In this study, effort has been made in the evaluation and enhancement of thermal transport characteristics of metal matrix composites and contact interfaces. The thermal management systems are important in today's faster growing industrial needs which are demanding the high end processors with highest speed and reliability of performance. The thermal management systems are used for applications like central processing unit (CPU) cooling, cooling of electronics circuit boards, cooling of mechanical and automobile systems like engine cooling. However, this work focuses on thermal management systems related to CPU cooling.

The thermal management systems in CPU cooling consist of a CPU and a heat sink in general. Generally, the heat sink is attached to the CPU by the manufacturer mechanically. There is possibility of high stress inducement in the CPU due to mechanical fastening and the heat transfer is not effective as there will be a 100% surface to surface contact. Also there is a high possibility of shorting of electronic circuitry of the CPU due to the high conductivity of the heat sink material.

In order to overcome these problems, effort is made to resolve the problem by two approaches, namely, by developing the metal matrix composites to match with the required properties of the heat source and the other approach is by developing new contact resistance models.

In this study, initially, the importance and motivation behind the evaluation of the thermal characteristics for the MMC’s as well as TIMs. Various methodologies of manufacture of the MMC’s are discussed along with the advantages and limitations. The
reinforcements in MMC’s are explained in details and the corresponding materials are listed. Thermal contact resistance in heat transfer applications are presented with examples. The heat transfer phenomenon at the interfaces is detailed with the classification based on contact criteria.

Next, literature available in the area of metal matrix composites in thermal management was presented. The literatures review is grouped as thermal properties of MMCs and processing of metal matrix composite materials for the sake of better organization of the review. The literature of the thermal interface materials are reviewed and are studied for thermal grease, thermal pads and other thermal interface materials. Finally literature review of thermal contact Resistance (TCR) models are given for single contact spot, surface roughness and deformation of contact spots. Important conclusions are drawn from the literatures review.

The development of new MMC’s was detailed along with the different compositions of the MMCs. For this, initially, baseline materials were explained in detail along their thermal properties. Six MMC’s have been proposed with varying compositions of aluminum and silicon carbide. Aluminum was varied in percentage composition from 25% to 65% and Sic was varied between 35% to 75%. The MMC’s were evaluated for the properties lie thermal conductivity, specific heat, thermal diffusivity, CTE, density and Young’s modulus. Also, the variation of these properties with respect to temperature is evaluated. Finally recommendations are given for the MMC’s based on the required property criteria of the heat source material.

As a second approach, the thermal contact resistance models are developed. A measurement system for contact resistances has been established by performing
measurements on the known properties of the greases. Application of thermal greases is given in detail. The measurement system is established by conducting the experiments.

Development of new contact resistance models is presented with the design and experimental evaluation for the properties. The new contact resistance models developed was PGH, PG1G2H and PG1FG2H. The measurement system that is validated in this research work is used for measuring the thermal contact resistance. For a gap of 100 microns between the heat source and the heat sink, the temperature gradients and the temperatures are derived for all the three models. Based on the temperatures, the next model is chosen for the desired purpose. Finally, the summary, conclusions are drawn and future work is defined.