IIT ROPAR

Spray Characteristic of Non-Newtonian Fuels Using a Novel Airblast Pressure Swirl Atomizer

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Introduction

Brief Overview of the Project

The project focuses on investigating the spray characteristics of non-Newtonian fuels using a novel airblast pressure swirl atomizer. This type of atomizer aims to enhance fuel atomization by combining a pressure swirl mechanism with a pre-filmer airblast process. Non-Newtonian fuels, which exhibit complex rheological behaviors, present unique challenges in atomization processes. The goal is to design an atomizer that can effectively handle these challenges and produce optimal spray patterns.

Objective

- Design a Novel Atomizer: Develop a new type of atomizer that integrates a pressure swirl mechanism followed by a pre-filmer airblast process.
- Characterize Spray Patterns: Analyze the spray characteristics of non-Newtonian fuels, including droplet size distribution, spray angle, and penetration length
- Optimize Atomization Efficiency: Improve the atomization efficiency for non-Newtonian fuels to enhance combustion performance and reduce emissions.
- Develop Experimental Setup: Establish a reliable experimental setup to test and measure the spray characteristics of the designed atomizer.

Background

Overview of Non-Newtonian Fluids and Their Characteristics

Non-Newtonian fluids are those whose viscosity changes with the applied shear rate. Unlike Newtonian fluids, which have a constant viscosity regardless of the shear rate, non-Newtonian fluids exhibit various behaviors, such as shear thinning (viscosity decreases with shear rate) or shear thickening (viscosity increases with shear rate). Common examples include polymer solutions, slurries, and certain biofuels.

Importance of Atomization in Fuel Spraying

Atomization is the process of breaking down a liquid into fine droplets, which is critical in fuel spraying applications for efficient combustion. Effective atomization ensures:

- Complete Combustion: Fine droplets mix better with air, leading to more complete and efficient combustion.
- Reduced Emissions: Better atomization helps in reducing pollutants like NOx, CO, and unburned hydrocarbons.
- Improved Engine Performance: Uniform and fine sprays enhance the overall performance and efficiency of engines.

Background

Combination of Pressure Swirl Atomizer with Pre-Filmer Airblast Process

While both pressure swirl and airblast atomizers have been extensively studied individually, there is limited research on combining these two methods. The novel approach of integrating a pressure swirl mechanism with a pre-filmer airblast process aims to leverage the advantages of both techniques:

- Enhanced Atomization: The combination is expected to produce finer droplets and more uniform spray patterns, especially for non-Newtonian fluids.
- Improved Fuel-Air Mixing: Better atomization can lead to more efficient fuel-air mixing, crucial for combustion processes.

This gap in research presents an opportunity to explore and innovate in the field of fuel atomization, particularly for non-Newtonian fuels.

Current Progress

Design of a Simple Swirl Atomizer:

- Created a basic model of a swirl atomizer using SolidWorks.
- The design incorporates the fundamental principles of pressure swirl atomizers.
- Attached is the drawing of the designed swirl atomizer for reference.

Literature Review and Understanding:

- Thoroughly read and tried to understand the research papers relevant to my project.
- The papers have provided foundational knowledge on the spray characteristics and design considerations of pressure swirl and airblast atomizers.

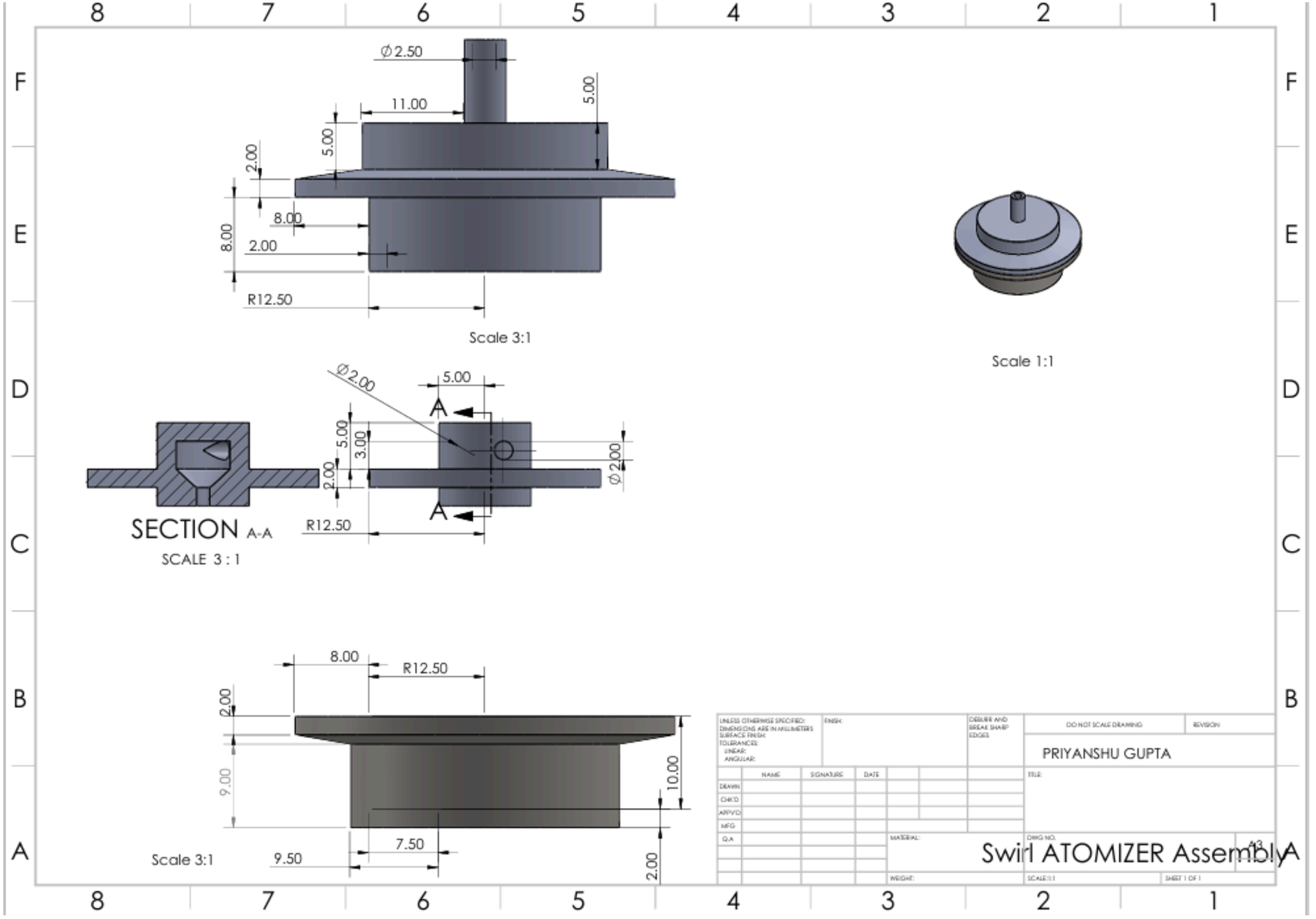
Educational Resources:

- Watching your lectures on Spray Theory and Application available on NPTEL to gain a deeper understanding of atomization principles and techniques.
- Recommended reading: "Atomization and Sprays" by Arthur H. Lefebvre, suggested by Dr. Lipika Kabiraj. The book has been instrumental in understanding the basics, but it does not include a design similar to the one I am proposing.

Initial Design Concept:

- Developed a rough sketch of the proposed atomizer that combines a pressure swirl mechanism with a pre-filmer airblast process. This concept aims to leverage the strengths of both atomization techniques for improved performance with non-Newtonian fluids.

Basic Swirl Atomizer



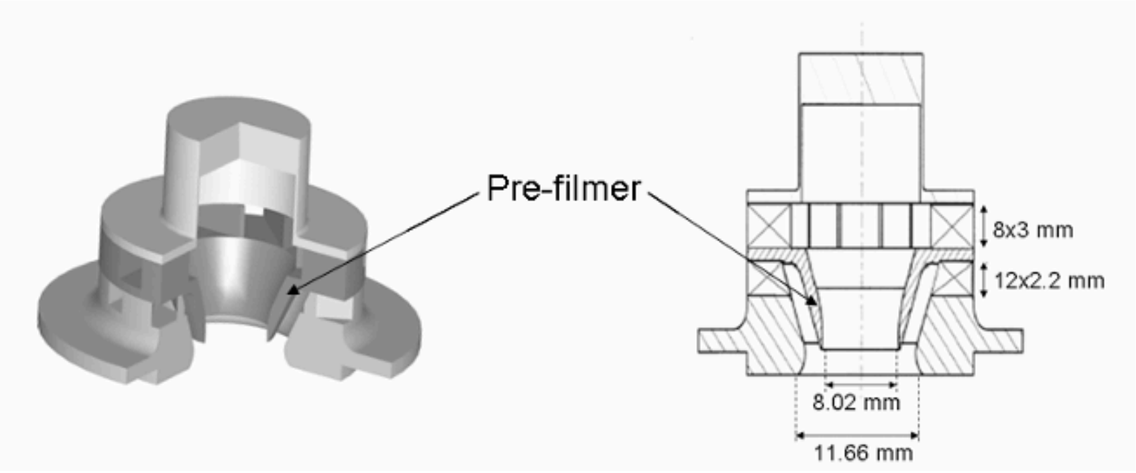


Figure 2.2: MTU airblast atomizer with pre-filmer

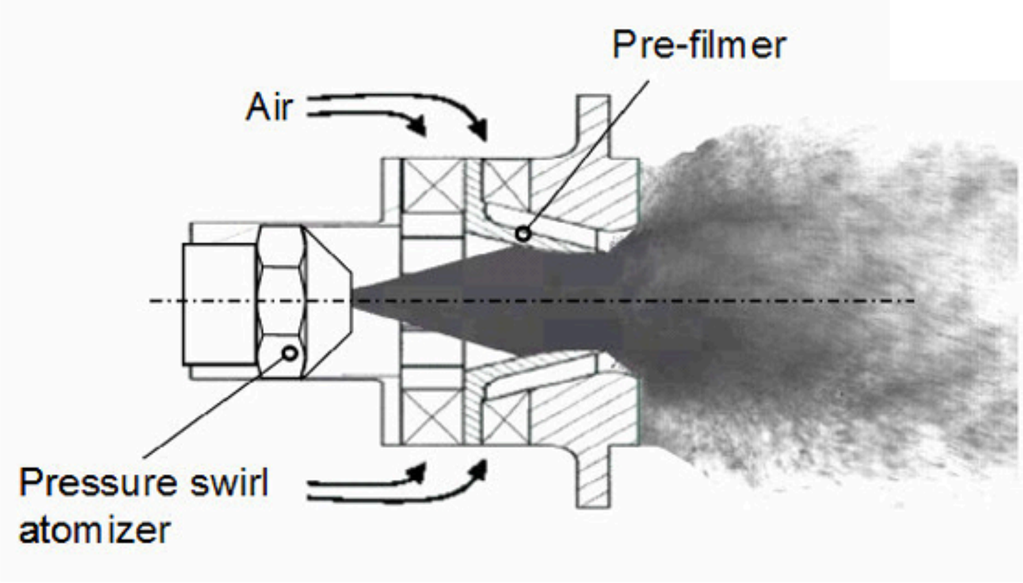


Figure 1.1: Airblast atomizer with pre-filmer.

These are the drawing I came over which can be used for designing

Specific Question

Detailed Questions I Seek Guidance On

1. Key Design Considerations for the Novel Atomizer
    - What are the critical factors to consider when integrating a pressure swirl mechanism with a pre-filmer airblast process?
    - How can I optimize the design to handle non-Newtonian fluids effectively?
2. Type of Airblast Atomizer
    - Which type of airblast atomizer should I use: Pre-Filming or Plain Jet Airblast Atomizer?
    - What are the advantages and disadvantages of each type in the context of non-Newtonian fuel atomization?
3.

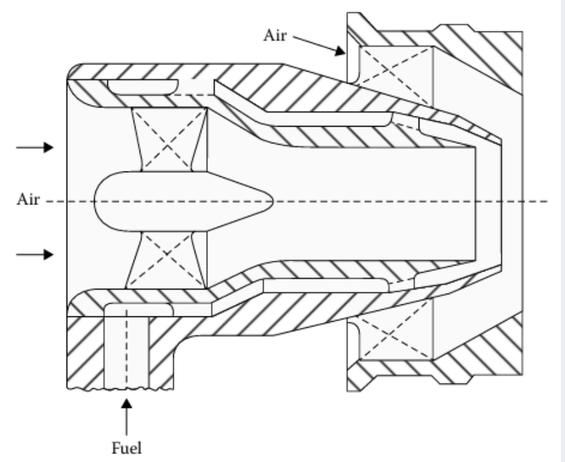


FIGURE 4.50
Prefilming airblast atomizer. (Courtesy of Parker Hannifin Corp.)

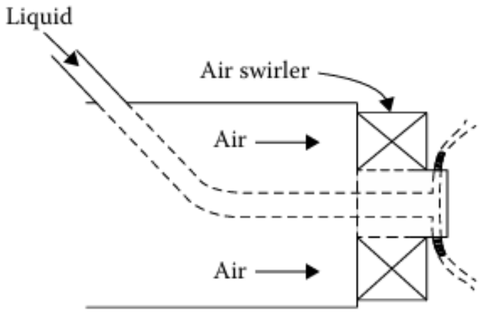


FIGURE 4.52
Plain-jet airblast atomizer. (From Jasuja, A. K., *ASME J. Eng. Power*, 101, 250–258, 1979.)

Specific Question

- Availability of 3D Models or Blueprints
  - Do you have any existing 3D models or detailed blueprints of similar atomizers that could serve as a reference?
  - Any resources or examples that could guide me in refining my design?
- Recommendations for Experimental Setup and Testing
  - What are the best practices for setting up experiments to test the spray characteristics of the novel atomizer?
  - Are there specific measurement techniques or instruments that are particularly useful for analyzing non-Newtonian fluid sprays?

Current Challenge

I am currently facing difficulties in the design phase, particularly in combining the pressure swirl mechanism with the pre-filmer airblast process and ensuring the proper fittings within the atomizer. This challenge is preventing me from moving forward with the manufacturing and experimental testing phases of the project.

Your guidance on these specific questions would be invaluable in helping me overcome these challenges. Once the design is complete, I plan to proceed with manufacturing and conducting experiments to analyze the spray characteristics.

Thank You