Abstract

Investigating the effects of condensation in transient heat conduction analysis under the dehumidifying condition on a wet fin surface, especially considering the thermal relaxation time, is crucial as it may expand a new dimension in the field of heat transfer. Researchers have pointed out the limitations in the conventional Fourier heat conduction model in the last few decades. In physical nature, heat wave propagation takes a definite time duration, called the thermal relaxation time. This realistic behavior of thermal waves brought out an arena for researchers to focus on this thermal relaxation time because of its essential applications in upcoming fields like in composite fin heat transfer where the fin size is too small, and the thermal relaxation occurs for a concise duration. Some other direct-indirect application covers thermal treatment for cancer patients, laser welding, bio-heat transfer, high-speed aviation engines, refrigeration and air conditioning, nuclear reactors, etc. The extended surface, called fins, is widely used as evaporative coils in refrigeration and air conditioning applications when the moisture in the air condenses on the fin surface as the fin temperature maintains below the dew point temperature of surrounding humid air. For efficient heat transfer and to enhance the rate of heat transfer from the fin surface, fins of various geometries and designs are being used in multiple applications. Given this, the author proposed one novel fin design for better fin performances under various boundary conditions.

Looking at the emerging application, the composite mini-micro size fin designs with a minimal thermal relaxation time might be essential in the near future task. This research aims to develop an analytical tool to analyze the temperature distribution on condensed fin surface with different fin geometries under various thermos-physical parameters under dehumidification. The present study considers the influence of parameters like Vernotte number, Biot number, and different boundary conditions for transient heat conduction.

In this thesis, an analytical solution called the Separation of variables has been developed with modified boundary conditions about practical aspects than existing research work. Fourier and non-Fourier analyses are carried out on wet fin surfaces to understand the effect of thermal relaxation time in different cases. Apart from this, the present study is not limited to conventional rectangular and pin fins profiles. Still, the author has attempted a unique revolutionary fin design, and researchers have yet to try it to improve heat transfer enhancement.

The research outcome has pointed out that the fin efficiency with the dry surface is always more than the wet surface fin condition for the equal Biot number at the base. The condensation on the fin surface amplifies the magnitude of the temperature response curve, thereby taking more thermal relaxation time. The non-Fourier heat conduction analysis shows a notable deviation in temperature response compared to Fourier heat conduction. It demonstrates that the proposed new fin design arrangement enhances the heat transfer rate and provides a compact fin design solution to save space and manufacturing costs.

The results obtained from the analytical model are well-verified with existing numerical and analytical research papers. The present work also compares those with the published work and is found to be well within engineering accuracy requirements.