Proceedings of the International Conference on Industrial Engineering and Operations Management

Publisher: IEOM Society International, USA DOI: 10.46254/GC02.20240017
Published: December 01, 2024

Design and Fabrication of Vacuum-Assisted Compression Mould for Thermoplastic Polymers with Experimental Validation

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Abstract

The manufacturing of thermoplastic materials, particularly polypropylene, is crucial for various industrial applications due to their lightweight, versatile, and durable properties. Compression moulding is a favored method for producing high-strength components; however, traditional open mould systems often result in defects such as air bubbles and voids, which weaken the mechanical integrity of the final product. This research introduces an advanced vacuum-assisted closed mould system designed to enhance the compressive strength and overall mechanical performance of polypropylene specimens. By applying vacuum, entrapped air is effectively removed, ensuring uniform material flow and reducing defects. Experimental results show a substantial improvement in mechanical properties: stress at 0.4 strain increased from 34.98 MPa in conventional compression moulding to 47.2 MPa with vacuum assistance, reflecting a 35% increase. Young's modulus increased from 432.61 MPa to 620.46 MPa, representing a 43% enhancement in stiffness. These improvements demonstrate that vacuum-assisted moulding not only enhances material properties but also promotes more efficient manufacturing by minimizing waste and reducing post-moulding machining. This advancement highlights the potential of vacuum-assisted systems to meet growing industrial demands for high-performance, mechanically robust thermoplastic components.

Keywords

Polypropylene, Compression moulding, Vacuum-assisted moulding, Mechanical properties, compression test.