BIOGRAPHICAL SKETCH

Ankit Gupta is a Ph.D. candidate and graduate research assistant in the Mechanical Engineering Department at Tennessee Technological University with expertise in additive manufacturing processes (laser sintering and fused filament fabrication) and advanced materials (metal alloys, ceramics and high temperature polymers). During the course of these studies, he has gained solid and hands-on experience with continuous and short-fiber reinforced composite based additive manufacturing and low-cost metallic printing, their fabrication, characterization, homogenized analytical modeling and analysis. He has been a member and active participant in the Society of Manufacturing Engineers (SME-S215) student chapter for 3 years. Ankit expects to receive his Ph.D. in May 2022.

EDUCATION

Ph.D. Engineering
Tennessee Tech University, 2018 – 2022 (Expected)

M.S. Mechanical Engineering
Indian Institute of Technology (Indian School of Mines)
Dhanbad, 2016 – 2018

B.S. Mechanical Engineering
University Institute of Engineering and Technology,
Kurukshetra, 2011 - 2015

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College of Engineering

TENNESSEE TECH

The Department of

Mechanical Engineering

Announces the Dissertation Defense of

Ankit Gupta

In Partial

Fulfillment of the Requirements

For the degree of

Doctor of Philosophy in Engineering

January 24, 2020

12:00 p.m.

Held in

Brown Hall, Room 241

Tennessee Tech University

Zoom Link: https://tntech.zoom.us/j/5706264721

FIELD OF STUDY

Mechanical Engineering

DISSERTATION TOPIC

Thermo-Mechanical Characterization and Modeling of Short Fiber Reinforced Composite Material Fabricated Using the Fused Filament Fabrication Process

EXAMINING COMMITTEE

Dr. Ismail Fidan (Chairperson)

Dr. Michael Allen

Dr. Joseph Biernacki

Dr. Andy Pardue

Dr. Vahid Motevalli

Dr. Frank Alifui-Segbaya

ABSTRACT

Additive Manufacturing (AM) is the field in which technological advancement is moving faster than the speed of light and has been successfully applied in various applications. It is defined as the field that can make almost anything. The Fused Filament Fabrication (FFF) process, one of the most promising AM techniques, is used for rapid prototyping and functional testing with advantages of minimal wastage, less cost, flexibility, and the capability to produce complex parts with excellent quality. Due to the intrinsically limited mechanical properties of pure thermoplastic materials, there is a critical need to improve the mechanical properties of fused filament fabricated pure thermoplastic materials. One of the possible methods is adding reinforcement materials. The reinforcement can be in the form of fibers (carbon fiber, glass fibers, etc.), whiskers, metal powders (zirconia, alumina, titanium). This research study is going to present composite materials fabrication using the FFF process with the matrix as high-temperature polymer (polycarbonate) and acrylates (polymethyl methacrylate), and test if adding reinforcements (different content and length) can improve the mechanical and thermal behavior of the final 3D printed (3DPed) composite part for applications in aerospace, the medical field, automobiles, sporting, and other daily goods. The entire process of creating the composite materials (CMs) using the FFF is called as Fiber Reinforced Additive Manufacturing (FRAM). The feedstock filaments are fabricated from plastic pellets with different fiber volume fractions and are used for creating the 3DPed composite parts. After the fabrication, effects on the mechanical properties including orthotropic tensile properties, flexural properties, and compression properties are investigated. Thermal characterization of fabricated composite is done by analyzing creep, storage and loss modulus at high temperature, thermal degradation temperature, and thermal conductivity. Surface morphology of short carbon fibers (SCFs) or short glass fibers (SGFs) reinforced composite materials is performed by observing the distribution of fibers, fiber length, fiber breakage, the orientation of fibers, and interaction area of fiber with the matrix material and gives this research a novelty from other researches. Fractography analysis is also performed on 3DPed tensile, flexural and compression samples to observe fiber behavior inside the matrix after the testing using scanning electron microscopy (SEM). Statistical analysis is performed to find out the most influential process parameter and their interaction for deciding the final mechanical performance of the 3DPed part. A micromechanical model like the Mori-Tanaka (MT) method with two-step homogenization is applied successfully to partially oriented short fibers reinforced 3DPed composite materials for the accurate prediction of effective orthotropic mechanical properties. The methodology developed in this study also offers opportunities that could be explored in the dental field concerned with the “design and manufacture” of devices. The study assessed the viability of FRAM for fabricating complete denture bases: polymethylmethacrylate (PMMA) as the matrix is reinforced with SGFs using the FFF process. This provides the opportunity of producing affordable and patient-specific composite dentures with improved clinical properties.