MODELING AND ANALYSIS OF

THERMAL META MATERIAL

A PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

MECHANICAL ENGINEERING

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2018-2022

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ACKNOWLEDGEMENT

We wish to take this opportunity to express our deep gratitude to all the people who have extended their co-operation in various ways in doing our project work successfully. It is our pleasure to acknowledge the help of all the individuals.

I sincerely express my gratitude to **Prof. E SRINIVASA REDDY,** Acharya Nagarjuna University College of Egg & Tech, Guntur. I express heartly thanks to **Dr. M. GOPI KRISHNA**, Asst. Prof and HOD, Department of Mechanical Engineering for his support and encouragement. We express profound sense of gratitude for our guide **Sri. TOUSEEF AHAMED**, Asst. Prof, Department of Mechanical Engineering for her valuable guidance we have received during the project work.

We would wish to thank **Sri MD. TOUSEEF AHAMED,** Asst. Prof, Department of mechanical engineering for his valuable support. we whole heartedly thank all the staff of Mechanical Engineering department for giving me their assistance, signifying the requirements at college and encourage me at every time.

Last but not least, we would like to thank all of our friends for their co-operation.

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ABSTRACT

Metamaterials are defined as artificially designed micro-architectures with unusual physical properties, including optical, electromagnetic, mechanical, and thermal properties. This study proposes a thermal metamaterial that provides an efficient thermal cycle with two conflicting objectives:

(i) high thermal resistance as a thermal insulator and

(ii) high cooling capability as a heat exchanger.

To enable these conflicting objectives, we used cellular lattice structures fabricated by additive manufacturing (AM). An efficient design method based on a finite element (FE) mesh was developed to obtain boundary-conformal lattices for arbitrary 3D shapes. FE analyses were then conducted to evaluate the structural and thermal behaviors of the lattice structures. The designed lattice structures were fabricated by powder-bed fusion (PBF) type AM using ABS material.

Thermal Analysis were then performed to evaluate the thermal resistance of the lattices with various strut diameters, and the resulting thermal resistance increased five to fifteen times in comparison with that of the pure material. Flow Analysis was also performed to evaluate the cooling capability of the lattices, which showed that the lattice structures could act not only as a thermal insulator but also as a heat exchanger. Consequently, the developed lattice structures can be regarded as a thermal metamaterial that is useful in various applications that require a high thermal cycle of heating and cooling.

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