ISETC2025

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2 ND INTERNATIONAL SCIENCE, ENGINEERING AND TECHNOLOGY COLLOQUIUM



THE POWER OF SCIENTIFIC INNOVATION

INTELLIGENT SOLUTIONS FOR A SUSTAINABLE WORLD

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PREFACE

Welcome to the 2nd International Science, Engineering and Technology Colloquium 2025 (ISETC 2025)!

It is with great pleasure that we present this year's colloquium, a distinguished gathering of scholars, researchers, and professionals dedicated to the advancement of applied sciences. Held virtually on 9th July 2025, ISETC 2025 serves as a platform to highlight cutting-edge research, foster meaningful networking, encourage collaborations, and explore innovative solutions to global challenges.

This year's theme, "The Power of Scientific Innovation: Intelligent Solutions for a Sustainable World" highlights our shared goal to solve global challenges through applied science. It celebrates innovation as a key to building a more sustainable and resilient future. We're proud to feature keynote speakers and presenters who bring fresh insights, bold ideas, and breakthroughs shaping tomorrow's world.

We would like to extend our heartfelt appreciation to the Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, for their outstanding support and assistance throughout the planning and execution of the event. Their dedication has been instrumental to the success of this colloquium. We would like to sincerely thank all participants and researchers for their valuable contributions. We also appreciate the reviewers for their careful evaluations and helpful feedback. Your hard work and support mean a lot to us.

As editors, we are proud to present this collection of proceedings. It is an honour to bring together the interesting and meaningful work of our speakers and authors. We hope the ideas shared will lead to new discoveries, encourage more research, and help solve global challenges through science and innovation.

Warm regards,

Dr. Emi Norzehan Mohamad Mahbob
Dr. Saiyidah Nafisah Hashim
Ms. Lili Widarti Zainuddin
Ms. Nurul Nazwa Mohammad
Ms. Rozaina Saleh

ISETC 2025 Proceedings Editors

THE EFFECTS OF PRINTING SPEED AND INFILL DENSITY ON MECHANICAL PROPERTIES BY USING FUSED DEPOSITION METHOD (FDM) FOR MEDICAL IMPLANT

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Abstract: Medical implant is commonly used in order to generate damaged tissue in patient's body. Bone tissue engineering is one of the methods to generate new structure of bone tissue. However, development of bone tissue engineering must consider the material of the component in terms of the properties and the biocompatibility. In addition, conventional fabrication technique was used previously but the problems found in customization of the parts and less cost effective. Therefore, Polylactic Acid (PLA) was introduced for used in medical implant as it gave compatible mechanical properties for human body and Fused Deposition Modeling (FDM) as additives manufacturing process used to fabricate the samples. Thus, this study focused on determining the effects of different printing parameters on its mechanical properties on PLA material by using 3D printing method. 27 samples of Dog-bone shape based on ASTM D638 standard were fabricated using FDM with PLA material. Two printing parameters which were printing speed (80mm/s, 100mm/s and 120mm/s) and infill density (30%, 60% and 90%) were set and had been tested on tensile testing machine to determine the mechanical properties of the samples. Based on previous studies, the suitable ultimate tensile strength for human bone was around 51MPa to 133MPa with Young's Modulus around 1GPa to 22.3GPa were set as a reference value. The highest value of tensile strength and Young's Modulus gained from the parameter 100 mm/s printing (22.3147 MPa) and 90% infill density (0.8419 GPa) respectively. Finite Element Analysis was conducted on lattice scaffold design using mechanical properties of optimum printing parameters which was 100 mm/s speed with 90% infill. Result showed that maximum stress (Von Misses) was 20.6408 MPa and minimum stress was 0.688 MPa. The lattice scaffold design then was fabricated using optimum printing parameters as a prototype. These findings as a prior study will be beneficial for future research in medical field.

Keywords**:** *3D printing, FDM, PLA, mechanical properties*

INTRODUCTION

Medical implant is very demanding in terms of mechanical properties, as it is required to withstand various forces and stresses within the human body. Implant components require high precision control structure to achieve optimal mechanical properties. Therefore, it will be more expensive. However, with the advancements in additive manufacturing methods, specifically Fused Deposition Modeling (FDM) is now possible to optimize the printing parameters to achieve better mechanical properties for medical implant component (Winarso et al., 2022). To optimize the mechanical properties of the medical implant component, it is necessary to study and adjust the FDM printing parameters. There are many factors that can influence the mechanical properties of FDM printed medical implant components (Popescu et al., 2018). To achieve an accurate mechanical property of Polylactic Acid (PLA) and quality structure for medical implant component, it is possible by using FDM technology with precise printing parameters. However, variation of printing settings in 3D printer might affect the mechanical properties of the material and the performance of the printed component. Therefore, it will lead to lacking or unsafe for the usage and reducing patient's quality of life. By using the findings from the printing parameters from previous study and this project, the FDM printing process can be optimized to manufacture the prototype of the scaffold with better quality and suitable for medical application.

MATERIALS AND METHODS

This study focused on using FDM and Polylactic Acid (PLA) as filament material purchased from Smith3D Sdn. Bhd. Ender 3 Pro 3D printer used to fabricate the Dog-bone samples according to ASTM D638. The mechanical properties of the printed samples obtained after conducting the tensile testing using Universal Tensile Machine (UTM). Two printing parameters were selected which are printing speed (80 mm/s, 100 mm/s and 120 mm/s) and infill density (30%, 60% and 90%). Others printing parameters such as nozzle temperature, nozzle size, layer height and infill pattern were set as default based on Ultimaker Cura Slicer.

RESULTS AND DISCUSSION

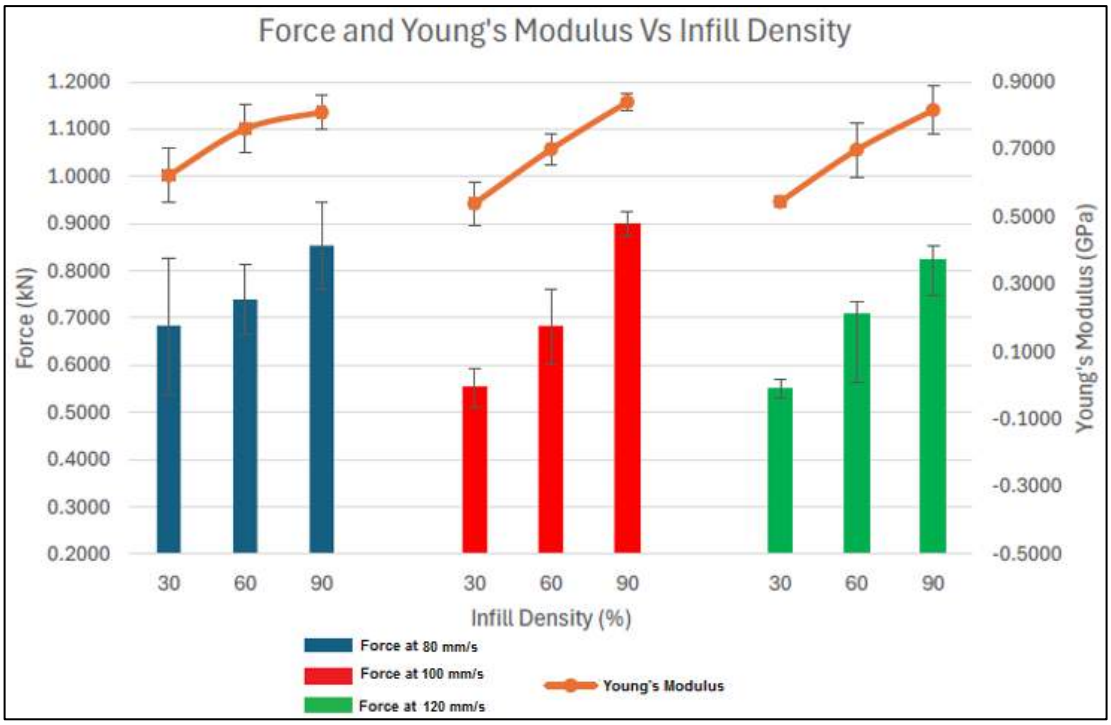


Figure 1. Relationship between force infill density based on the printed samples

Referred to Figure 1, three important mechanical parameters were investigated which were tensile load, tensile strength, and young's modulus. These characteristics are critical in determining the performance and durability of materials under stress. The experiment was carried out at three different printing speeds: 80 mm/s, 100 mm/s, and 120 mm/s, with corresponding infill densities of 30%, 60%, and 90. Across all tested print speeds (80 mm/s, 100 mm/s, and 120 mm/s), increasing the infill density from 30% to 90% consistently led to higher failure forces, with the peak force observed at 90% infill printed at the 100 mm/s speed. At any given infill density, parts printed at lower speeds exhibited higher failure forces, likely due to improved interlayer adhesion facilitated by longer cooling and bonding times. Higher infill densities result in a more solid internal structure, thus requiring more force to deform or break the sample. In addition, it provides greater resistance to loading due to improved load distribution and reduced stress concentration.

Young's Modulus were directly proportional to infill density. This happened because increased infill densities improve interlayer adhesion and load distribution inside the printed structure by reducing internal voids. The material's resistance to applied pressures is increased by denser structures because it has more surface area for stress distribution (Pandzic et al., 2019). Young's Modulus used to measure the material stiffness (Keat et al., 2019). It also rises along with infill density thus implying that the denser the structure and stiffer the printed component. A greater Young's modulus gave less material deformation under stress. Therefore, the material was good for structural applications

which need both strength and stiffness since it can withstand more load and resist deformation more successfully at higher infill densities (Pandzic et al., 2019). In contrast, Young's Modulus remained largely unaffected by print speed, indicating that stiffness is predominantly governed by geometric infill rather than processing speed.

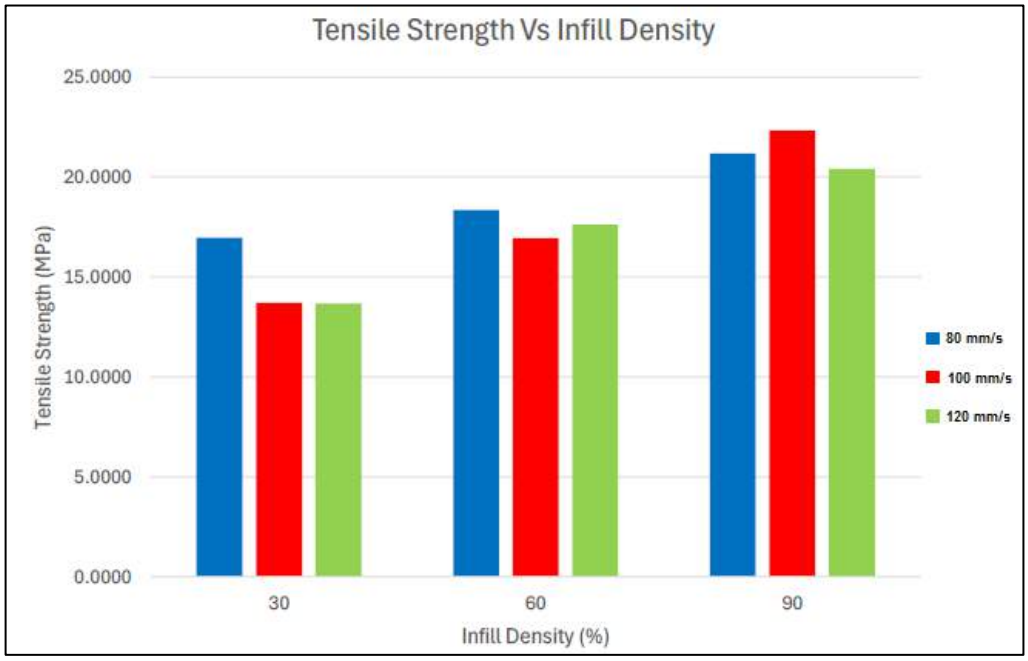


Figure 2. Relationship between Tensile Strength and Infill Density

As observed in Figure 2, tensile strength had been seen to increase with infill density at all speeds. At 30% infill, tensile strength showed lower value compared to 60% and 90% infill. However, it indicated improvement when the infill reached 90%. The maximum tensile strength was at 100 mm/s with 90% infill density and the minimum tensile strength was at 120 mm/s with 90% infill density. Since the printed sample with the less porosity, higher infill densities usually improve stress resistance. It also created more solid and continuous interior structures. Furthermore, printed sample with a denser infill reduce the existence of internal voids and enhance the printed parts capacity to bear with the applied stresses (Keat et al., 2019)**.** This is particularly crucial for applications such as medical implants, where material failure under stress poses a substantial danger. This trend as showed in Figure 2 agreed with previous researcher, Sriya Ambati et al. (2022) found that infill density has significant impact on the tensile strength values of 3D printed samples. Triawan et al. (2022) also discovered the similarities pattern between tensile strength and infill density which stated that a sample's infill density was determined by how much plastic filament was integrated into its body. A greater infill density required more plastic to be involved into the sample and contribute to higher tensile strength.

CONCLUSIONS

In conclusion, the purposes of this research was to study the effects of the printing parameters on mechanical properties of by using Fused Deposition Modeling (FDM) method with optimum printing parameters. Two printing parameters were manipulated, which are printing speed (80mm/s,100mm/s and 120 mm/s) with infill density (30%, 60% and 90%) to determine the properties of the samples. Maximum mechanical properties obtained were 0.8993 kN (Tensile Load), 22.3147 MPa (Tensile Strength) and 0.8419 GPa (Young's Modulus). The optimum mechanical properties along with its printing parameters were 100 mm/s speed paired with 90% infill. Further research should continue to improve these properties by incorporating other materials and enhance higher mechanical properties values. The development of new PLA-based materials is believed to be beneficial for the medical implant field.

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Sekian, terima kasih.

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Setuju.

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