Air Gap Membrane Distillation Research Project

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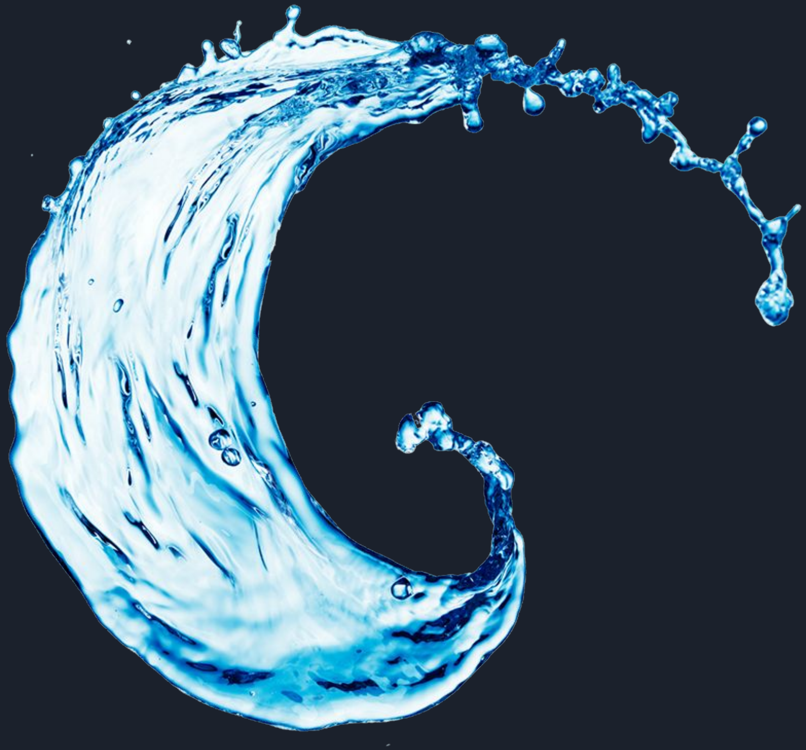
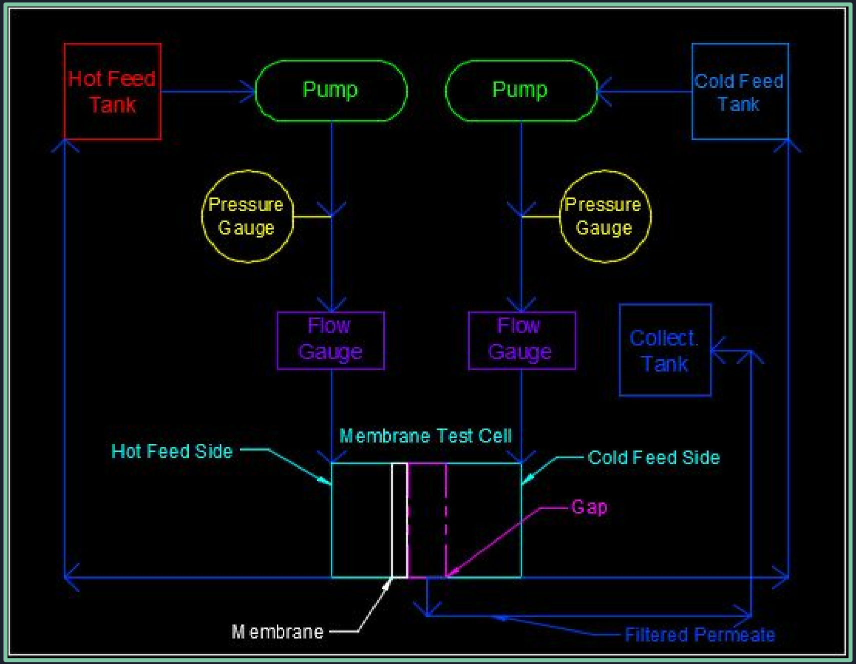
Overview

- Introduction to AGMD
- Objective
- Literature Review
- Preliminary Design
- Testing Variables
- Q & A



What is Air Gap Membrane Distillation?

- Distillation process that utilizes thermal separation
- Vapor pressure difference move steam molecules across the membrane and gap
- Molecules condense as they move towards the cold feed[1]
- Air-gap provides insulation and minimal heat transfer losses[2]



AGMD vs Other Distillation Techniques

- Reverse osmosis membranes are currently the most popular technology for desalination of groundwater

- Membrane distillation processes operates at lower pressures and requires lower temperatures, causing it to be cheaper

- Can generate high-purity water and even concentrate aqueous solutions[1]

Current Objectives

- Design a test cell and test bench for research at our lab

- Validate current literature and optimize system in hopes of large scale use

Literature Review Findings

Literature Review

Title of Article	Material Used in Membrane	Pore Size
Membrane scaling and prevention techniques during seawater desalination by air gap membrane distillation	low-density polyethylene (LDPE)	0.3 µm
Water desalination using graphene-enhanced electrospun nanofiber membrane via air gap membrane distillation	See table 1	
Effect of operating parameters and membrane characteristics on air gap membrane distillation performance for the treatment of highly saline water	see table 1	
Air gap membrane distillation: A detailed study of high saline solution	flat sheet polytetrafluoroethylene (F	0.2, 0.45 and 1.0 µm
Electrospun dual-layer nonwoven membrane for desalination by air gap membrane distillation	see table 4	
Air gap membrane distillation for enrichment of H218O isotopomers in natural water using poly(vinylidene fluoride) nanofibrous membrane	PVDF nanofibrous membrane	0.25 ± 0.05 µm
Experimental and numerical study of air-gap membrane distillation (AGMD): Novel AGMD module for Oxygen-18 stable isotope enrichment	Polytetrafluoroethylene (PTFE) me	0.45 microns
Superhydrophobic condenser surfaces for air gap membrane distillation	PVDF	
Water and air gap membrane distillation for water desalination – An experimental comparative study	hydrophobic flat PTFE	379 ± 8 nm
A new enhancement technique on air gap membrane distillation	polytetrafluoroethylene (PTFE)	1 µm
Produced water treatment: Application of Air Gap Membrane Distillation	TF200, TF450, TF1000	0.2, 0.45, 1 micron
Evaluation of air gap membrane distillation process running under sub-atmospheric conditions: Experimental and simulation studies	VMD	0.2 micron
" " "	Polymethyl meth-acrylate	0.2 micron
Artificial neural network modeling and optimization of desalination by air gap membrane distillation	Filtron Minisette, TF450, (PTFE supportec	0.45 micron
Air gap membrane distillation on the different types of membrane	Nine types of Membranes (PTFE,PVDF,P	varying sizes (TABLE 1)
Improvement of the Membrane Distillation performance through the integration of different configurations	polypropylene	0.2 µm
Evaluating energy consumption of air gap membrane distillation for seawater desalination at pilot scale level	microporous low-density polyethylene (LD	0.3 µm
Performance evaluation of hollow fiber air gap membrane distillation module with multiple cooling channels	polypropylene	0.2 µm
Improving the performance of the air gap membrane distillation process by using a supplementary vacuum pump	micro-porous hydrophobic polytetrafluoroe	0.2-0.25 µm
Study on a new air-gap membrane distillation module for desalination	TIPS-iPP	0.2 µm
Treatment of high salinity solutions: Application of air gap membrane distillation	polytetrafluoroethylene	0.2-0.45 µm
Studies in vacuum membrane distillation with flat membranes	PVDF and ePTFE	0.05-0.45 µm
Production of drinking water from saline water by air-gap membrane distillation using polyvinylidene fluoride nanofiber membrane	Polyvinylidene fluoride nanofiber	

Literature Review Takeaways

- The greater the temperature difference = Higher Flux
- More Turbulence = More Flux
- Materials: PTFE
- Variable parameters:
    - Membrane pore size and thickness
    - Temperatures
    - Pressures

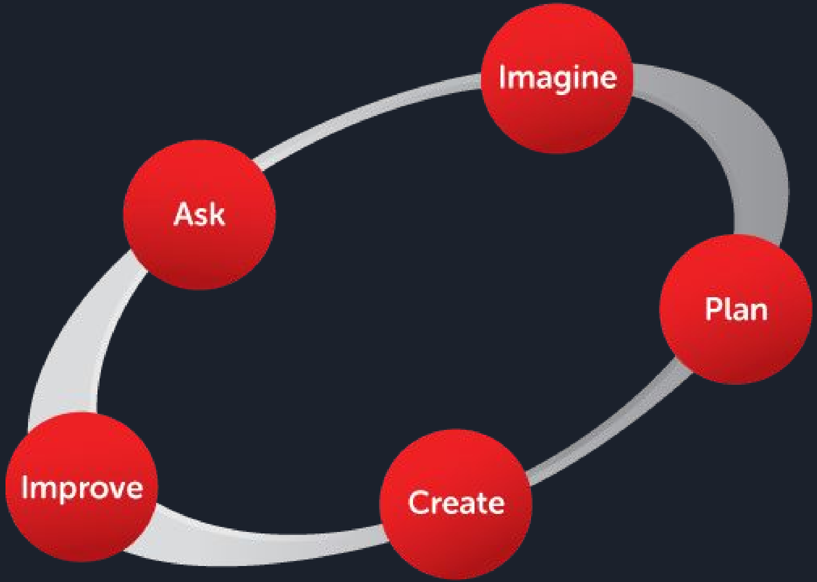
Preliminary Design

Designed Components:

- Hot Feed Channel
- Membrane Enclosure
- Membrane Enclosure Seal
- Cold Feed Channel

Design Constraints and Considerations:

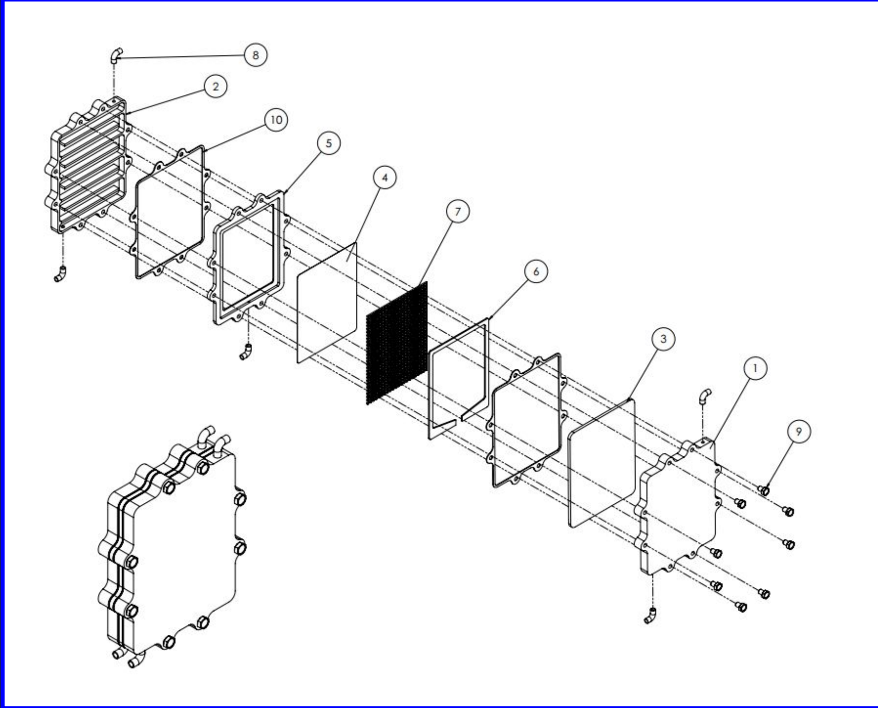
- Size & Geometry
- Leakage
- Performance



Testing Cell Overview

Exploded View of Preliminary Design

1. Cold Feed Channel
2. Hot Feed Channel
3. Cold Feed Cover Plate
4. Membrane
5. Membrane Enclosure
6. Membrane Enclosure Seal
7. Steel Mesh
8. Piping
9. Screws
10. Gaskets



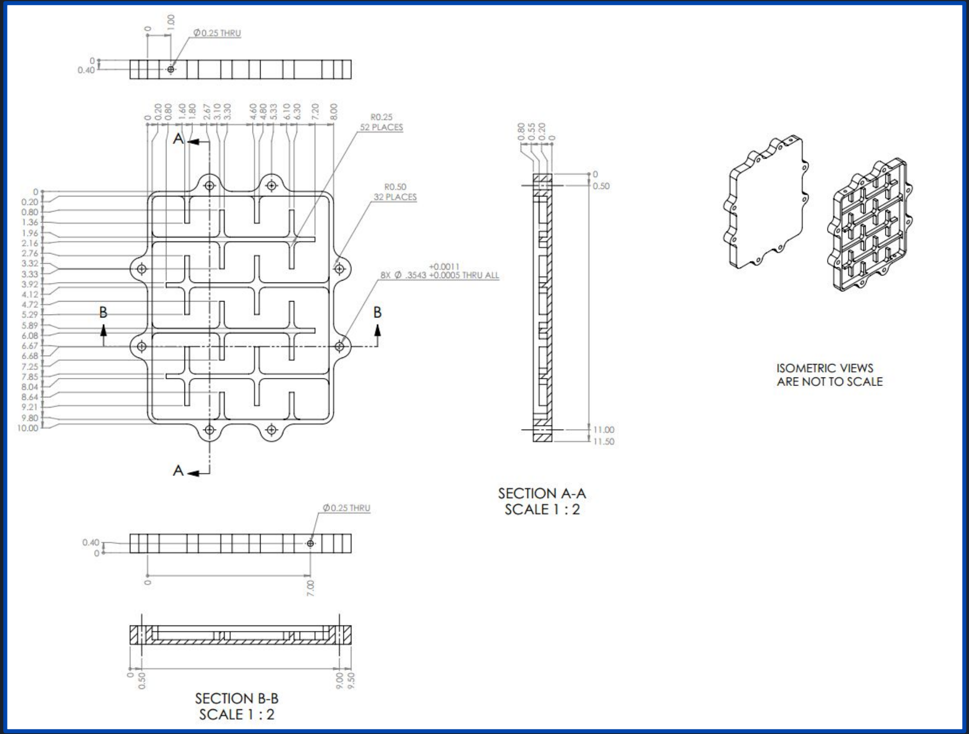
Hot Feed Channel

Key Features:

1. Size - 9.5” x 11.5”
2. Vertical and Horizontal Baffles
3. Feed water Inlet and Outlet

Role:

- Heats up the grey water



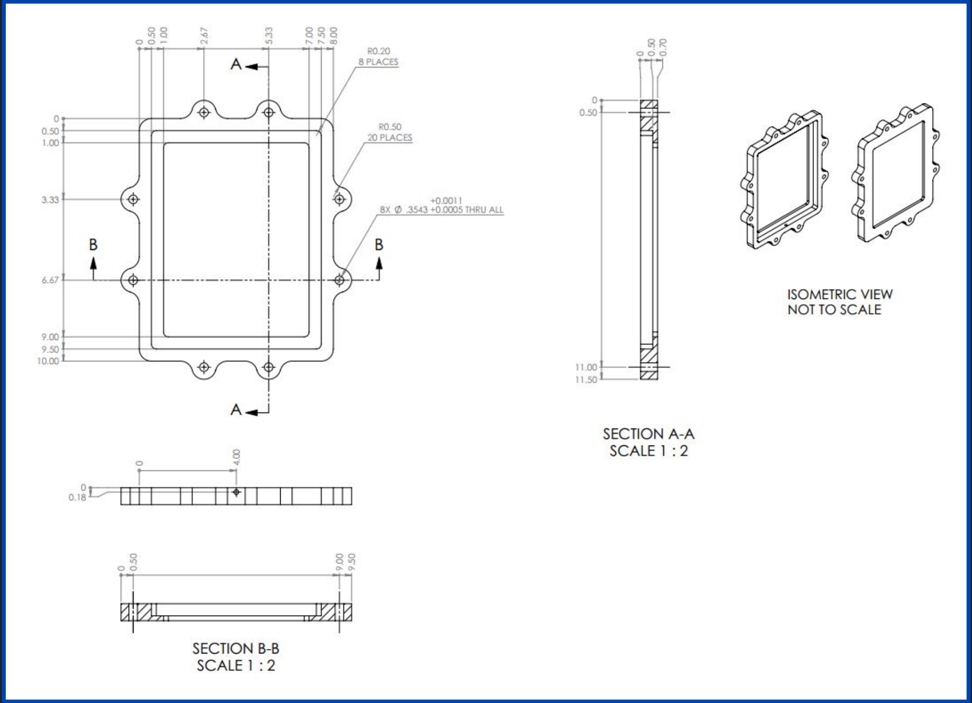
Membrane Enclosure

Key Features:

1. Size - 9.5” x 11.5”
2. Clean water outlet hole

Role:

- Houses membrane
- Collects clean water
- Gap b/w membrane & cold plate



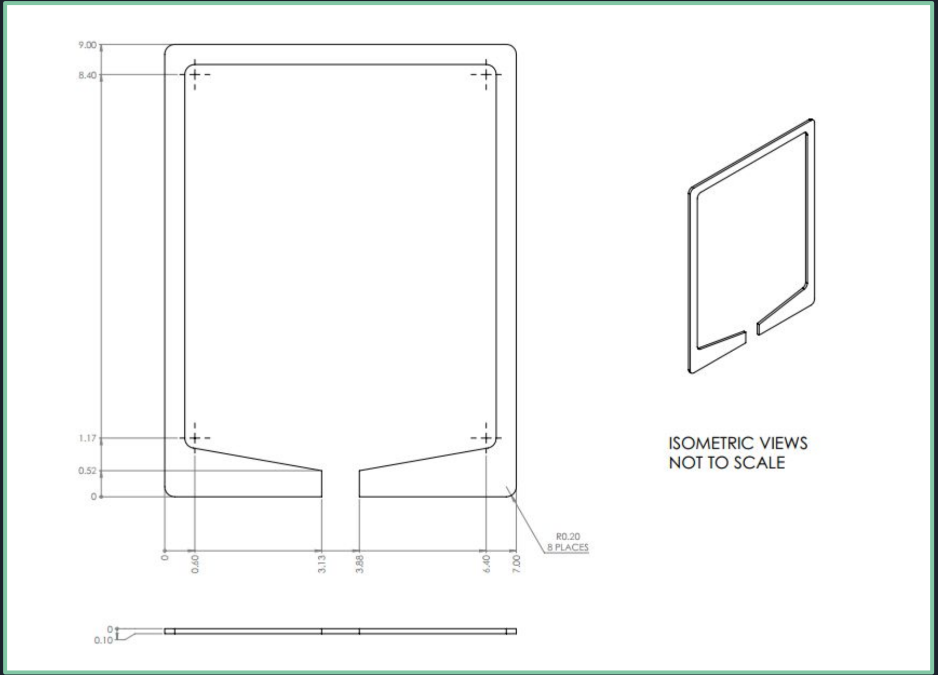
Membrane Enclosure Seal

Key Features:

1. Size - 7” x 9”
2. Thin rectangular frame
3. Angled surface to lead clean water to bottom

Role:

- Supports membrane



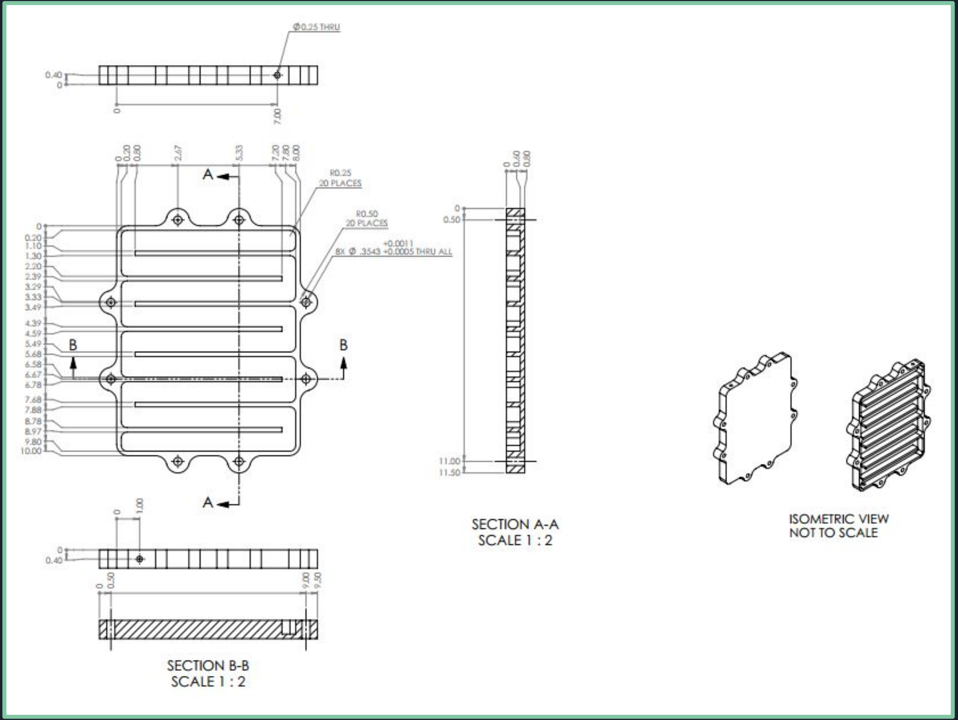
Cold Feed Channel

Key Features:

1. Size - 9.5” x 11.5”
2. 8 Baffles
3. Feed water Inlet and Outlet

Role:

- Condensing permeated vapor



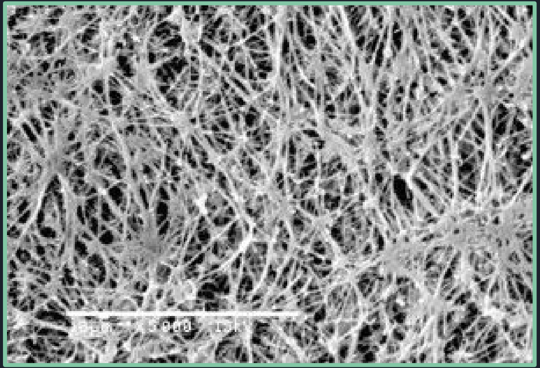
Testing Variables

Membrane Types

Membranes: Provided by Sterlitech

Effects:

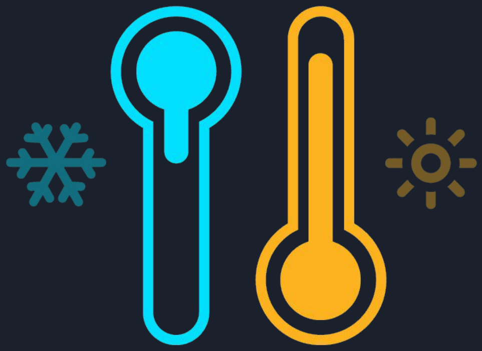
- Permeability
- Water Purity
- Amount of water produced



Type	Material	Pore Size (microns)	Water Entry Pressure (psi)	Membrane Thickness (mm)
QL209	PTFE	0.45	21	0.15-0.25
QL211	PTFE	0.45	21	0.23-0.30
QL822	PTFE	0.2	50	0.13-0.20

Feed Temperature

Applied to both hot / cold feeds



Effects:

- Vapor phase formation on hot feed side
- Rate of heat transfer from condensing plate on cold feed side
- Overall permeate production

Temperatures:

- Cold Feed: 15-25 Degrees Celsius
- Hot Feed: 50-80 Degrees Celsius

Gap Size

Effects:

- Cooling space of water vapor by air
- Amount of heat absorbed by cold feed

Sizes:

- Typical gap sizes: 3-7 mm
- Current gap size: 6.5mm

Current Progress

- Completed preliminary research on AGMD
- Designed test cell for AGMD
- Designed test bench

- Ready to manufacture and start testing

Future Goals

- Record data for variable parameters
- Optimize setup
- Use residual waste heat for hot feed
- Remodel design for mass production

Acknowledgments

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References

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2. Atia E. Khalifa, Water and air gap membrane distillation for water desalination – An experimental comparative study, Separation and Purification Technology, Volume 141, 2015, Pages 276-284, ISSN 1383-5866, http://dx.doi.org/10.1016/j.seppur.2014.12.007.