Traversing Defrost System Summary:

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In a time where energy efficiency is a prime objective, air to air heat exchangers have become a staple in many new HVAC designs. However, when outside air temperatures fall below 32° Fahrenheit, the warm, moist exhaust air from the building mixes with the cold, dry incoming air and causes frost to form inside the fins of the heat exchanger. In developing a system to control freezing in air-to-air heat exchangers Des Champs laboratories traversing system optimizes the heat transfer of the air, while still being able to defrost the heat exchanger. The system works by blocking a section of incoming air with a traversing plate that runs horizontally across the heat exchanger. While the cold air is blocked from entering the heat exchanger, the warm, supply air behind the plate prevents the formation of frost. Although some efficiency of the heat exchanger suffers, the system still allows for the heat exchanger to operate cost effectively.

The thermal engineering aspect of the design works beautifully, with the 3 inch wide traversing plate moving across at a rate of 3 in/min. The problem lies with the mechanical design of how the plate travels across the heat exchanger. Des Champs originally developed a lead screw design, where a lead screw was connected to the plate by a drive nut and an electric geared motor supplied the power to turn the screw. The u-shaped track constrained the plate with rollers attached to the top and bottom of the plate. However, binding issues frequently arose through the relatively large tolerances of the bent sheet metal of the heat exchanger compared to the small tolerances of the drive mechanism. Therefore, our team's main focus became developing a drive mechanism that eliminated all binding issues.

The objective of the project was to develop a simple, reliable, and cost-effective traversing defrost system. The system needed to be adaptable to run off a single electric motor across multiple heat exchangers. Further, the system needed to be less than $500 dollars in total cost. Finally, a prototype of the most robust design would be assembled in order to show clearly the concepts and feasibility of the final design.

In our group's initial brainstorming session, we developed three viable options that we would later present to Des Champs. First, we developed a belt drive system for the traversing plate. The idea sprung from studying the driving mechanism on a printer carriage. We hypothesized that the main issue that Des Champs' design faced was binding due to a possible tolerance issue with the installation of the system. Therefore, a belt design was developed in order to decrease the possibility of binding from a traversing plate and drive track.

Second, we developed a double lead screw design that dealt with the binding of the plate with the track by stopping the misalignment, using two points of contact on the plate. Further, a chain drive coupled with a gear train would be used in order for the electric motor to supply power to the lead screws.

And finally, we developed a gear track design that would use spur gears at the top and bottom of the plate to travel in a machined gear track. The concept attempted to solve the binding issues by using a very precise gear track system. Further, the plate would be constrained vertically at both ends by the gear track.

After we presented our three initial designs to Des Champs, the belt drive design was chosen as the design that we would develop into a modified model. In attempting to solve the binding problem, while still being able to deliver a smooth operation across the face of the heat exchanger, we designed a double-loop pulley system with two points of contact on the plate. The two points of contact allows for the control of the plate to prevent binding, while the belt drive system would create a smooth mechanical operation. However, after extensively researching commercially available belts, we determined that, in our particular application, a belt would not

be a viable option due to the durability and cost constraints of the project. The belt suffered mainly in temperatures below freezing, where it would be likely to become brittle. Further, the economics of purchasing a belt steered our group into the direction of using a chain. In selecting a chain, we first developed a mathematical model in Microsoft Excel to predict the amount of chain sag that would occur. Second, we estimated the tension required on the chain in order to avoid exceeding the allowable sag.

The concept of the final design stemmed from the overwhelming task of physically constructing the double loop chain design. We needed a simpler design that did not bind, while being cost effective. We decided to return to the basic idea of a power lead screw for the driving mechanism, but to modify the track which guided the traversing plate across the heat exchanger. The modification was simple and elegant. We allowed for the ends of the plate to be free-floating in order to compensate for the tolerance issues of the bent sheet metal of the heat exchanger. This idea was accomplished by designing an L-shaped track and placing a nylon bolt at the top and bottom of the traversing plate. The nylon bolts served as free floating guides for the plate as it spun with the supplied torque of the power screw. The clearance of the plate and the track allowed for the system to not be over- constrained and over guided. Also, in order to compensate for the free ends of the plate, the weight of the system was supported by the drive screw. Finally, bearings were mounted on both ends of the heat exchanger, while only one bearing had a snap ring as the other was left free in order to compensate for thermal expansion.

The underlying theme with our design was to allow for the new system not to be over constrained. We left the ends of the traversing plate free-floating in order to negate binding issues. Further, we made the plate ride along the drive rod in order to compensate for the tolerance issues with the machining of the heat exchanger. Our final design was simple and elegant. It allowed for the traversing of the plate across the heat exchanger without over constraining its path.