ABSTRACT

Mixing is a crucial process in the food industry, particularly in chocolate processing, as it directly affects the quality of the final product. Chocolate is classified as a non-Newtonian fluid with high viscosity, requiring an effective mixer design to generate optimal flow patterns and achieve high mixing homogeneity. This study aims to analyze the effect of ribbon helical mixer design variations on flow patterns and mixing homogeneity of chocolate fluid using Computational Fluid Dynamics (CFD) simulations. The design variations involve the number of helical ribbon revolutions (1 and 2) and the addition of a screw on the center shaft. Geometries were created using SolidWorks and simulated in ANSYS Fluent 2024, with the non-Newtonian pseudoplastic fluid modeled using the Power-Law approach and the RNG k-ε turbulence model. Simulations were conducted under transient conditions with an impeller rotation speed of 20 RPM and a maximum flow time of 1000 seconds. The evaluation included velocity vector visualization, mass fraction tracer contours, tracer distribution graphs, and torque analysis. Results indicated that the ribbon helical design with 1 revolution and without a screw produced more active flow patterns, more uniform tracer distribution, and lower torque consumption compared to other designs. In contrast, the addition of a screw on the center shaft did not significantly improve mixing performance and instead led to the formation of stagnant zones at the bottom of the tank. This study recommends the 1 revolution ribbon helical mixer without a screw as the most optimal configuration for chocolate mixing in terms of energy efficiency and homogeneity. These findings are expected to contribute to the development of more efficient mixer designs in the processing of non-Newtonian fluids.

Keywords: Computational Fluid Dynamics, ribbon helical mixer, non-Newtonian fluid, homogeneity.

INTISARI

Pencampuran bahan dalam industri makanan, khususnya fluida cokelat, merupakan proses krusial yang mempengaruhi kualitas produk akhir. Fluida cokelat tergolong fluida non-Newtonian dengan viskositas tinggi, sehingga memerlukan desain *mixer* yang mampu menghasilkan pola aliran efektif dan homogenitas tinggi. Penelitian ini bertujuan untuk menganalisis pengaruh variasi desain *ribbon helical mixer* terhadap pola aliran dan homogenitas pencampuran fluida cokelat menggunakan metode simulasi *Computational Fluid Dynamics* (CFD). Variasi desain terdiri atas jumlah putaran pita heliks (1 dan 2 *revolution*) serta keberadaan *screw* pada poros pusat. Geometri dirancang menggunakan perangkat lunak SolidWorks dan dianalisis dengan ANSYS *Fluent* 2024, dengan pemodelan fluida non-Newtonian *pseudoplastik* menggunakan pendekatan *Power-Law* dan model turbulensi k-ε RNG. Simulasi dilakukan dalam kondisi *transient* dengan kecepatan putar 20 RPM dan waktu simulasi maksimum 1000 detik. Evaluasi dilakukan melalui visualisasi vektor kecepatan, *contour* sebaran *mass fraction tracer*, grafik persebaran *mass fraction tracer,* dan grafik *torque*. Hasil menunjukkan bahwa desain *ribbon helical* 1 *revolution* tanpa *screw* menghasilkan pola aliran lebih aktif, distribusi *tracer* lebih merata, serta konsumsi *torque* yang lebih rendah dibandingkan desain lainnya. Sebaliknya, penambahan *screw* pada poros pusat tidak memberikan dampak signifikan terhadap efisiensi pencampuran dan justru menyebabkan terbentuknya zona stagnan di area bawah tangki. Penelitian ini merekomendasikan desain *ribbon helical* 1 *revolution* tanpa *screw* sebagai konfigurasi paling optimal untuk pencampuran fluida cokelat dalam efisiensi energi dan kualitas homogenitas. Temuan ini diharapkan dapat memberikan kontribusi terhadap pengembangan desain *mixer* dalam aplikasi industri pengolahan fluida non-Newtonian.

Kata kunci: *Computational Fluid Dynamics, ribbon helical mixer*, fluida non-Newtonian, homogenitas.