Kelp Drying Feasibility Study

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Abstract

The kelp industry in Alaska is one that is growing rapidly and has garnered increased attention throughout the state. Alaska's cold and clean waters make great conditions for kelp growth, so that it can be harvested and sold as an edible product. A large issue with the kelp harvesting process is the efficiency of drying of the kelp. This design project was tasked with helping Saltwater Inc and Regeneration North find the most effective, affordable, and environmentally friendly way to dry kelp in Homer, AK as well as other coastal communities in the future.

Figure 1 - High Tunnel Installation 2022 (1)

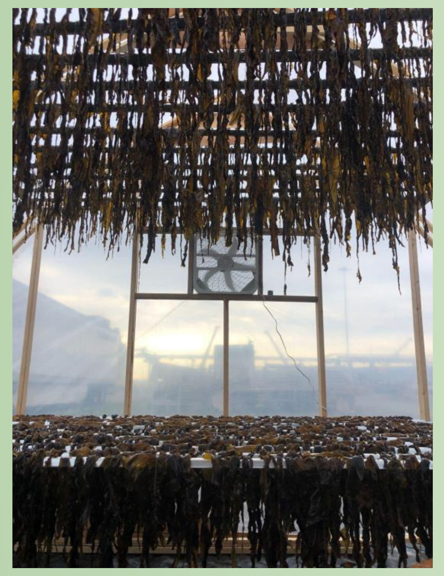

Figure 2 - High Tunnel Drying 2022 (1)

Project Statement

Determine optimal high tunnel design to process sugar and ribbon kelp to less than 10% moisture content for food grade utilization. When determining the optimal high tunnel design, utilization of simple installation methods and low energy consumption are both desired by the client. These should be prioritized, as the installation locations will be within remote locations throughout Kachemak Bay, where energy sources can be costly and materials difficult to procure.

Figure 3 - Kelp Drying in a High Tunnel in 2022 (1)

Methods

Computational Fluid Dynamics (CFD)

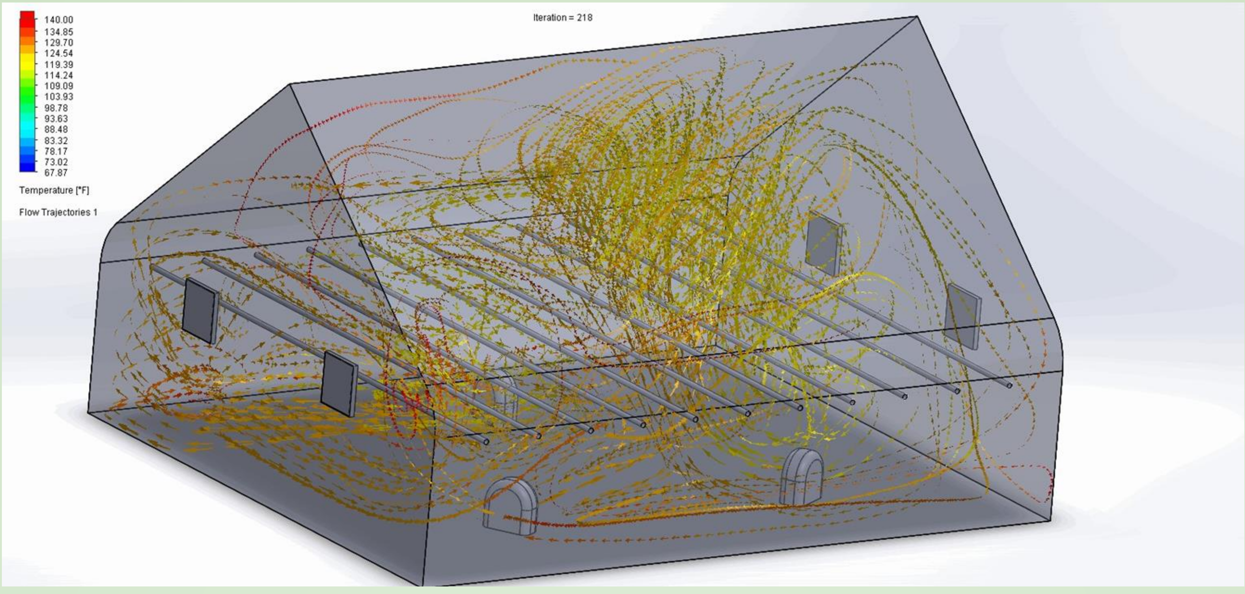

Figure 4- Solidworks Model of High Tunnel with all Fans in Operation

A model of the high tunnel was created in SolidWorks so that a flow simulation could be run to determine optimal placement of fans. The fans Regeneration North are looking to use this summer are four 20" inlet/exhaust shutter fans that run at 2760 CFM and three 20" horizontal air flow (HAF) fans that run at 3340 CFM.

For the analysis, a heat flux of 116W/m^2 was assumed at the walls to model the average sunlight during the day in Homer, AK. The average outdoor humidity in Homer during the summer was assumed to be 75%. The internal HAF fans had to have assumed fan curves based off of a fan with similar CFM to input into Solidworks. Multiple simulations were ran with different fan placements to determine the optimal fan locations.

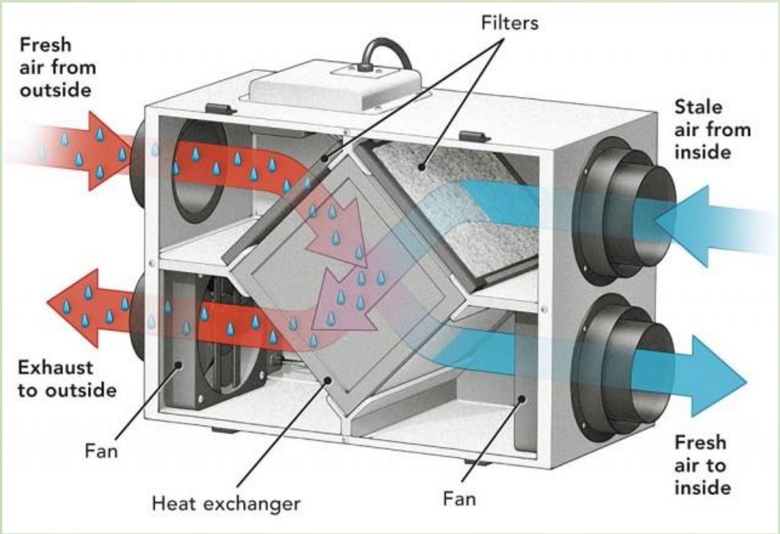

Figure 5 - Heat Recovery Ventilator - Air Exchanger (2)

One option provided to the client is installing an HRV in the high tunnel, which would good help retain heat, save energy, and maintain desired humidity levels inside.

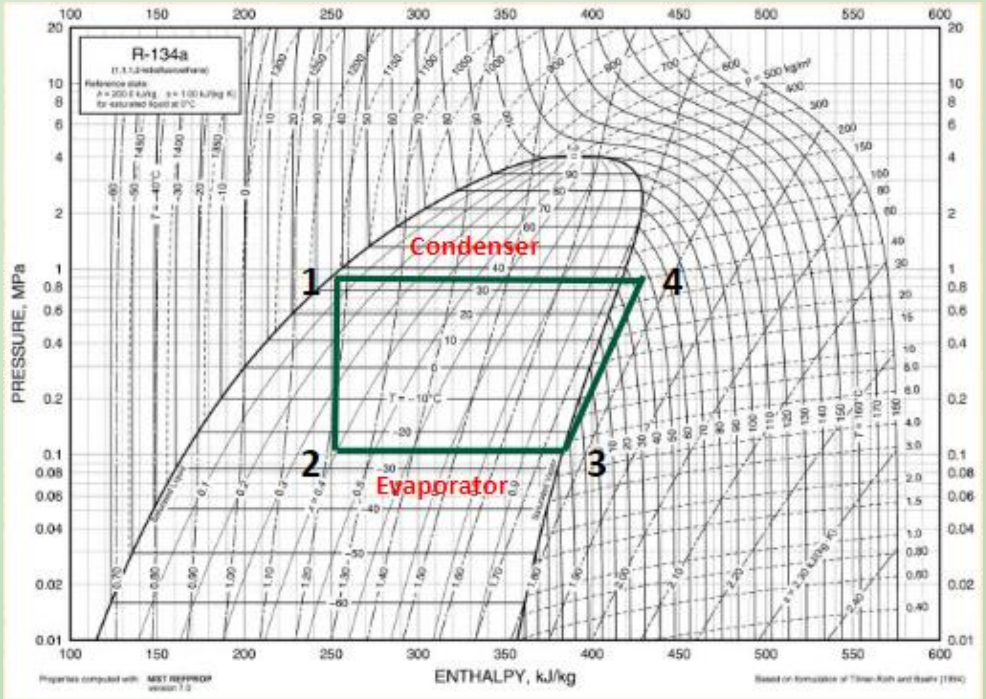

Figure 6 - Refrigeration Cycle

Another option that was analyzed was recovering waste heat off of an adjacent freezer van. Used to find COP=3 and Heat Rejected=1.08kW.

Conclusions

- One of the high tunnels used this summer should have three HAF fans, exhaust fans with shutters, and a dehumidifier sized appropriately for the air space. When it warms up during the day, the exhaust fans can be shut to trap in the heat. The dehumidifier will pull the moisture from the tunnel and help the drying process significantly. One possible option to retain heat as well would be to line the walls of the tunnel with a material like bubble wrap. From the CFD analysis, the humidity decreased by 50% and the temperature increased by 33%.
- The second high tunnel should include a Heat Recovery Ventilator option to recycle wasted heat, which is appropriately sized for the space per ASHRAE Standard requirements. (3)
- The second high tunnel should also include a dehumidification unit appropriately sized for the air space. ASHRAE Standard 62.1 recommends relative humidity be controlled to less than 65% to control microbial growth. (4)
- After building a refrigeration cycle, it was found that the coefficient of performance was 3. Refrigeration units should have a COP value between 2 and 4 so this is an acceptable value. The cycle was then used to find the heat rejected, which came out to be 1.08 kW. This is a relatively small value for heat rejection. The heat rejection capture feasibility was further investigated by seeking input from a heat recovery vendor, stating the unit was too small to viably recover heat from utilizing their available technology.
- We recommend humidity and temperature sensors be purchased and installed both inside and outside the high tunnels to log data throughout the kelp harvesting season. Affordable options are available and have been provided to the client. This information will be valuable for future analysis.
- Important data such as dry times and energy consumption should be recorded and studied both throughout and at the end of harvesting season to determine which method is best moving forward.

Acknowledgements

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Regeneration North

References:

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(3) ASHRAE, 2016, *Ventilation and Acceptable Indoor Air Quality in Residential Buildings, ASHRAE Standard 62.2 - 2016*
(4) ASHRAE, 2016, *Ventilation for Acceptable Indoor Air Quality*, ASHRAE Standard 62.1 - 2016