Adsorption Cooling System Using Exhaust Heat

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Project Background:

Heat Waste in Energy Production:

- Heat is the most dominant byproduct of energy production
- 70% of energy used in power production becomes waste heat
- Waste heat is not easily reusable because it is difficult to store and transport
- Low grade waste heat (~100℃) is particularly difficult to utilize due to its relatively low temperature [III]

Repurposing of Waste Heat:

- Some methods of repurposing waste heat have been developed, such as heating homes with waste heat from factories
- This requires enhancement of the heat to a higher temperature
- The process takes an extensive amount of energy [IV]

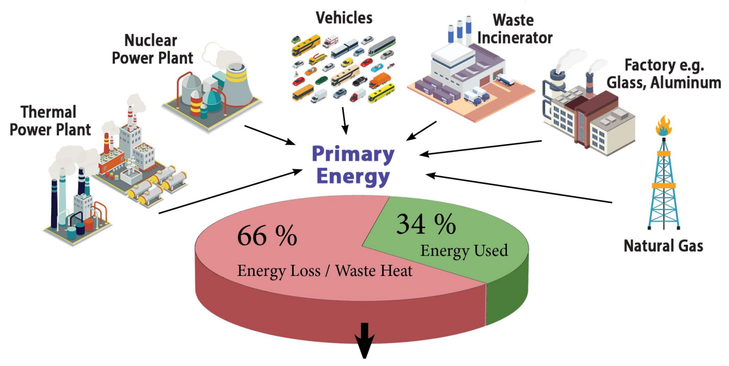

Figure 1: Almost twice as much energy is lost to waste heat in power production than is used.

Proposed Solution: Adsorption Cooling

What is Adsorption Cooling:

- Adsorption cooling uses the process of low temperature evaporation to cool water with the aid of an adsorbent
- It uses low grade heat directly in the regeneration of the adsorbent (desorption)

Why Adsorption Cooling:

- There is a constant need for cooling in homes and industries alike
- Adsorption cooling is beneficial because it uses low electricity usage, no mechanical components, lower operational costs and the use of a natural refrigerant, reducing pollution [II]
- This makes an adsorption cooling system more energy efficient and environmentally friendly than other cooling methods

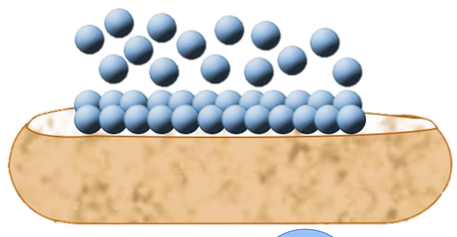

Figure 3A

ADsorption **vs.** **ABsorption**

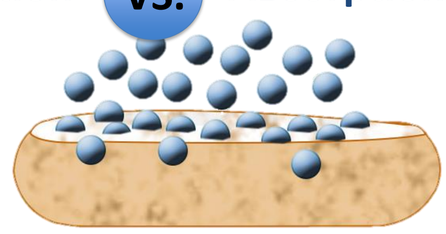

Figure 3B

Adsorption is when molecules stick to the surface of a solid, and Absorption is when molecules penetrate the surface of the solid, as demonstrated in figures 3A and 3B

Cooling by Adsorption: How it Works

Step 1: Evaporation

The process of cooling takes place in the evaporation chamber. During evaporation, energy is drawn from the water to the vapour, causing lower energy levels in the water, which translates into lower temperature.

Step 2: Adsorption/Desorption

Water vapour travels to the adsorption chamber where it adsorbs, or sticks, to the surface of the silica gel. When the silica gel becomes saturated, the chamber is then put into desorption by utilizing the exhaust heat in the form of hot water, releasing the water vapor into the condenser.

Step 3: Condensation

In the condenser the water is then cooled enough to return to a liquid state, and then returned to the evaporator where the cooling cycle begins again.

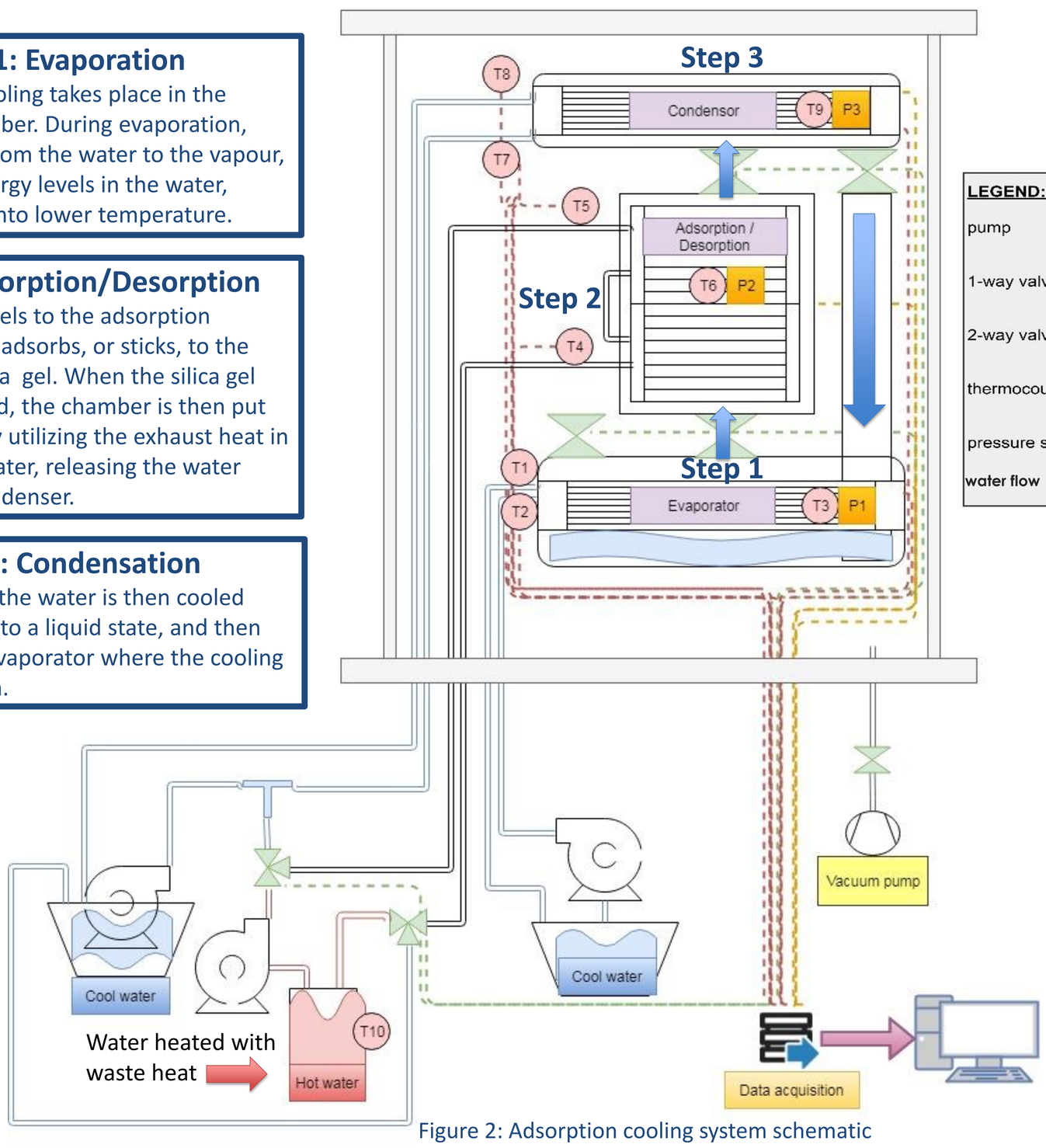

Figure 2: Adsorption cooling system schematic

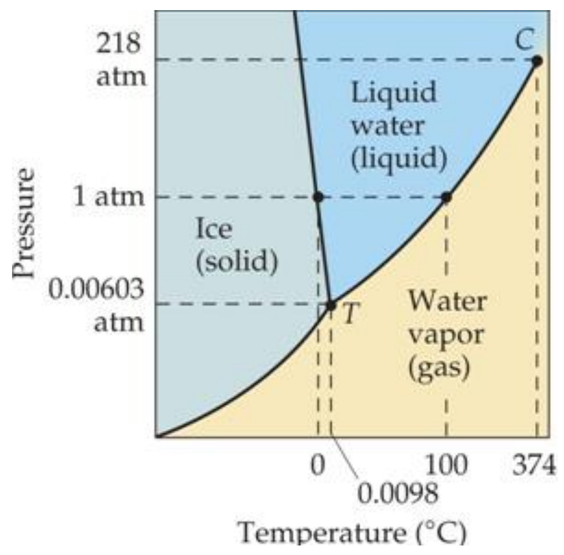

Figure 4: Phase Diagram

In order to use evaporation as an effective cooling mechanism, the boiling point of water must be lowered to below room temperature. Lowering the pressure reduces the boiling point temperature, as indicated in figure 4.

Goals Achieved:

- Construction and assembly of the primary cooling system
- Setup of electronics to control the system and measure results
- Integration of electronics into cooling system

Future Work:

- Investigating what variables can be changed in order to reach maximum efficiency
- Adapt the setup for practical application
- Create a dual phase adsorption cooling system
- Automation of the system

Select References:

I. Wang, D., et. al. (2010). A review on adsorption refrigeration technology and adsorption deterioration in physical adsorption systems. *Renewable and Sustainable Energy Reviews*
II. Wang, R., et. al.(2006). Adsorption refrigeration—An efficient way to make good use of waste heat and solar energy. *Progress in Energy and Combustion Science*
III. Forman, C., et. al.(2016). Estimating the global waste heat potential. *Renewable and Sustainable Energy Reviews*
IV. Irvine, G., et. Al. (2010). Energy from Waste: Reuse of Compost Heat as a Source of Renewable Energy. *International Journal of Chemical Engineering*

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