining our MVR distiller ADR 100.
- ☞ In case of increasing water consumption after installing MVR distiller, it is possible to add additional MVR distiller easily.

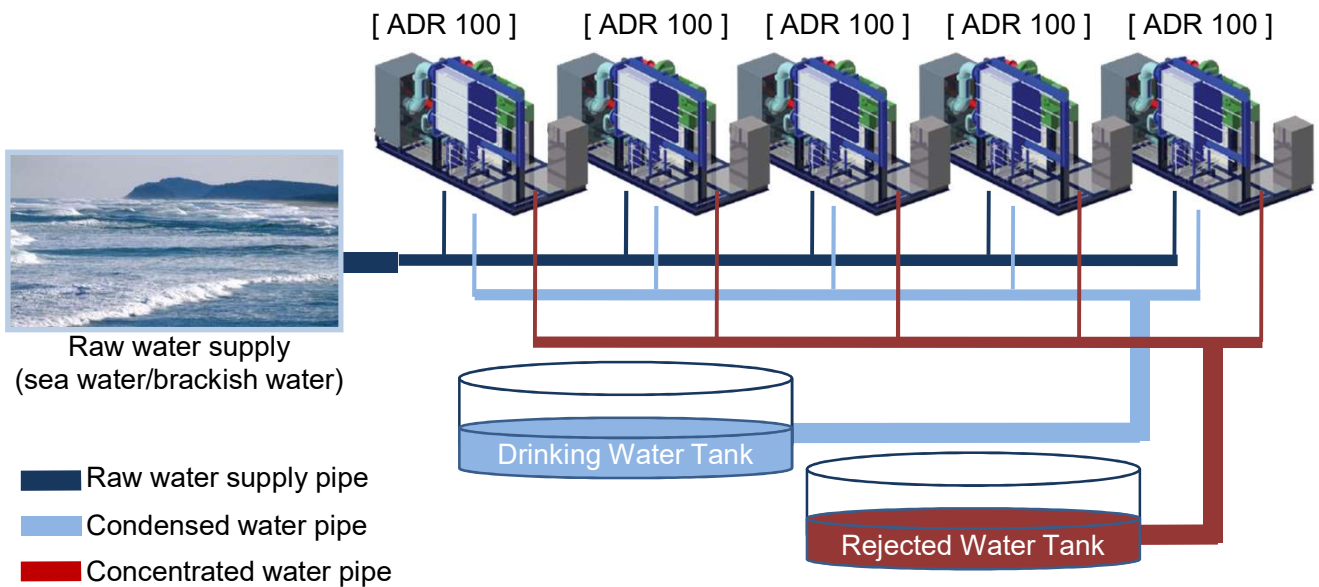




[Tiling-Up Model : ADR 300]



[Tiling-Up Model : ADR 500]





Water Production Cost Analysis (Sample)



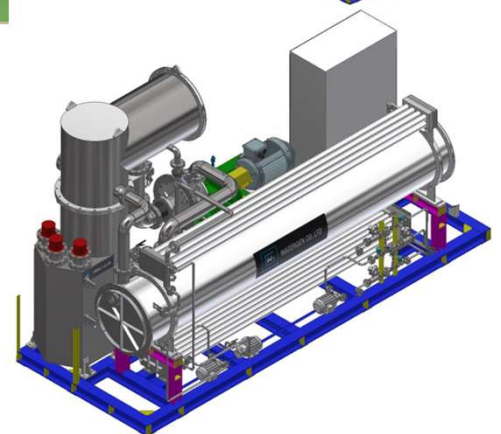
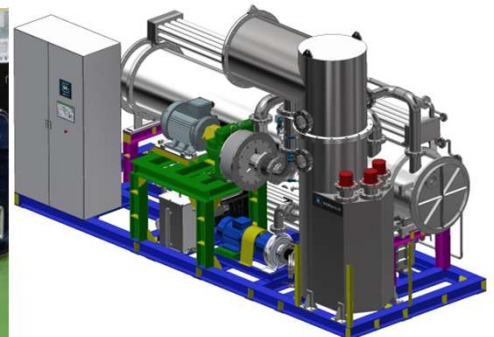
Turbo MVR Distiller (ADR 100 OLD Model)

Electric Energy
Required for Water Production :

= 40 (Watt. hour/liter)
= 40 (kWh/ton)
(* included for all components in MVR system)

Water Production Cost :

= 40 (kWh/ton) * 60 KRW/kWh
= 2,400KRW/ton [Equivalent to 2USD/ton]
on Korean Power price of 60 KRW/kWh
= 2.4 KRW/liter



MVR Distiller (ADR 25-100 NEW Model)

When we evaluate the amount of electricity that we use to make water, we use 40 Watt-hour per 1 L of water. That makes 40 kWh per 1 ton of water. In Korea, 1 kWh is about 60 Korean Won, so when we are making 1 ton of water, we are spending 40(kWh/ton) * 60 (won/kWh) = 2,400 Won. When converted to 1 L, it is 2.4 Won. The cost of electricity is different in every country, but you can calculate it by the same procedure we showed you. You can then see if making clean water is cheap or not.

[100 ton/day] →
[100,000 Bottles(1 Liter)/day]

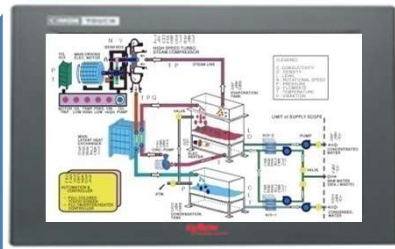


[Estimated number of persons to drink]

- 1) If 1 person needs 10 (liter/day) of water
→ 100,000 (liter/day)/10 (liter/day) = 10,000 (persons)
- 2) If 1 person needs 100 (liter/day) of water
→ 100,000 (liter/day)/100(liter/day) = 1,000 (persons)
- 3) If 1 person needs 200 (liter/day) of water
→ 100,000 (liter/day)/200(liter/day) = 500 (persons)
- 4) If 1 person needs 300(liter/day) of water
→ 100,000 (liter/day)/300(liter/day) = 330 (persons)



Automatic Controller of Turbo_MVR Distiller



**10 inch Full Color
Touch Screen
on Windows 7**



High Performance Control System :

The system is composed of the basic unit made of the high performance programmable logic controller (LS_GM6_PLC), with the special modules(sending & receiving 4-20 mA signal from/to sensors, temperature, pressure, level meter, flow meter, inverters, etc), and the 16,700,000 true color HMI touch screen used for taking and confirming a user's operational commands, displaying status and trends, and storing of data.

It is equipped with RS232, RS485, and Ethernet communication ports to communicate with other equipment, and it is programmed to enable remote operation with an existing other system, and also to control a number of MVR distillers efficiently and individually.

HMI Hardware Features :

- ◆ Embedded high speed CPU
- ◆ Visualizes up to 16.7 mega colors
- ◆ Supports serial(RS232C,RS422,RS485) and Ethernet communication
- ◆ Resistive type soft touch
- ◆ Supports Window 7 (32 bit)
- ◆ Including USB and SD memory card slot for data storing

HMI Software Features : (provides the same environment as SCADA)

- ◆ Edit project data
- ◆ Defines TAGs in Real-time DB
- ◆ Configures network
- ◆ Sets up advanced functions (Log, Alarm, Trend, Recipe ...)

Visible & Easy Operation on Human-Man-Interface System

**with Full Colored Touch Screen
helps your reliable and easy operation :**

The visually and easy-to-use HMI touch screen panel takes the user input parameters required for operation, shows the status map, the trends of the major parameters, alarms, and the causes of any errors, as well as the storage capacity of the operational data.

Following the directions on the touch screen, you first push the start button, and simply watch the operational status.

If there are any problems with the equipment, it shows where, why, and when the problems began at a glance, automatically saving the data and stopping the equipment safely.

In other words, you can become a professional operator without any special training.





Questions and Answers :

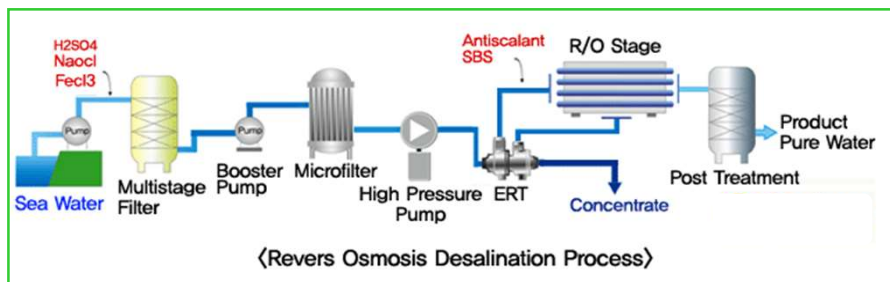
Q1 What is the operational status of the "RO" filter desalination machines below 100 ton/day class in Korea ?

A1 In Korea, desalination machines using the "RO" filter have been installed at many islands, but few machines have operated more than six months. This shows that there are many difficulties in operating those under optimized operating manuals.

We figured out the reasons why people couldn't run these machines longer.

- The lifespan of "RO" filter has been known to be about two to three years, but in reality it only holds for five to six months. Also membrane replacing expenses were higher than people had thought.
- The high-pressure pump had frequent breakdowns, also the components of the pump were from overseas which made them hard to obtain.
- The unprofessional operators felt the dangers in handling the chemicals, leading to inappropriate prescription of agents which resulted in contamination to drinking water.
- In addition, many chemical agents are used to sterilize and protect the membrane, but these cannot kill bacteria perfectly.

For reference, Korea Water Resources Corporation (K-water) has installed and controlled "RO" filter desalination systems in the below 100 (ton/day) class on many islands, and then recently reported that making 1 ton of drinking water costs above 8,000 (Korean won), equivalent to 7.3 US \$.

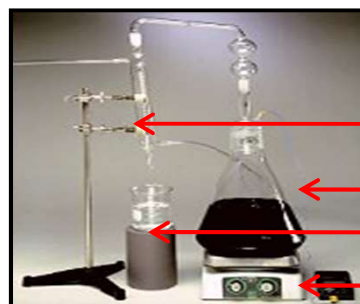


Q2 How can we estimate the quality of distilled water derived from any raw water in a local site after treatment by the Turbo MVR distiller ?

A2 You may think that the Turbo MVR will fail to provide clean water. In that case, use the simple version of distiller apparatus as a test. That simple apparatus and our MVR work by the same principles, so the result will be absolutely the same.

This device is a simple version of our distiller apparatus. You pour some raw water in the flask and boil it up to 100 °C. With the generated steam, you cool it with cold water and you can get the distilled water. Please ask a local public officer to check the quality of this distilled water.

If you have any trouble looking for any of the Equipment around you, then simply use your pot at home and make steam and cool it. You will get the same result.



Water Cooler

Raw Water

Distilled Water Collector

Electric Heater



Q3 Compare the specific characteristics between Turbo MVR and RO-Filter distiller system.

A3

Evaluation Items	MVR Distiller	RO	Remark
Contamination of inflow seawater	Not effected	Critical issue	Needs tube well, pretreatment facility
Chemical dosing	Not required	Absolutely required	sulfuric acid, chlorine, Fecl3 etc
Sterilizing for water	Not required	Absolutely required	
Pre Treatment Facility	Not required	Absolutely required	
Post-Treatment Facility	Not required	Absolutely required	
Quality of Drinking Water	Excellent (TDS<100ppm)	Good (100<TDS<500ppm)	TDS<500ppm standard of drinking water
Main A/S Items	Seal part of low pressure industrial pump	Parts of high pressure pump	MVR : 1-2kgf/cm2 RO : 50-70kgf/cm2
System Constituents	Very simple	Very complex	
Brine Disposal	No chemicals, No problems	Environmental severity with various chemicals	Needs of special pollution treatment facility
Periodic Replacing Items	Not	Filters (NF, RO)	
Initial Cost of Distiller	High	Low	
Usage of Brine (Concentrated sea water)	Yes (Salt, Minerals)	No (containing various chemicals)	
Technology Level	High	Low	Possible in advanced Nations

Q4 Compare the specific characteristics between Turbo MVR and MED & MSF distiller system.

A4

Evaluation Items	MVR Distiller	MED	MSF	Remark
Comparative Energy Efficiency	25	2	1	Based on 1 stage
Equipment Size	Very small	large	Very large	Based on same capacity
Power resource	Electricity only	Electricity + steam	Electricity + steam	





Application : Malignant Waste Water Treatment System

High efficiency high speed Turbo MVR system converting waste water into clean renewable water & volume reduction...

- Effective for all types of non-volatile malignant waste water -> Multipurpose
- Absolutely no periodic replacement of parts -> Reduces operating cost
- **Absolutely no use of chemicals** -> Reduces operating cost
- **No need for sterilization** -> 100% sterilization with high temperature -> Reduces operating cost
- No special need for pre/post treatment system -> Takes the smallest installation space
- **Can be installed anywhere** -> Cope with small demand
- System reduced in size -> Transportable package (20 feet standard container size)



Sample for malignant waste water treatment :

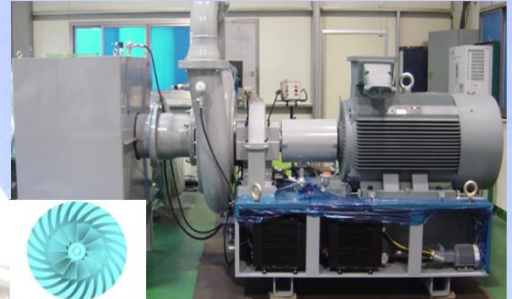
- Treatment Place : Plating factory in Ansan city, Korea
- Influx waste water specification : Volume 90 (ton/day), TDS 16,300 (ppm)
- Efflux condensate clean water : Volume 80 (ton/day), TDS 48 (ppm)
- Efflux concentrated waste water : Volume 10 (ton/day), TDS 147,000 (ppm)
- Total volume reduction ratio : 1/9
- Treatment price per condensate water ton : below 5,000 (korean won/ton) [= 4 US\$/ton]

No.	items	unit	Disposal Regulation Limit (korea) on specified area				Sampling : '08.05 (Plating Factory)		
			Clean	"A"	"B"	"C"	By korea chemical test institute		
							Influx	Efflux	Treat(%)
1	BOD	mg/ℓ	40	80	120	30	79.4	9.1	88.5
2	COD _{Mn}	mg/ℓ	50	90	130	40	484	28.3	94.2
3	SS	mg/ℓ	40	80	120	30	186	2.0	98.9
4	T-N	mg/ℓ	30	60	60	60	504	6.01	98.8
5	T-P	mg/ℓ	4	8	8	8	0.85	0.05	94.1
6	CN ⁻	mg/ℓ	0.2	1	1	1	ND	ND	
7	Cr	mg/ℓ	0.5	2	2	2	1.42	0.02	98.6
8	Fe	mg/ℓ	2	10	10	10	62.2	0.14	99.8
9	Zn	mg/ℓ	1	5	5	5	183	0.11	99.9
10	Cu	mg/ℓ	1	3	3	3	0.07	0.03	57.1
11	pH	-	5.8~8.6	5.8~8.6	5.8~8.6	5.8~8.6	5.7	6.8	
12	Conductivity	μs/cm	Reference				24,700	57	99.8
13	Na	mg/ℓ	Reference				5,180	1.77	100.0
14	Ni	mg/ℓ	Reference				1.41	0.02	98.6
15	TDS	mg/ℓ	Reference				16,300	48.0	99.7





Turbo Steam Compressor's Characteristics for MVR Distiller System



1. Extensive Experience / Usage

We developed a highly reliable and efficient high-speed turbo blower and steam compressor with a user-friendly automatic controller, after over 20 years of experience in development !

These Turbo systems are suitable for the aeration of sewage and waste water disposal plants that require oil-free compressed air, conveying chemical/cement/crop powders, supplying oxygen in fish farms, incinerator, other industrial use, and specially compressing low pressure steam for a MVR distiller.

2. Design and Manufacture through Optimization Analysis

Main components of the Turbo system are optimized ; a high-speed impeller using a complete 3 -dimensional aerodynamic flow analysis and CATIA modeling, the tilting pad bearings and high-speed gears using vibration and rotor dynamic analysis !

3. Compact Turbo system & Simple Repair

One of the typical characteristics of turbo machines is that when the impeller, a major part of the machine, rotates at high speeds, its size reduces in reverse proportion to the speed. It is easy to maintain and repair small components including the impeller, but not everyone can develop high-speed turbo machines. It is pure technological strength that matters !

4. Convenient Operation

The Turbo system provides a visually operated and easy-to-use true color HMI control panel, which takes user input parameters required for the operation, and displays the status map, the trends of major parameters, alarms and causes of error, and the storage capacity of operational data !

5. No additional Facilities

The Turbo system generally uses oil to protect the bearings and gears, and it requires cooling water to cool the unit continuously. This requires a cooling tower, large and separate equipment installed on the outside. This is prone to causing problems, such as germ problems inside the tower in the summer and the freezing and bursting of pipes in the winter..

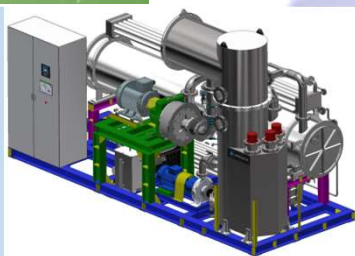
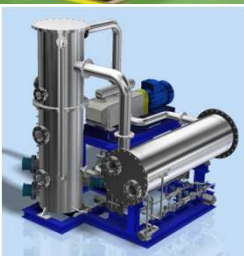
Our Turbo system has applied an air-cooling system to replace this hassling system, minimizing in the process of the cooling load of the gear and bearing oil, and reducing the maintenance and repair items.





We hope to work together in near future

Our Products will be seen all around you



WATERGEN Co.Ltd (www.watergen.kr)



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VER4 :WTG2012