

Enhancing Recycling Efficiency for Beverage Cartons

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Abstract

Paper-based multi-layer packaging (MLP) such as beverage cartons is increasingly regarded as a sustainable alternative to plastic due to the biodegradability of cellulose fibres. However, despite global consumption exceeding 250 billion beverage cartons in 2023 - requiring approximately 5 million tonnes of slow-growing softwood - only 20-30% of these fibres are successfully recycled. The primary challenge lies in the polyethylene (PE) barrier layers, which impede water penetration, extending disintegration times from 2-4 minutes (plain paper) to 20-40 minutes. This prolonged processing increases energy consumption and leads to fibre contamination by residual plastics, reducing pulp quality.

This study simulates industrial hydropulping conditions, examining the delamination and disintegration mechanisms of MLP under turbulent flow. Cavitation was shown to weaken interfacial bonds between PE and paper, accelerating separation. Additionally, we investigated the influence of propeller design and vessel geometry on flow characteristics, highlighting their critical role in optimising hydropulping efficiency. Given that MLP recycling remains significantly slower than conventional paper recycling, these insights offer a pathway to improving fibre recovery rates, reducing energy demands, and enhancing the overall sustainability of beverage carton recycling.

Keywords: hydropulping; beverage carton; multi-layer packaging; recycle; paper