Our design is able to remove 50 kW from a facility and maintain a temperature of 25°C and pressures of 1 atm. The key goal is to remove 50 kW of waste heat from an arbitrary facility while maintaining temperature and pressure conditions of 25°C and 1 atm.

**Abstraction and Introduction**

The design challenge is to investigate the technology and controls needed to dissipate heat generated from an industrial processes to a lunar environment. The design will be a multistage cycle with R11 as the operating fluid. A shell and tube heat exchanger supports and optimizing the array of heat pipes.

**Discussion**

Facility heat exchanger:
- 50kW of waste heat is removed from the facility via a hot water loop
- Shell side contains hot water
- Tube side contains R11 refrigerant

Radiators and Heat Pipes:
- Radiation is the only way to reject heat since there is no atmosphere on the moon
- Heat pipes rapidly transfer heat from the R11 to the ~400 m² of panels
- Weight is minimized by using thin hexagonal supports and optimizing the array of heat pipes

Heat Shielding:
- A shield is required to prevent our system from heating up due to the direct sunlight during the day
- AZ-93 coating will be applied to the outside of the radiators to reflect the radiation and prevent our heat pipes from becoming inefficient

**Methods**

**Engineering Equation Solver (EES) and SolidWorks:** It has a larger database of information regarding fluids and is more efficient when performing traditional calculations ourselves.

**Thermodynamics:** Using our knowledge of thermodynamics, we compared single loop, cascading, and multistage cycles.

**Materials**

- **Shell and tube heat exchanger:** 304 Stainless Steel with copper tubes inside
- **Pipes and valves:** 304 Stainless Steel is chosen to balance weight, strength, and durability
- **Heat Shield Coating:** AZ-93 White Thermal Control, Inorganic Paint minimizes the amount of solar radiation absorbed while still rejecting 89-93% of the heat
- **Radiator Assembly:** Aluminum 6061-T6 is commonly used for space application
- **Heat Pipes:** Ammonia is commonly used in space application

**Results**

- The shell and tube heat exchanger is 35.64 kg, making it lighter than the alternative air heat exchanger.
- This system requires 22 kW of power at lunar noon; this exceeds the power budget in order to achieve a reasonable size and weight for the radiator panel.

**Conclusion**

- Our design is able to remove 50 kW from a facility and maintain a temperature of 25°C and pressures of 1 atm. It will weigh about 12475 kg and has a maximum power requirement of 22 kW.
- Our final design is a multistage cycle with R11 as the operating fluid. A shell and tube heat exchanger operates inside the facility, and a heat pipe radiator rejects heat into the vacuum of space via radiation.
- **Next steps:** For future improvements, we would recommend looking into optimizing the design of the radiator panel and consider axial grooved wick structures to improve heat pipe efficiency.

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