



A new method of defrosting evaporator coils

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ABSTRACT

A new method is presented to defrost evaporator coils of heat pumps using air as a heat source. At low outdoor temperatures the evaporation temperature can drop below the freezing point of water, the water vapor in the air then freezes on the outer surface of the coil. This increases air side pressure drop and reduces the heat transfer capability of the evaporator coil, leading to a decrease in system efficiency. Long frost build-up times would lead to a partly or totally blocked evaporator coil, rendering the system inoperable. To maintain the functionality of the system it is therefore necessary to remove the frost regularly. For a reversible air conditioning system this is typically done by reversing the flow of the system. In the reversed mode the outdoor coil serves as a condenser, hereby melting the frost on the coil surface. Each of these defrost cycles however further reduces the system efficiency substantially. The new method uses an actively distributing valve which is able to feed parallel evaporator passes individually. With this valve single evaporator circuits are regularly shut off. While no refrigerant is evaporated in a closed circuit, the coil surface temperature increases and the flow of the ambient air is sufficient to defrost this part of the evaporator as long as the air temperature is above 0 °C. Experimental results show that under standard frost conditions the evaporator can be kept frost-free and even under severe conditions most of the highly inefficient system reversals can be avoided. Thereby system efficiency is increased significantly.

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1. Introduction

1.1. Frost growth

A vapor compression heat pump absorbs heat from the ambient on a low temperature level and transfers it to a high temperature level where the heat is rejected and used e.g. for heating a house. For heat pumps using ambient air as heat source frost forms on the evaporator surface in operating conditions with low temperature and high humidity air and evaporator surface temperatures below the freezing point. A number of studies experimentally investigate the mechanisms and effects of frost growth on finned tube heat exchangers under varying operating conditions and evaporator geometries.

Air inlet temperature, relative humidity, air mass flow rate and evaporator surface temperatures are identified to strongly influence the frost formation. Lee and Kim [1] present both frost thickness after a constant time period and averaged energy transfer resistance as indicator for frost formation under varying air

conditions. For increasing air temperatures between 4 °C and 10 °C and a constant humidity ratio both frost thickness and energy transfer resistance decrease continuously indicating that with higher temperatures thinner but denser frost layers are formed. With increasing relative humidities both frost thickness and energy transfer resistance increase indicating thicker, less dense frost formation. With increasing inlet air velocity however frost thickness increases while energy transfer resistance decreases indicating both thicker and denser frost layers. These observations are explained with the interaction of two different frost growth mechanisms: 1) frost growth at the surface which increases frost thickness and the insulating effect of the layer and is induced by high mass transfer and 2) vapor diffusing into the frost layer which increases frost density and thereby reduces the insulating effect. Tassou and Marquand [2] investigate the effects of frost formation on heating capacity and COP for air temperatures between 5 °C and −3 °C at a constant relative humidity of 60%. The degradation on both heating capacity and COP is found to be increasingly larger for higher air temperatures. Also increasing relative humidities at a constant air temperature are found to lead to faster degradations of capacity and efficiency. Votsis and Tassou [3] as well as Yan *et al.* [4] present the air pressure drop over the coil as an indication of the frost formation. Both keep relative humidities constant at 82% and

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