

Mechanical Engineering Doctoral Defense

Improving the Refrigeration System for a
Distributed Cold Supply Chain

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Abstract

"Failures in the cold chain, the system of refrigerated storage and transport that provides fresh produce or other essentials to be maintained at desired temperatures and environmental conditions, lead to food and energy waste. The mini container (MC) concept is introduced as an alternative to conventional refrigerated trucks ("reefers"), particularly for small growers. The energy consumption and corresponding GHG emissions for transporting tomatoes in two cities representing contrasting climates is analyzed for conventional reefers and the proposed mini containers. The results show that, for partial reefer loads, using the MCs reduces energy consumption and GHG emissions. The transient behavior of the vapor compression refrigeration cycle is analyzed by considering each component as a "lumped" system, and the resulting sub-models are solved using the Runge Kutta 4th-order method in a MATLAB code at hot and cold ambient temperatures. The time needed to reach steady state temperatures and the temperature values are determined. The maximum required compressor work in the transient phase and at steady state are computed, and as expected, as the ambient temperature increases, both values increase. Finally, the average coefficient of performance (COP) is determined for varying heat transfer coefficient values for the condenser and for the evaporator. The results show that the average COP increases as heat transfer coefficient values for the condenser and the evaporator increase. Starting the system from rest has an adverse effect on the COP due to the higher compressor load needed to change the temperature of the condenser and the evaporator. Finally, the impact on COP is analyzed by redirecting a fraction of the cold exhaust air to provide supplemental cooling of the condenser. It is noted that cooling the condenser improves the system's performance better than cooling the fresh air at 0% of returned air to the system.

To sum up, the dissertation shows that the comparison between the conventional reefer and the MC illustrates the promising advantages of the MC, then a transient analysis is developed for deeply understanding the behaviors of the system component parameters, which leads finally to improvements in the system to enhance its performance."



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