Optimization of CFD Simulation of Mixer Machine for Liquid Soap Machine with Capacity of 160 Liters

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Abstract. Liquid soap plays a very important role in people's lives, but if the manufacturing process is not done well it will have fatal consequences, such as in the process of making liquid soap in SMEs (Small and Medium Enterprises) many still do it manually or semi-automatically, the target users are small businesses. middle school so that it can develop further. The combination of stirrers in liquid soap machines is an option to increase the capability of the manufacturing process. In this study, CFD analysis compared 3 types of stirrer shapes using Solidworks with a fluid speed of 5 m/s. The simulation results show that in the speed distribution, the highest average occurs in stirrer 2, namely 5,185 m/s. Meanwhile, stirrer 1 gave the highest difference in average pressure distribution, namely 112411.60 Pa. After the CFD simulation was carried out, Topology Optimization was carried out on the stirrer shape using data obtained from the CFD simulation.

Keywords: CFD, Optimization, Soap, Simulation

1 Introduction

The soap is a sodium or potassium compound that has a long carbon chain and is reacted with fatty acids, especially triglycerides from vegetable oils or animal fats. Soap is produced by the saponification process, namely the hydrolysis of fat into fatty acids and glycerol under alkaline conditions. Process of making soap is a surfactant that is used with water for washing and cleaning. The Soap usually comes in the form of a molded solid called a bar because of its history and general shape. The use of liquid soap has also become widespread, especially in public facilities. When applied to a surface, soapy water effectively binds the particles in a suspension easily carried by clean water. Soap is an alkali metal (base) material with a long monocarboxylic acid chain. The lye solution used in making soap depends on the type of soap. The alkaline solution commonly used in hard soap is Sodium Hydroxide (NaOH) and the alkaline solution commonly used in soft soap is Potassium Hydroxide (Aan Jati Gunawan, 2020). CAD, which stands for Computer Aided Design, is computer software used to design a product in the design phase during the engineering process. Facilities in this application include material selection, process, dimensions and tolerances. The designs drawn can

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be 2-dimensional or 3-dimensional and can be seen from various points of view. The use of CAD can improve design quality, engineer productivity, and improve communication between designers and readers.

The previous research, many CAD software have been used to assist in designing or carrying out FEA analysis for manufacturing or other processes. The research conducted by Arifin, et. al (2022) and Arifin et.al. (2020) created a pontoon type water wheel using SolidWorks and design of the jig and fixture for making hole using inventor to determine of the deflection and the strength of the tools.[1] [2]. Effendi et. al. (2023) and Arifin et al. (2023) used inventor software to analyze the shape of the frame of an electric car and also the frame of a welding table [3][4]. Meanwhile Wang et. al (2020) used Moldex software to carry out an optimization analysis of the biconcave structure manufacturing process [5].

Then, there are some researchers used CAD CAE in designing construction, such as several researchers studied the ideal construction of wind turbines and water turbines, as well as, calculated forces using CFD analysis [6 - 10].

In this study will discuss about the CFD and find the optimal design of the mixer of the design liquid soap machine.

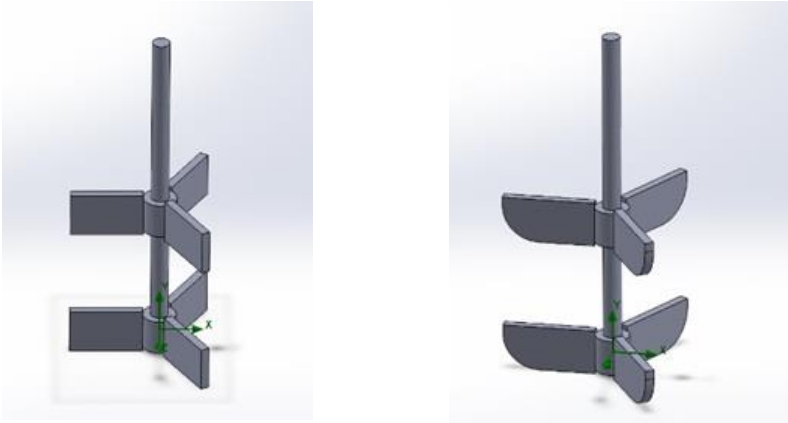
2 Methodology

In this research, the methods used include observation, literature study, making a liquid soap machine and stirrer, collecting test data and data analysis. The research steps carried out are depicted in the following flow diagram.

Model and design of dishwashing soap mixer machine with a capacity of 160 liters can be seen in figure 1.

Fig 1. Design Mixer Machine for Liquid Soap Making Machine with Capacity of 160 Liters

The both of mixer design options for a 160 liters capacity liquid soap making machine.



Type 1 Type 2

Fig 2. Type of Mixer of The Liquid Soap Machine

The analysis method is carried out by conducting research experiments and direct observations from the field systematically and sequentially by building cause and effect to obtain the desired data results which will then be analyzed, where the data obtained will be collected and then processed to produce conclusions for decision making. The methodology used is Finite element analysis (FEA), which is a method or numerical method for obtaining solutions to differential equations and integral equations. Solving differential equations is based on simplifying complex and numerous differential equations into ordinary differential equations, then solving them by integrating numerically using the Euler or Runge-Kutta method. In FEA, objects in the form of areas (2D) or volumes (3D) are broken down into small elements and then entered boundary values and initial values in existing formulas.

Starting with analyzing the problem, then conducting a literature study related to stirrers in mixing machines, designing the stirrer and selecting the materials to be used. After the stirrer design process is complete, a CFD simulation is carried out using Solidworks. CFD (Computational Fluid Dynamics) is a branch of fluid mechanics that uses numerical analysis and structured data to analyze and solve problems involving fluids. Computational Fluid Dynamics is a method that uses numbers, algorithms and computer assistance to carry out calculation analysis.

3 Result and Discussion

The success of the machine manufacture is needed the performance testing.
The tests carried out include:

CFD simulation on 2 type of mixer

The CFD simulation will be carried out with the type of flowing fluid, namely using mixed ingredients in dishwashing soap such as LABSA, NaOh, NaCl and SLS or Texapon. The result can be seen in figure 3 and 4.

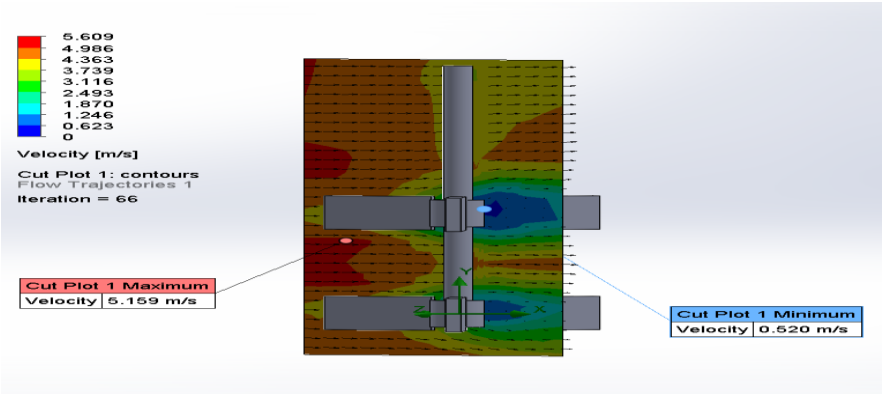


Fig 3. Velocity of Mixer 1

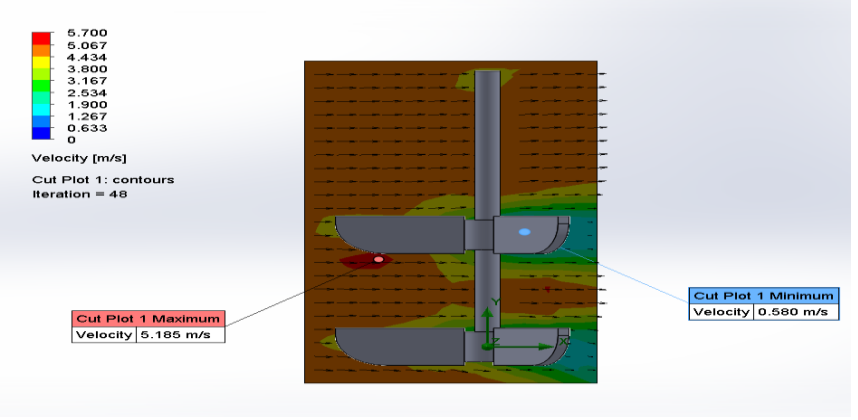


Fig 4. Velocity of Mixer 2

The results of the CFD simulation on the velocity distribution showed that the max value on mixer 2 was 5,185 m/s and the min value on mixer 2 was 0.580 m/s (figure 4).

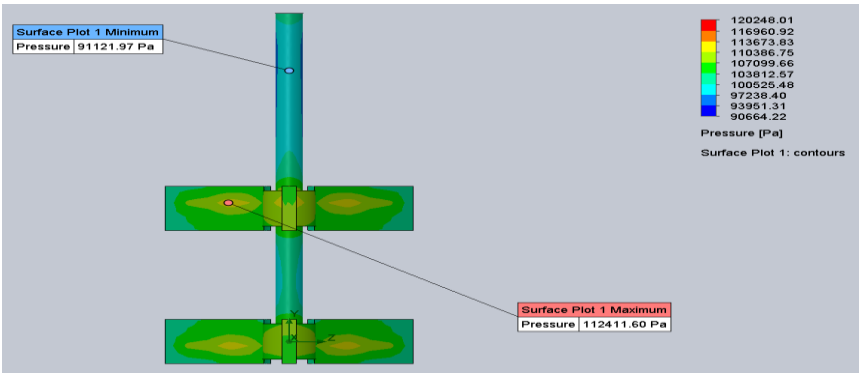


Fig 5. Pressure of Mixer 1

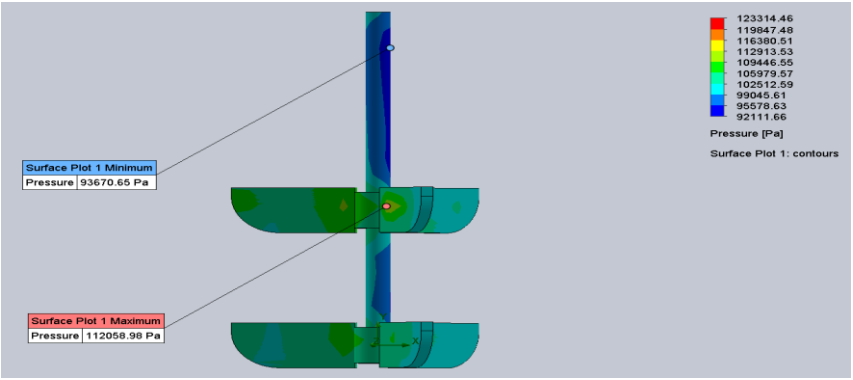


Fig 6. Pressure of Mixer 2

The CFD simulation results on the pressure distribution can be seen in figure 5 and 6. The max value on mixer 2 was 108968.41 Pa and the min value on mixer 2 was 93379.92 Pa.

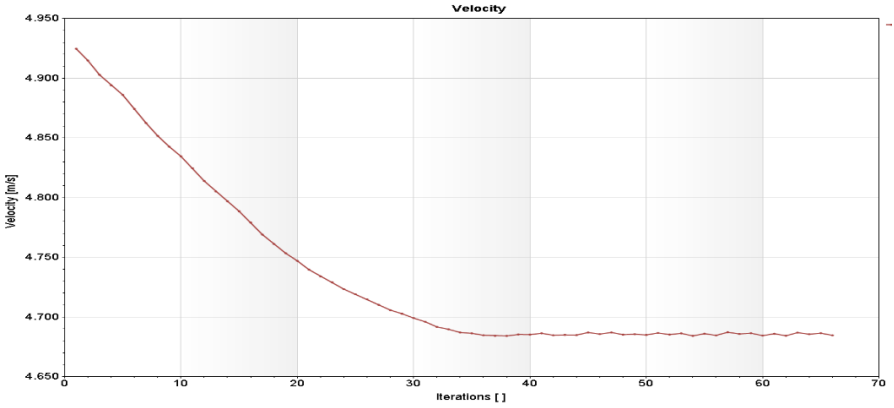


Fig 7. Graph Velocity of Mixer 1

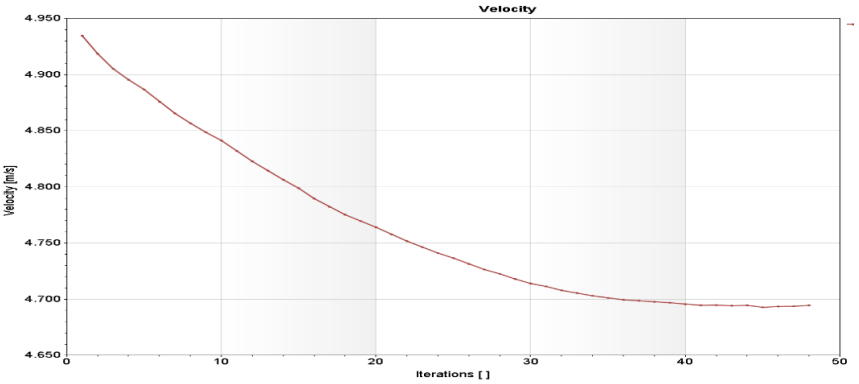


Fig 8. Graph Velocity of Mixer 2

It can be seen in the velocity graph that mixer 2 reached a stable point with approximately 48 iterations (figure 7) and mixer 1 reached stability even with approximately 68 iterations (figure 8).

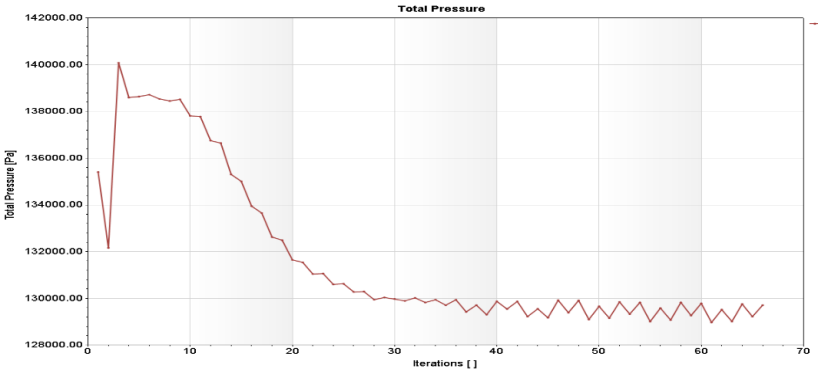


Fig 9. Pressure Graph of Mixer 1

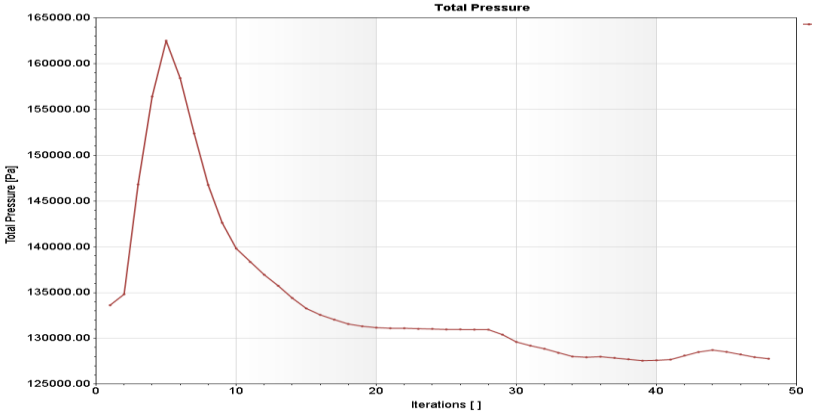


Fig 10. Pressure Graph of Mixer 2

It can be seen in the graph that the pressure on mixer 2 has reached a stable point after approximately 48 iterations (figure 9) and on mixer 1 does not appear to have reached stability at all (figure 10).

4 Result and Discussion

The conclusion of research related to the analysis of Computational Fluid Dynamic simulations on the shape of the mixer in a liquid soap making machine with a capacity of 160 liters are The CFD simulation, maximum results were obtained on mixer 2, with approximately 48 iterations and reaching a stable point in the Velocity and Pressure distribution. Then different results were obtained compared to the previous one but close to the same value, because in the second CFD simulation the results were maximum results were obtained on mixer 2 with 48 iterations and it had reached a stable point. This proves that the CFD Optimization process is very influential on the mixer simulation process to achieve maximum results.

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