

UNIVERSITI TEKNOLOGI MARA

**DESIGN AND FABRICATION OF
TWO COMPONENT POWDER
INJECTION MOULDING**

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Thesis submitted in fulfilment
of the requirements for the degree of
Master of Science
(Mechanical Engineering)

Faculty of Mechanical Engineering

October 2025

ABSTRACT

This research explores and validates the feasibility of a simultaneous two-component powder injection moulding (2C-PEVI) process using ceramic (alumina) and metallic (stainless steel) feedstocks. The study addresses key challenges in producing defect-free, multi-material components by analysing thermal and rheological properties, simulating interfacial behaviour, and evaluating the mouldability of the two materials using a custom-built 2C-PEVI machine designed for simultaneous co-injection. Differential Scanning Calorimetry (DSC) showed both binder systems began melting at approximately 55 °C, while Thermogravimetric Analysis (TGA) revealed total weight losses of 17.4% for alumina and 6.43% for stainless steel, confirming typical thermal behaviour during binder removal. Rheological tests confirmed pseudoplastic flow with shear sensitivity index below 1. Activation energy ranged from 0.1-2.9 kJ/mol for alumina and 7.13-10.43 kJ/mol for stainless steel, indicating suitability for injection moulding of complex geometries. Moldex3D simulations assessed interfacial behaviour during co-injection. Symmetrical weld lines were achieved with injection times between 0.4 s and 0.5 s, and improved results occurred when the injection pressure of polypropylene was lower than that of LDPE. Balanced injection profiles minimized weld line defects and enhanced interface quality. Experimental trials using the newly developed 2C-PEVI machine confirmed the feasibility of simultaneous co-injection. Optimal injection temperatures were identified as 190 °C for stainless steel and 230 °C for alumina, based on flow performance and alignment with simulation outcomes. In conclusion, this study demonstrates that simultaneous 2C-PEVI is a viable and effective method for fabricating multi-material components. It offers reduced cycle time, improved interfacial control, and contributes valuable data toward advancing process design for multi-material injection moulding.

ACKNOWLEDGEMENT

Firstly, I wish to thank God for giving me the opportunity to embark on my MSc and for completing this long and challenging journey successfully. My gratitude and thanks go to my supervisor Prof Dr. Muhammad Hussain bin Ismail and Prof. Madya Ts. Dr. Nor Hafiez Mohamad Nor.

My appreciation goes to the Captain and crewmembers of the Mechanical Engineering Faculty including Assistant Engineers Mohd Fami bin Abu, Arzuan bin Kasim, Mohd Emy Azly bin Mohd Arnawi, Mohd Harysham bin Zainal Abidin, Mohd Rahimi bin Abdul Rahman and Mohd Helmi bin Omar, for providing the facilities and assistance during the sampling process. Special thanks to my colleagues and friends for helping me with this project.

Finally, this thesis is dedicated to the loving memory of my wife and family for the vision and determination to educate me. This piece of victory is dedicated to all of them. Alhamdulillah.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

This chapter describes research background, problem statements, research scopes and limitations and significance of the study. The research background consists of short and brief information regarding two-component powder injection moulding (2C-PIM), brief explanation on the advantages of using two different materials as well as necessity to conduct 3D simulations on injection in the study. Subsequently, scope of the study is introduced after addressing the problem statement and research objectives. In short, this chapter is to convince the importance of the study and justification of this research in investigating the research problems raised. Several critical information that requires further explanation in a different chapter are carefully mentioned.

1.1 Research Background

The conventional fabrication of small metal parts by mechanical machining such as turning and milling is very difficult, time and cost intensive. Thus, a time and cost effective near-net-shape forming process with the advantage of shape complexity, material utilization and high final density called Powder Injection Moulding (PIM) was introduced (Ammosova et al., 2021 and Momeni et al., 2023). The process also allows the mass production of low cost, high performance and complex geometries.

In addition, powder injection moulding (PIM) can be adapted to combine different materials within a single part through the two-component powder injection moulding (2C-PIM) process (Basir et al., 2020). This technique, inspired by multi-material plastic injection moulding, enables the integration of different colours or materials in a single operation. The 2C-PIM process closely mirrors the conventional PIM workflow, which includes four main steps: (i) mixing metal or ceramic powders with binders to form feedstock, (ii) injection moulding, (iii) debinding, and (iv) sintering (Momeni et al., 2023). However, 2C-PIM involves the use of two distinct feedstocks and requires slight modifications to both the mould design and injection machine setup.