

The background of the cover features a close-up, slightly blurred view of a 3D printing process. Two extruders at the top are depositing orange filament onto a blue, lattice-like structure. The lighting is dramatic, with a strong orange glow from the left and a blue glow from the right, creating a high-contrast, industrial aesthetic.

VACUUM SYSTEM INTEGRATED ADDITIVE MANUFACTURING

**A New Approach to Improve
3D Printed Parts Tensile Strength**

**JOHN WONG HUANG UNG
SHAJAHAN MAIDIN**

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TABLE OF CONTENTS



Preface.....	ix
List of Abbreviations	xi
List of Symbols	xiii

CHAPTER 1 INTRODUCTION TO ADDITIVE MANUFACTURING	1
General Additive Manufacturing Process.....	3
Advantages and Disadvantages of Additive Manufacturing.....	7
Additive Manufacturing Related Technologies.....	13

CHAPTER 2 INNOVATION IN ADDITIVE MANUFACTURING TECHNOLOGY	17
Computer-Aided Design and Other Technologies	18
CLASSIFICATIONS OF AM PROCESSES.....	21
DESIGN FOR ADDITIVE MANUFACTURING	29
EXTRUSION-BASED SYSTEM	34
Fused Deposition Modeling	35
Principles of FDM	36

Parameters of FDM.....	41
Limitations of FDM.....	45
VACUUM SYSTEM.....	47
Gas Properties.....	49
APPLICATIONS OF VACUUM SYSTEM	53
Design and Modules of Vacuum System.....	57
Vacuum Measurement	61
Vacuum-Assisted Studies	62
OTHER AND RELATED STUDIES	63
Feasibility of Heat Transfer in Vacuum Environment	70
SUMMARY	75
CHAPTER 3 AN OPPORTUNITY IN VACUUM	
SYSTEM FDM PROCESS.....	77
Design consideration of Vacuum Chamber	77
Transient Thermal Flow Analysis on Vacuum System.....	78
Pilot Test	78
Design of Experiment (DOE).....	79
EXPERIMENT PREPARATION AND PROCEDURE.....	81
Machine Calibration and Setup	81
Specimen Preparation	82
Specimen Testing.....	83
Scanning Electron Microscope (SEM)	84
Analysis of Variance (ANOVA).....	86
SIMULATION AND PILOT TEST	87
Design and Analysis of Vacuum Chamber	87
Transient Thermal Flow Analysis.....	94
Fabrication of Vacuum System.....	100
Pilot Test of Vacuum-Assisted FDM	103
SUMMARY	107

CHAPTER 4 DISCOVERY OF VACUUM SYSTEM FDM....	109
ABS and PLA Specimens	109
Tensile Stress and Strain.....	111
Layer Thickness-Layer Bonding	115
Layer Thickness versus Vacuum Pressure	118
Tensile Strength of Injection Molding versus FDM Parts	123
MICROSTRUCTURE OBSERVATION.....	124
ANOVA for Full Factorial Model	128
Analysis of Variance Table.....	129
Model Diagnostic Report.....	132
Optimisation Set of Parameters	134
SUMMARY	135
CHAPTER 5 CHALLENGES AND FUTURE PERSPECTIVE.....	137
FUTURE PERSPECTIVE	139
References	141
Index	151

VACUUM SYSTEM INTEGRATED ADDITIVE MANUFACTURING

A New Approach to Improve 3D Printed Parts Tensile Strength

Additive manufacturing (AM) has come a long way and has begun to be acknowledged and accepted in numerous industries such as aerospace, automotive, medical, and even art. Fused deposition modeling (FDM), as one of the AM technologies, is a popular and most used technology based on the polymer extrusion method. Despite having the advantage to produce part without any complexity restrictions, the known poor mechanical strength for a functional part produced is the limitation. Literature has found out that one of the main reasons for anisotropic behaviour, which was the insufficient bonding between layers, was found weakest at the z-axis. The layer-by-layer bonding occurred too fast and was not fully fused together, causing weak structural strength and easily shattered through pulling force. It was found that vacuum technology could improve layer bonding by reducing convective heat transfer. In a vacuum environment, the reduced amount of air molecules hindered the heat energy from being released from the deposited filament. The pilot test confirmed that the different level of vacuum pressure does affect the tensile strength of the printed parts. A total of 20 experiment runs with 60 printed specimens were conducted with two parameters, namely layer thickness and vacuum pressure. Results have found out that the highest percentage improvement (16.77 %) was 18.0846 N/mm² produced by 0.20 mm/21 inHg, while the highest strength was measured at 0.25 mm/21 inHg, giving 19.7202 N/mm². The z-axis produced in a vacuum environment was now at 77.67 % of strength produced by x-y axes signifying reduced anisotropic behaviour. It was found out that under a scanning electron microscope (SEM), the specimens produced under vacuum pressure had a better bonding formation compared to normal atmospheric ones. Lastly, the ANOVA method had validated the significance of the set of parameters and the optimised parameter was 0.25 mm/21 inHg for recommended tensile strength while 0.22 mm/21 inHg for recommended tensile strain. The vacuum-assisted FDM has proven to be feasible, and this study had increased the understanding of vacuum technology and FDM to improve the tensile strength of the printed part. Further improvements of vacuum-assisted FDM will allow the creation of mechanically stronger complex parts in a wide range of applications.



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