TRENDS IN THERMAL DESALINATION

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OBJECTIVES

I. **Presenting the recent trends in thermal desalination processes.**

II. **Highlighting the modifications proposed or studied by our research team at Imam, KAU and UET universities.**

CONTENT:

I. Thermal desalination processes
II. Recommendations of the NRC
III. A novel Horizontal Evaporator
IV. Evaporative HTC in VFFE
V. Green Anti-scalant
VI. Decrease the specific energy consumption
VII. High temperature freezing
VIII. Single Effect TVC
IX. Hybrid venting system

THERMAL DESALINATION PROCESSES

I. **Most of the desalinated water about 87% (81% MSF & 13% MEE) in the Gulf is produced by the thermal desalination processes.**

II. **Thermal processes will remain the leading technology in GCC for , at least, the next two decades.**

ADVANTAGES OF THERMAL PROCESSES IN THE GCC

1. Proven processes, and there are no technical barriers.
2. Huge experience in operation & maintenance.
3. Extremely high quality of the desalinated water.
4. Very high operating reliability.
5. Less sensitive to feed water pollution.
6. Use of low grade energy.
7. Can be manufactured locally with available technology in the GCC.
8. Use few chemicals for pretreatment.
9. The predominant technology on large power and water projects.

DISADVANTAGES OF THE THERMAL PROCESSES

I. **High capital cost.**
II. **High specific energy consumption.**
III. **Impact of brine disposal on the environment**

REVIEW THE DESALINATION AND WATER PURIFICATION TECHNOLOGY ROADMAP

National Research Council (NRC)

I. Clear, understandable logic and scientific basis for each of the critical objectives.
II. Analyses of recent technological
III. Advancements, descriptions of current limitations.
IV. Values from which future advancements can be measured.

REDUCING THE COSTS (NRC)

I. **The use of alternative energy sources, particularly waste heat.**
II. **The use of innovative cooling systems.**
III. **Evaluate nonmetallic or polymeric heat transfer materials could significantly reduce capital costs.**
IV. **Augmentation of the heat transfer rate.**
V. **Identifies corrosion mitigation techniques or develops materials of construction that resist corrosion**

A NOVEL H EVAPORATOR

- **FEATURES**

1.The heat transfer surface is made of polymer matrix composites materials. The K for composite polymers materials can achieve up to 20 W/m K.

2. The condensation takes place over the external surfaces of the tubes.

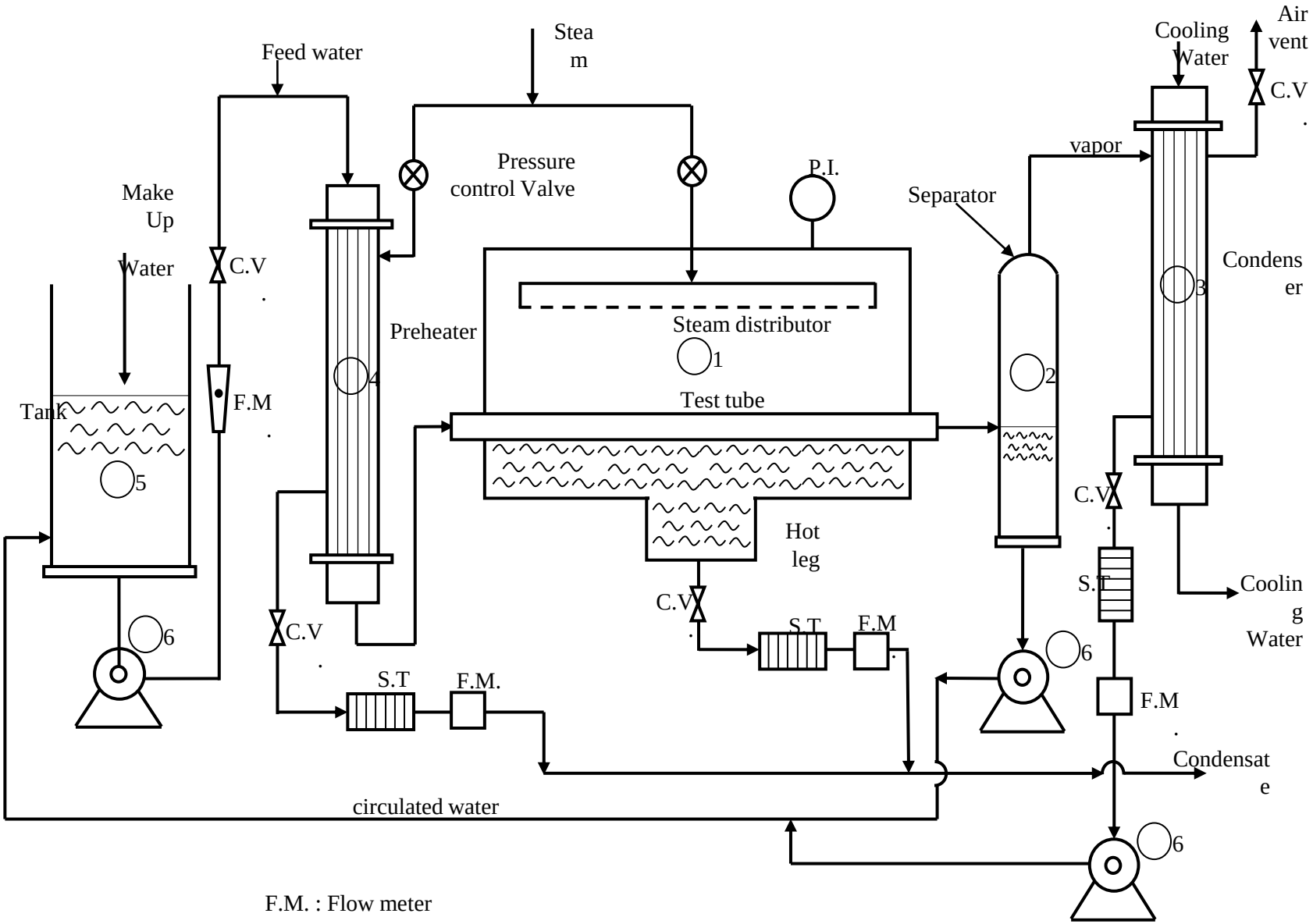
3. Tremendously high rate of heat transfer because condensation on the polymer surfaces promotes the drop wise condensation.

A NOVEL H EVAPORATOR

4. High resistance to erosion allows for a higher water velocity inside the tubes and consequentially elevated rate of heat transfer.

5. The system can adopt the mechanical on line cleaning to minimize the rate of scale formation. Also, cheap acids can be used to wash the heat exchangers.

6. Thermoplastics exhibit a desirable resistance to many chemicals.



F.M. : Flow meter

S.T. : Steam Trap

C.V. : Control Value

P.I. : Pressure gage

1Evaporator

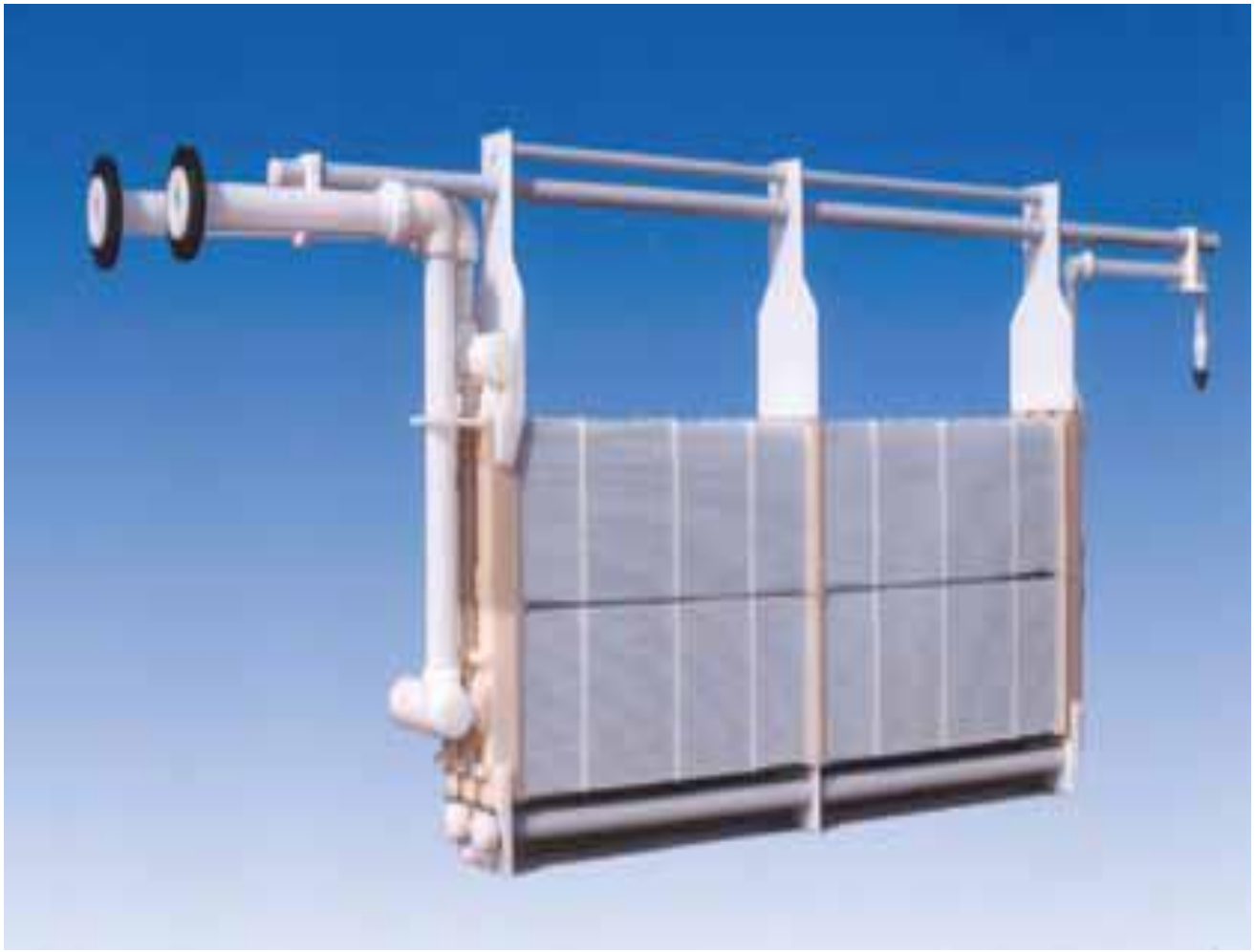
2Separation Tank

3Condenser

1Water preheater

2Feed water Tank

3Circulating Pump



EVAPORATIVE H T C IN VERTICAL FFE

I. Falling film evaporator characterized by a relatively low residence time, high heat transfer rates, comparatively low cost, high capacity, low hold-up, requires small floor space, can be easily cleaned, and high operating flexibility.

II. The heat transfer coefficient in the turbulent flow is about 28 times for the laminar flow at the same temperature difference and evaporation temperature,

EVAPORATIVE H T C IN VERTICAL FFE

The evaporation film (non-nucleate boiling regime) the nucleate boiling heat transfer

- **The minimum wetting rate (MWR)**
- **Fluid dynamic regimes**
- **Heat transfer coefficient**
- **effects of surfactant**

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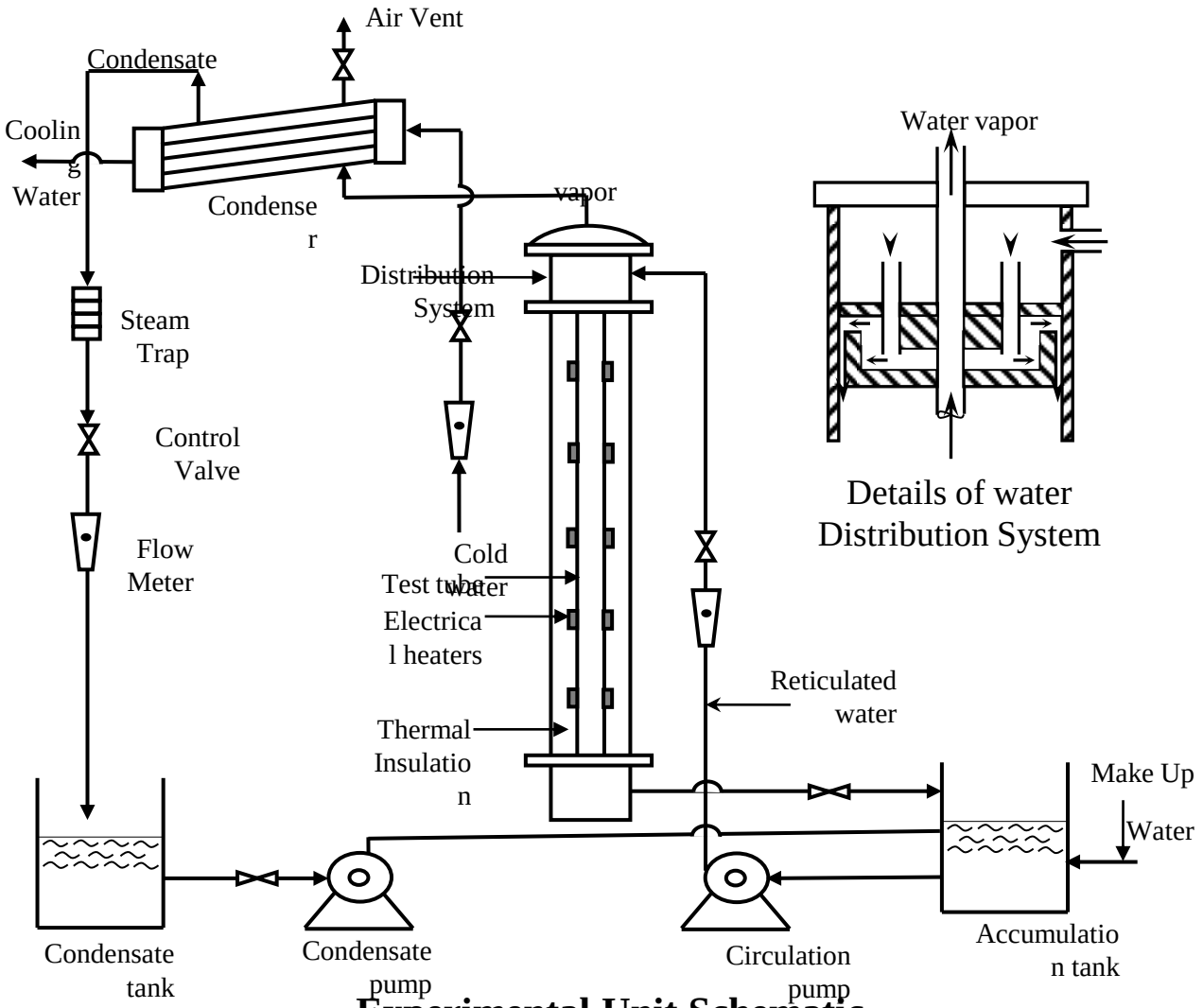


Experimental Unit Schematic

GREEN ANTI-SCALANT

- **Drawbacks of chemical inhibitors:**

1- Most of these chemicals are imported from foreign markets with high prices in GCC.

2- Unsafe to environment and health.

3- The discharge of a macronutrient may have drastic consequences

4- Excess dosing of chlorine may form by-products such as tri-hiolomethanes which are carcinogenic materials.

5- The use of metal salts such copper salts or/and zinc salts can damage the environment

GREEN ANTI-SCALANT

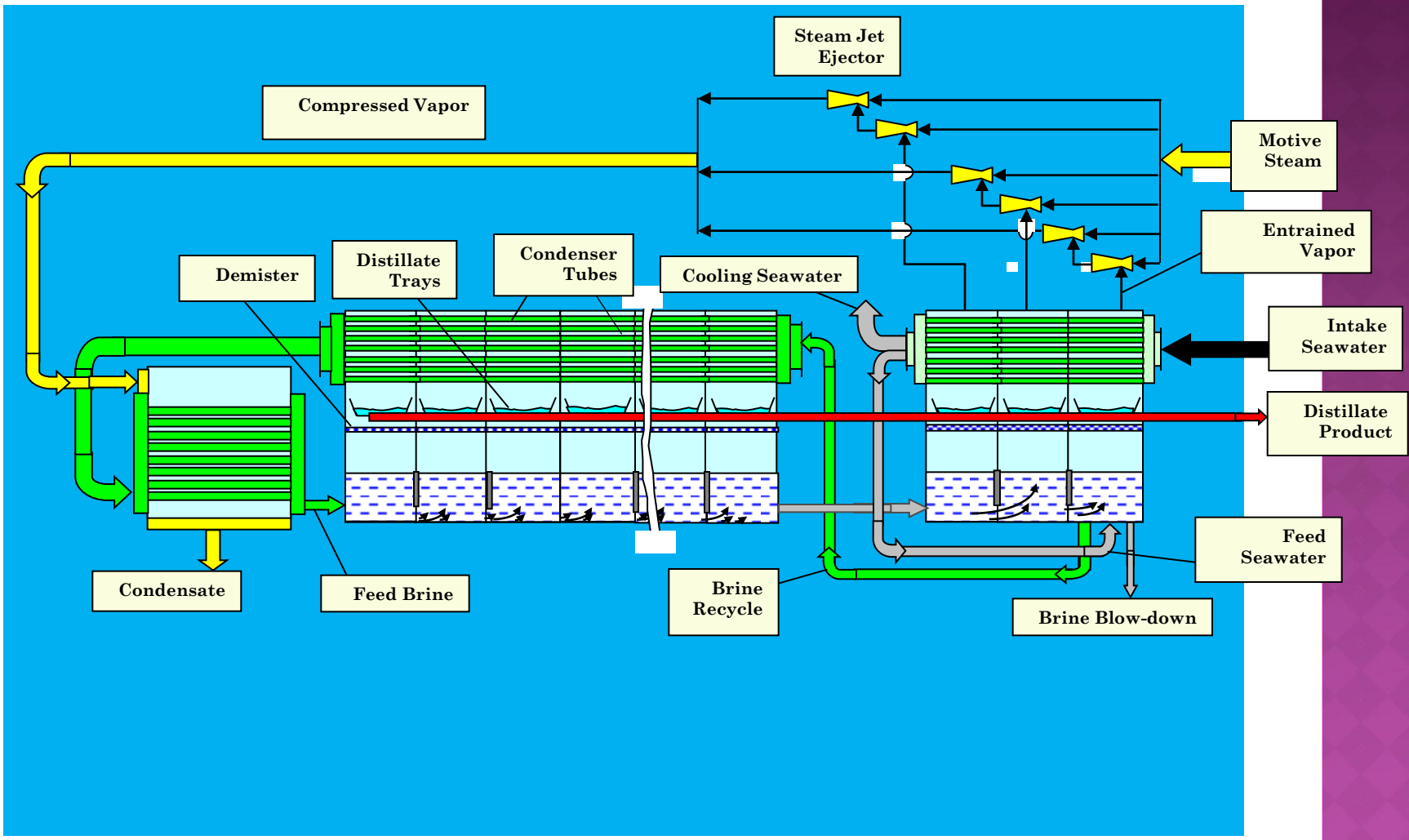
- The use of a controlled mass of some natural materials to control the scale formation in the thermal desalination units.
- This natural materials will create a very large surface area over which the scale will be formed. This will reduces the concentration of the scaling materials in the sea water.
- The natural materials will be abandoned to the sea with the rejected brine.
- The flow of natural materials through the heat transfer tubes will thinning the thermal boundary layer and consequently increases the heat transfer coefficient.
- The material is very cheap, biodegradable, and environmentally friendly.

DECREASE THE SPECIFIC POWER CONSUMPTION

MSF Thermal Vapor Compression

- This is achieved through upgrading the quality of part of the vapor formed in the heat rejection or heat recovery sections by thermal compression.
- The compressed vapor is used for heating of the brine recycle in the brine heater.

MSF THERMAL VAPOR COMPRESSION



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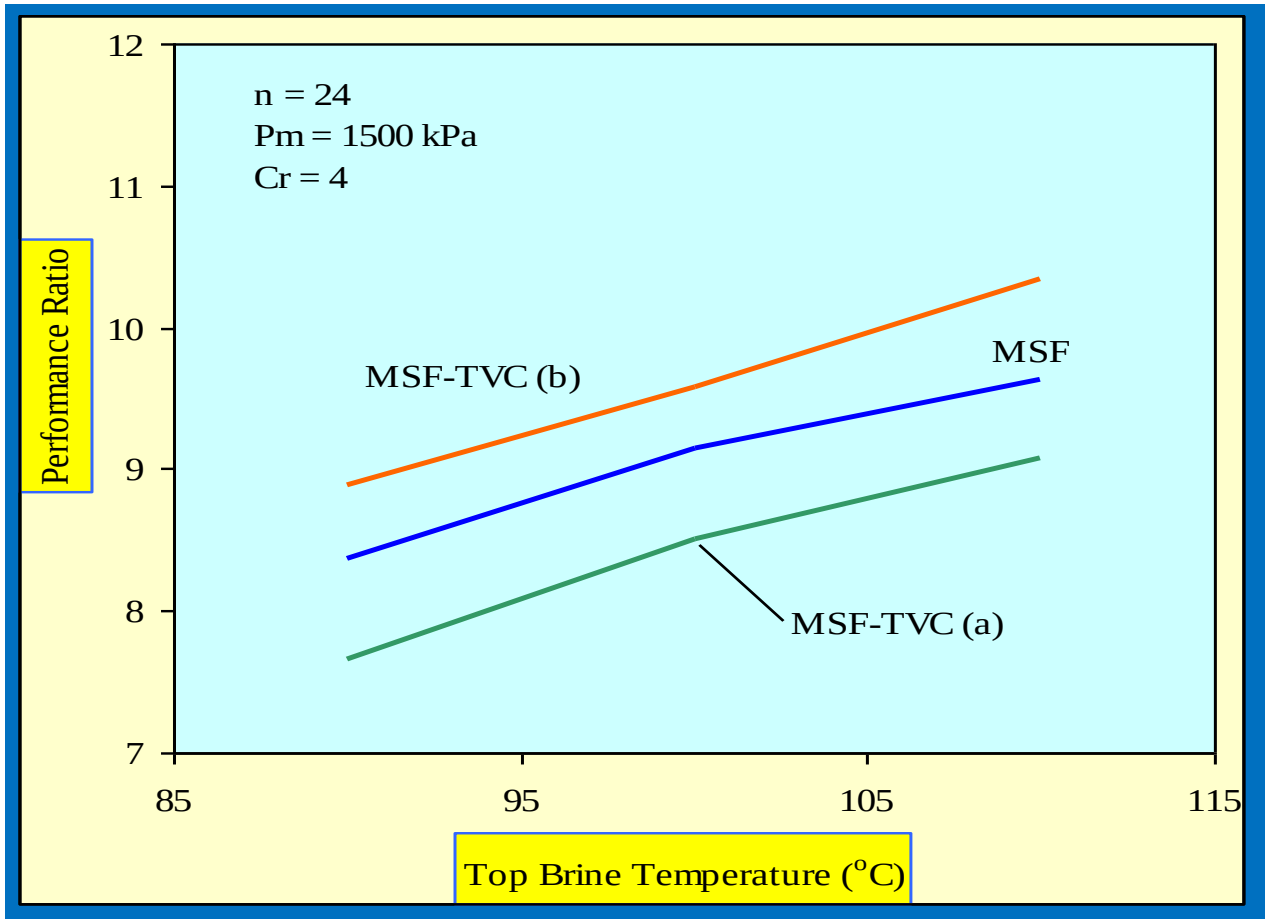

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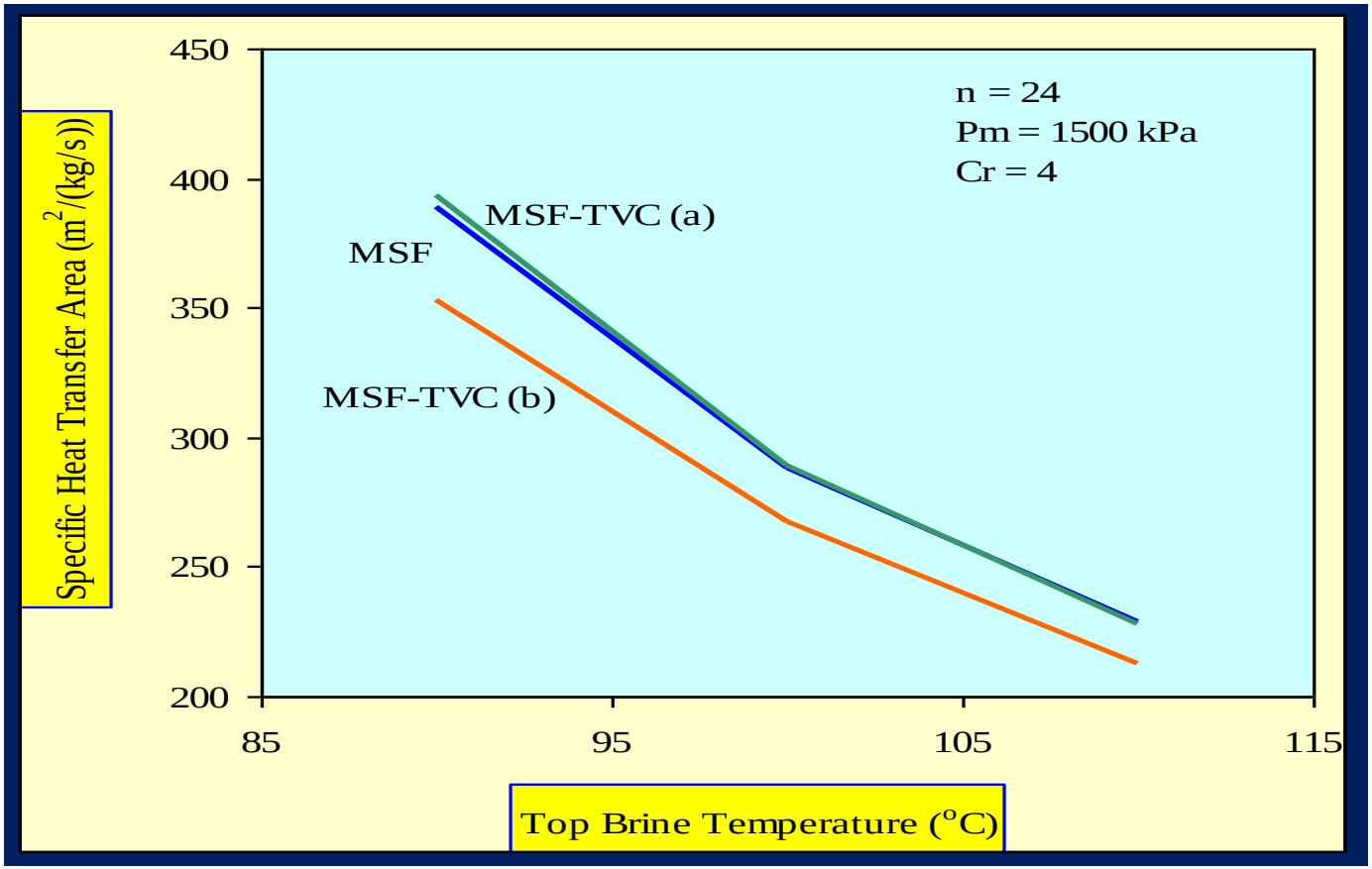

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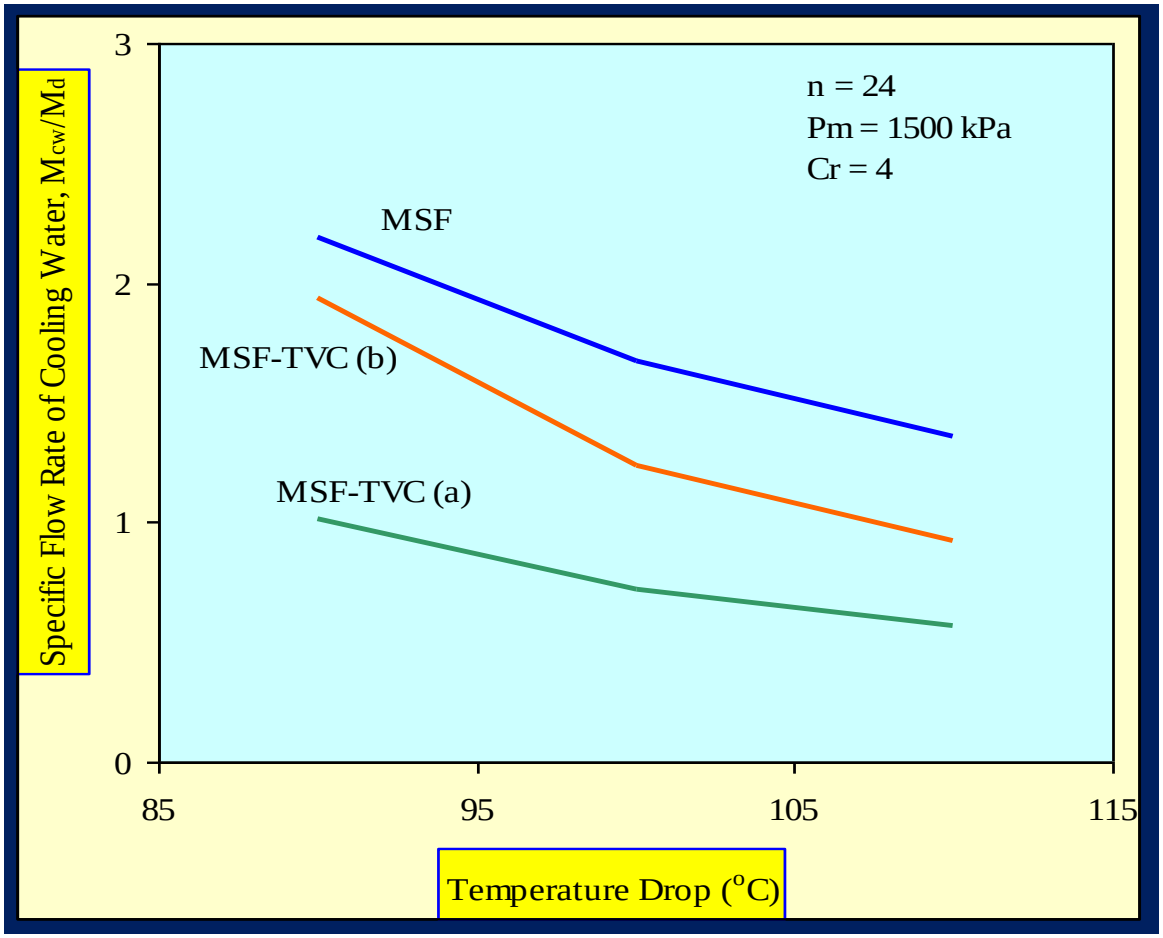


MSF THERMAL VAPOR COMPRESSION

I. Thermal vapor compression enhances the performance of the MSF system as a result of increase in the performance ratio and reduction in the specific flow rate of cooling water and the specific heat transfer area.

II. Vapor compression from stages operating at higher temperatures in the heat recovery section give higher performance ratios than for vapor compression from the heat rejection section.

III. The specific heat transfer area for the vapor compression mode from the heat recovery section gives lower specific heat transfer area from the heat rejection section.

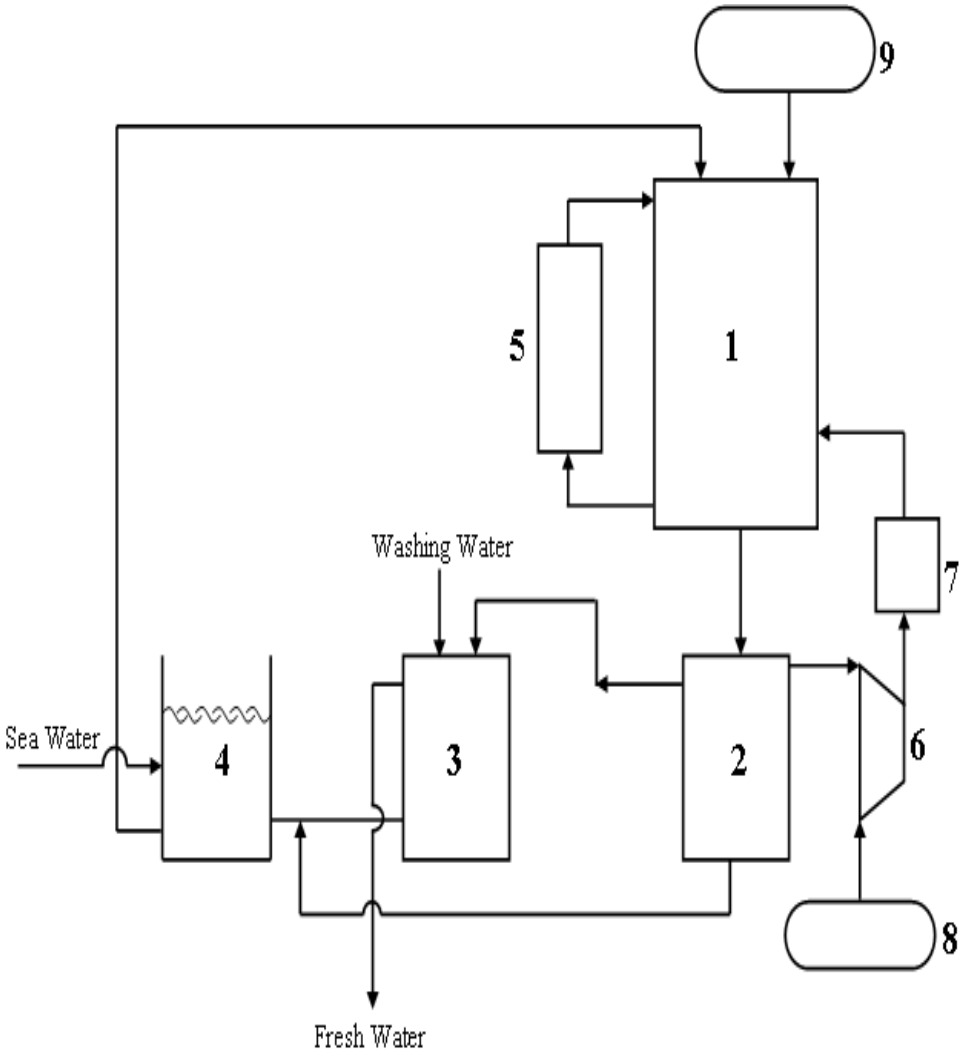
HIGH TEMPERATURE FREEZING

Principle:

I. When natural gas is thoroughly bubbled through salt water at a specified pressure and temperature a solid hydrate is formed. As the gas bubble moves up, gas diffuses out of bubbles, meets water and Gas hydrate is formed on the bubble surface.

II. During gas hydration process, the dissolved salts and other impurities are excluded.

III. these separated hydrates are melted to give water and natural gas.



1 Hydrate Reactor

2 Slurry Separator

3 Wash Colum

4 Sea Water tank

5 External Refrigeration Unit

6 Gas Compressor

7 Bubble generator

8 Natural gas cylinder

9 Nitrogen Cylinder

HIGH TEMPERATURE FREEZING

Main advantages:

I. **The unit can be produced locally with available materials of construction.**

II. **The process does not consume chemicals to control the scale formation or foaming.**

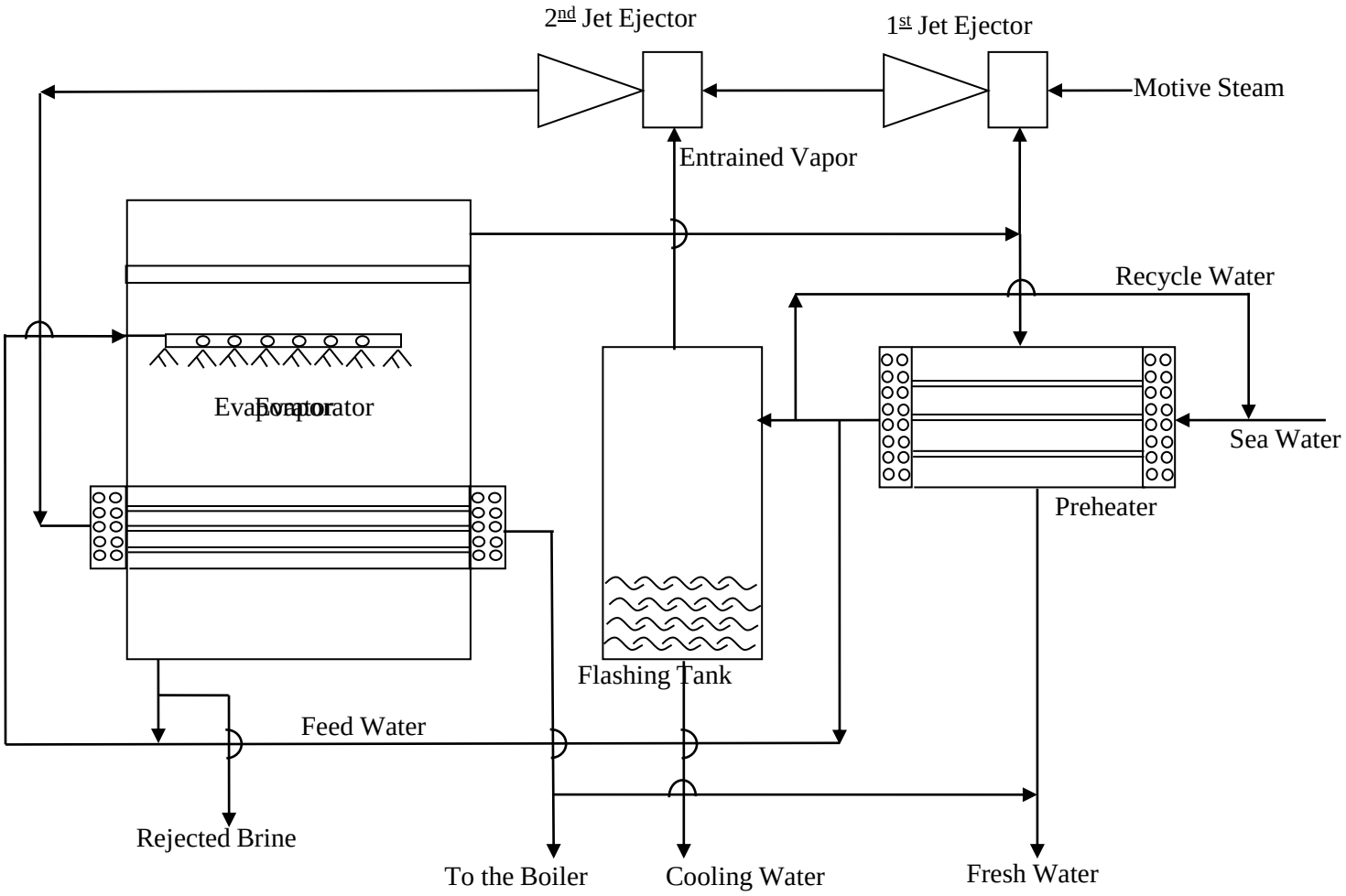
III. **The process does not pollute the sea or the underground water by dumping harmful chemicals with the rejected brine.**

IV. **The cost of the desalinated water by this process is about 2 SR/m^3 . This is 50% and 70% of the costs of the water produced from the large capacity MSF and RO plants, respectively.**

V. **It is very suitable for remote areas with low population capacity scattered in the Saudi Arabia**

SINGLE EFFECT TVC FOR WATER DESALINATION & AIR COOLING

I. About 70% of this heat is discarded with the cooling water
II. Such units are necessary to develop the remote arid areas all through the world. In particular, remote sparsely populated regions suffering from fresh water shortage and hot climate.
III. The system uses water as cooling fluid which is harmless cooling fluid.


2nd Jet Ejector
1st Jet Ejector
Motive Steam
Entrained Vapor
Recycle Water
Evaporator
Sea Water
Preheater
Flashing Tank
Feed Water
Rejected Brine
To the Boiler
Cooling Water
Fresh Water

HYBRID VENTING SYSTEM

I. Noncondensable gases have the effect of lowering the effective condensing side HTC.
II. The HT surface required to compensate these effects is about 8%.
III. Accelerates corrosion
IV. The function of the venting equipment is to maintain the vacuum.
V. Avoid the use of heavy bundle densities, gas baffles, vapor by-passing, small vent lines.

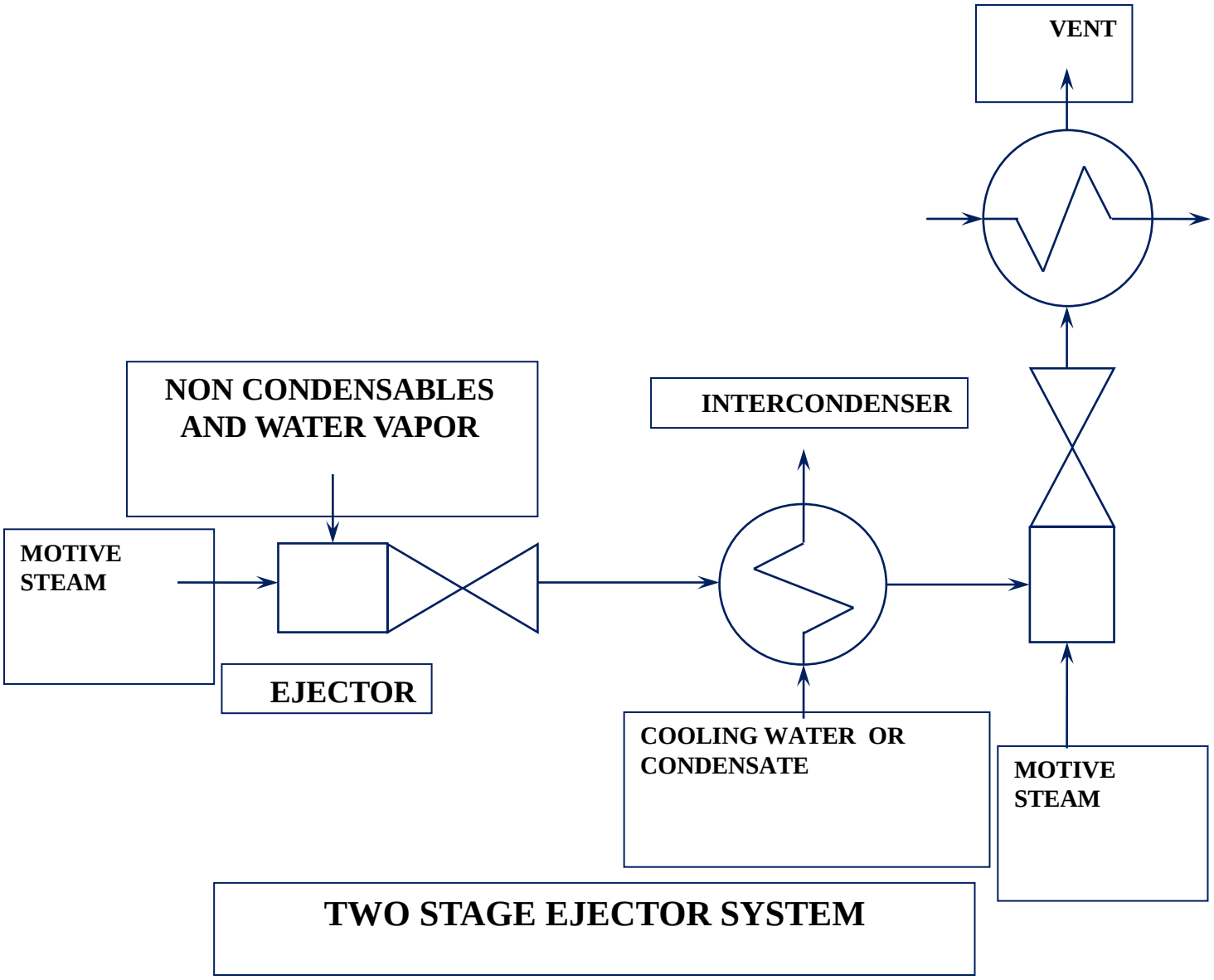
HYBRID VENTING SYSTEM

ADVANTAGES OF STEAM JET EJECTORS:

1. Low capital cost,
2. Low maintenance, most reliable,
3. Can maintain last stage pressure below design condition if air leakage is less than design.

DISADVANTAGES:

1. Not usually automated,
2. Separate hogging jet required,
3. Condensate drain required.


VENT
NON CONDENSABLES
AND WATER VAPOR
INTERCONDENSER
MOTIVE
STEAM
EJECTOR
COOLING WATER OR
CONDENSATE
MOTIVE
STEAM
TWO STAGE EJECTOR SYSTEM

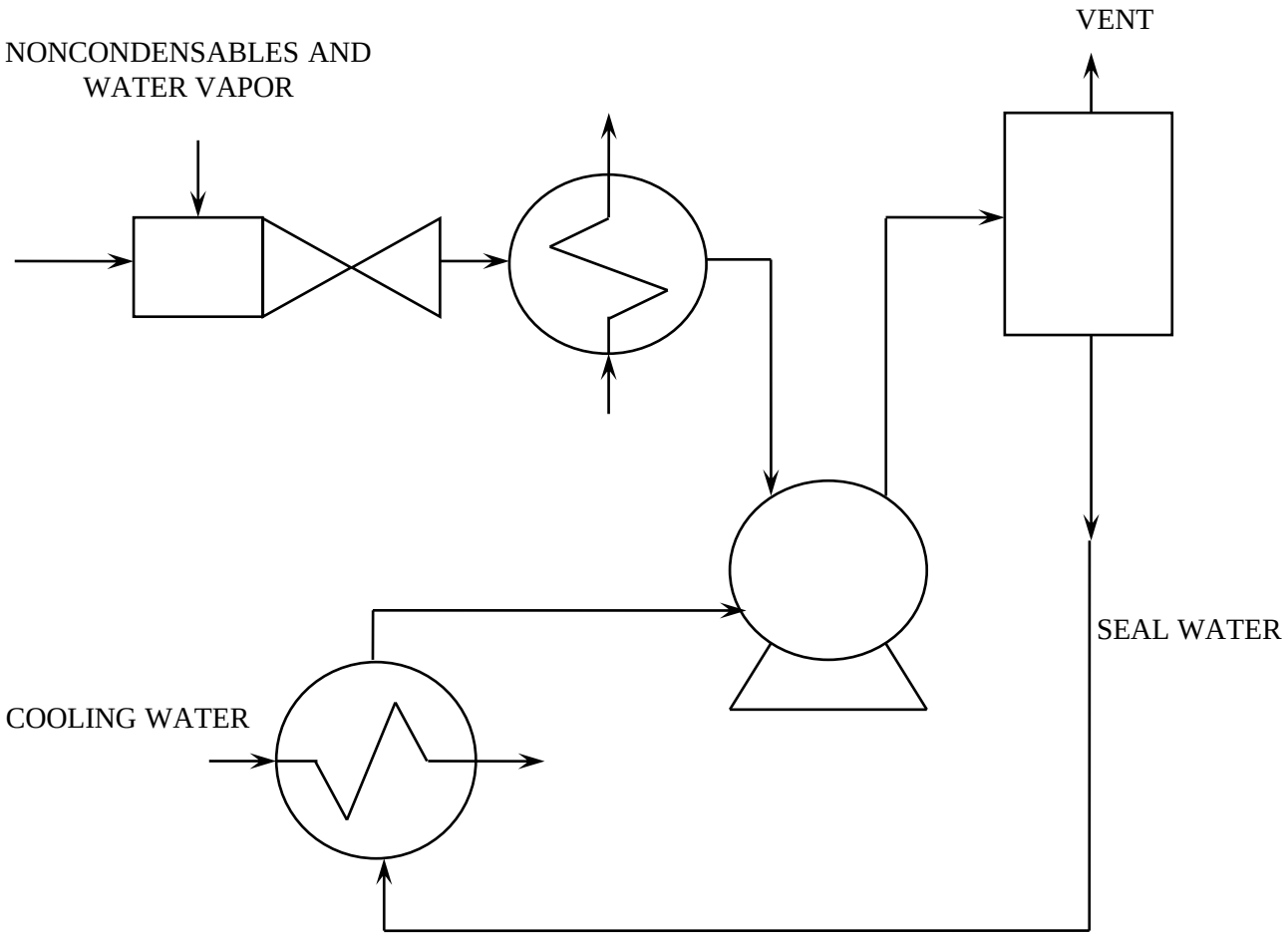
HYBRID VENTING SYSTEM

ADVANTAGES OF LIQUID RING VACUUM PUMPS:

- Compact and floor mounted,
- Fully automated,
- No separate condensate drain required,
- Capacity increases more rapidly at increased pressure ,
- No separate hogging is required.

Disadvantages:

- High capital cost
- Limited last stage pressure at part load



HYBRID SYSTEM

HYBRID VENTING SYSTEM

Advantages of the hybrid system:

1. Compact, floor mounted and fully automated.
2. Will not limited last stage pressure at part load conditions at design air leakage.
3. Can be designed for increased capacity.

Disadvantages:

1. Separate hogging ejector may be required.
2. Somewhat less responsive to the load increase.