# ABSTRACT

Two-phase materials such as foams, ceramics, composites and porous materials are used in many engineering applications. It is very important to estimate the Effective Thermal Conductivity (ETC) of two-phase materials to study where heat transfer behaviour in applications like thermal storage systems, catalytic convertors, heat exchangers and spacecraft structures.

The ETC of two-phase materials is influenced by primary and secondary parameters. The conductivity ratio (α) and the concentration of the solid phase (υ) are the primary parameters which have an appreciable influence on ETC. Secondary parameters such as grain shape and size, distribution of solid particles and its orientation, contact resistance and convection also have a substantial influence on ETC of two-phase materials.

Literature pertaining to the subject of this research work shows a lack of any mathematical model for determining the ETC considering the above mentioned parameters. Hence an analytical model for unit cell based on electric resistance analogy has been proposed in this research work for the estimation of the ETC of two-phase materials. Theoretical expressions have been derived considering the primary and secondary parameters for 2-D square, hexagonal and octagonal inclusions, and 3-D solid cube. One-dimensional heat conduction through the geometry dependent unit cell has been assumed. The models developed have been validated against the standard models and experimental data presented in the literature. The models have been found to predict ETC of various two-phase materials which are within the upper limit and lower limit, and more accurate for 3-D solid cube.

Further, numerical models have been developed for determining the ETC of various two-phase materials such as porous systems, suspension system, emulsion systems and solid-solid mixtures. The hexagonal and octagonal unit cells have been considered for the performance of 1-D and 2-Danalyses of heat conduction. The fluid flow analysis has been carried out for the determination of the convective heat transfer coefficient and in turn for estimation of ETC of two-phase materials. The predicted values of numerical models have been compared with experimental values published in literature. The results of numerical models are found to be in close agreement with experimental values published in literature. The values predicted by the numerical models have been seen to be well within the upper and lower limits for varying concentration, conductivity ratio and contact ratio.

An experimental study has been carried out using fabricated experimental setup based on transient plane heat source method. The ETC determined by the analytical expressions and numerical models have been compared and found to be in close agreement with experimental results. Hence the proposed analytical and numerical models can be effectively used for the determination of the ETC of two-phase materials used in heat transfer applications.