RAJALAKSHMI ENGINEERING COLLEGE
An AUTONOMOUS Institution
Affiliated to ANNA UNIVERSITY, Chennai

25 years OF ACADEMIC EXCELLENCE

Department of Artificial Intelligence and Data Science

Optimal Length Utilization

Dr.P.Indira Priya
M.E.,Ph.D.,
Professor

R JAI SAARATHI (221801019)
O JOEL SAM (221801021)

Problem Statement

Develop an automated system to optimize pipe cutting in industrial manufacturing, minimizing material waste and maximizing efficiency. The system will analyze stock data to determine optimal sizes and quantities of pipes for cutting, aiming to reduce usage of large pipes, improve material utilization, and enhance overall operational efficiency.

Motivation

- **Material Waste Reduction:** Minimize the amount of pipe material discarded as scrap during the cutting process.
- **Cost Savings:** Reduce procurement and inventory costs by optimizing pipe usage.
- **Improved Efficiency:** Streamline the pipe cutting process, leading to faster production cycles and increased output.
- **Sustainability:** Promote environmentally friendly practices by reducing material waste and conserving resources.

Objectives

Develop an advanced algorithm to optimize pipe cutting with minimizing waste and meeting specific length requirements. Create a practical tool for industry application, test its effectiveness, and ensure its versatility for various cutting scenarios. Reduce operational costs, improve resource utilization, and support environmental sustainability by significantly decreasing material waste.

Abstract

This project develops an advanced algorithm for optimizing pipe cutting from larger stock lengths, aiming to minimize waste and reduce operational costs. The algorithm enhances resource utilization by efficiently meeting specific length requirements and supports sustainability by lowering material waste. A practical software tool will be created, validated with real-world data, and compared to traditional methods. The project will provide adaptable solutions for various scenarios and include detailed documentation to support implementation and ongoing improvement.

Introduction and Overview of the Project.

Efficiently cutting pipes from larger stock lengths is a vital process in industries such as construction, manufacturing, and plumbing. The challenge, known as the pipe cutting problem, involves optimizing the way these large pipes are cut into smaller, required lengths to minimize waste and reduce costs. Traditional methods often result in substantial material waste, leading to higher operational expenses and environmental impact.

Literature Survey

S.No	Author Name	Paper Title	Description	Journal	Volume/Year
1	A. Kumar, D. Verma, and A. Kumar	A Review of Cutting Stock Problem Solutions with Metaheuristics: Recent Trends and Future Directions	A review of various metaheuristic techniques for solving cutting stock problems, highlighting recent trends and future research directions.	IEEE Access	Vol. 11, 2023

Literature Survey

S.No	Author Name	Paper Title	Description	Journal	Volume/Year
2	Y. Li, H. Wang, and Z. Liu	An Adaptive Genetic Algorithm for the Cutting Stock Problem with Multiple Patterns	This paper presents an adaptive genetic algorithm for solving complex cutting stock problems, emphasizing its flexibility and efficiency.	IEEE Transactions on Evolutionary Computation	Vol. 27, No. 1, 2023

Literature Survey

S.No	Author Name	Paper Title	Description	Journal	Volume/Year
3	J. K. Lee and J. K. Kim	Enhanced Integer Programming Approaches for Large-Scale Cutting Stock Problems	The study explores how enhanced integer programming can optimize material usage in large-scale cutting operations, offering robust solutions.	IEEE Transactions on Evolutionary Computation	Vol. 20, No. 2, April 2023

Existing System

- **Manual Cutting Plans**: Operators develop cutting plans manually, which can lead to inefficiencies and higher material costs. This method often fails to optimize waste management effectively and struggles with complex length requirements. The lack of systematic approach can result in suboptimal use of stock material. Consequently, this approach may lead to excessive leftover material and increased operational expenses.
- **Heuristic Algorithms**: Methods like First Fit and Best Fit allocate pipe lengths based on immediate fit, providing quick solutions. These algorithms are simple and easy to implement but do not always ensure the minimum waste. They may not consider the overall optimization of material use, leading to inefficient cutting patterns. The approach is often limited in handling complex scenarios and varying demands.

Drawback of Existing System

- **Inefficiency**: Manual planning often results in suboptimal cutting patterns, leading to increased material waste
- **High Costs**: Higher material costs due to inefficient use of stock pipes.
- **Time-Consuming**: Developing and adjusting plans manually is labor-intensive and slow.
- **Limited Flexibility**: Difficult to adapt to complex or changing cutting requirements.

Proposed System

- **Advanced Optimization Algorithm**: A smart method that finds the best way to cut pipes, saving material and meeting size needs.
- **Real-Time Data Processing**: Quickly analyzes data to create the best cutting plan right away.
- **User-Friendly Interface**: Easy-to-use design for entering data and seeing the best cutting plans.
- **Versatility**: Can handle different types of pipes and cutting needs across various industries.
- **Sustainability**: Focuses on reducing waste and saving resources, helping the environment.
- **Feedback Loop**: Continuously improves the cutting plan by learning from real-world results.

Methodology

1.Define Problem

- Reduce waste, optimize pipe cutting efficiency.

2. Data Acquisition

- Upload & validate pipe sizes/quantities (CSV).

3. Optimization

- Best Fit Decreasing (BFD) algorithm for minimal waste.

Methodology

4. Simulation & Validation

- Test and validate cutting patterns.

5. Results

- Visualize patterns, export reports (CSV, PDF).

6. Continuous Improvement

- Monitor, refine, and improve over time.

Algorithm

The **Best Fit Decreasing (BFD)** algorithm is a heuristic approach used in the **pipe-cutting optimization** project to minimize material waste and improve efficiency. It sorts the required pipe lengths in descending order and iteratively fits each length into the most suitable available pipe stock, selecting the one that leaves the least leftover material. This ensures optimal allocation of pipe resources while adhering to constraints like available stock sizes

Steps in BFD Algorithm

1. Prepare Data:

- Define the raw pipe length (6000mm).
- List the required pipe lengths (600mm, 350mm, 460mm, etc.).

2. Sort the Required Lengths:

- Sort the required pipe lengths from **largest to smallest**.

3. Start Allocating Cuts:

- Find the raw pipe that best fits the cut (i.e., has the least leftover space).
- If no existing pipe fits, start a new one.

Steps in BFD Algorithm

4. Update Pipe Lengths:

- After each cut, update the remaining length of the selected pipe.
- Remove a pipe from the list if it’s fully used.

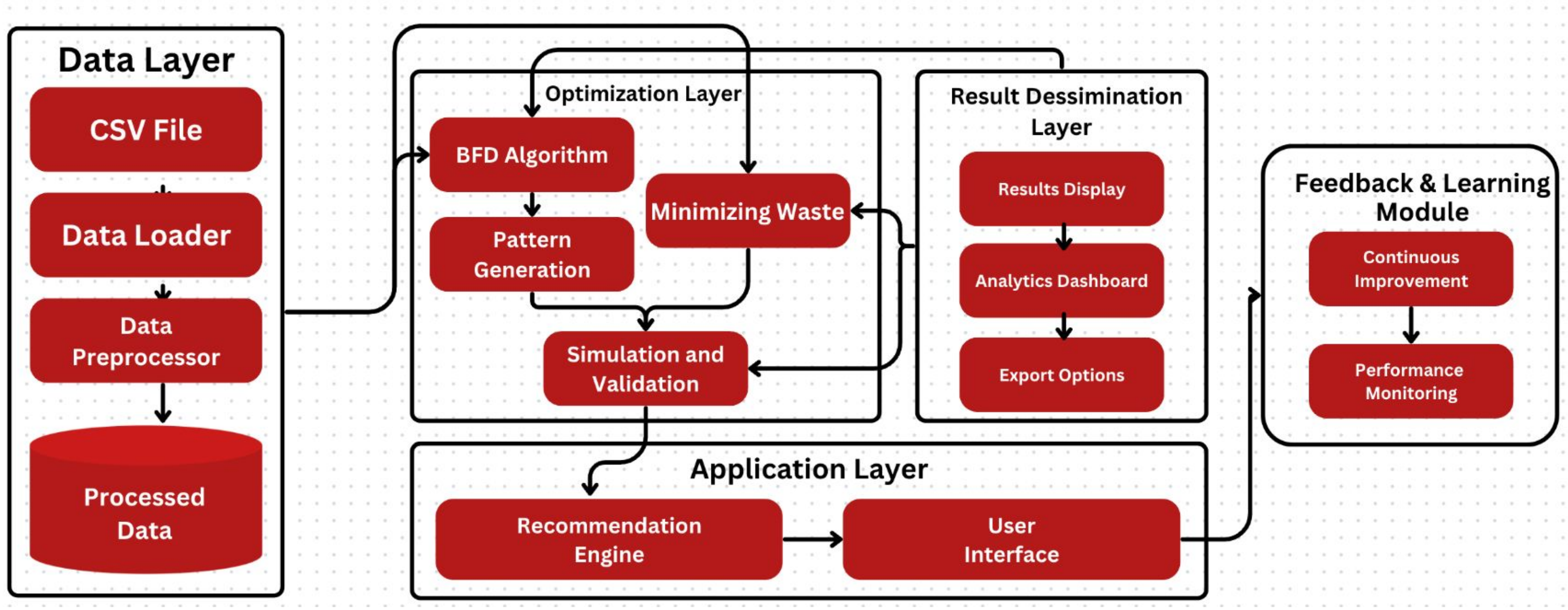
5. Repeat:

- Continue allocating cuts until all required lengths are assigned to pipes.

6. Result:

- The output will show how the cuts were made and how much scrap (leftover
- material) remains.

System Architecture



List of Modules

- **Data Acquisition Module**
  - Data Input Interface
  - Data Validation
- **Optimization Engine**
  - Algorithm Core
  - Pattern Generation
  - Simulation & Validation
- **Results Dissemination Module**
  - Results Display
  - Analytics Dashboard
  - Export Options
- **Feedback & Learning Module**
  - Performance Monitoring
  - Continuous Improvement

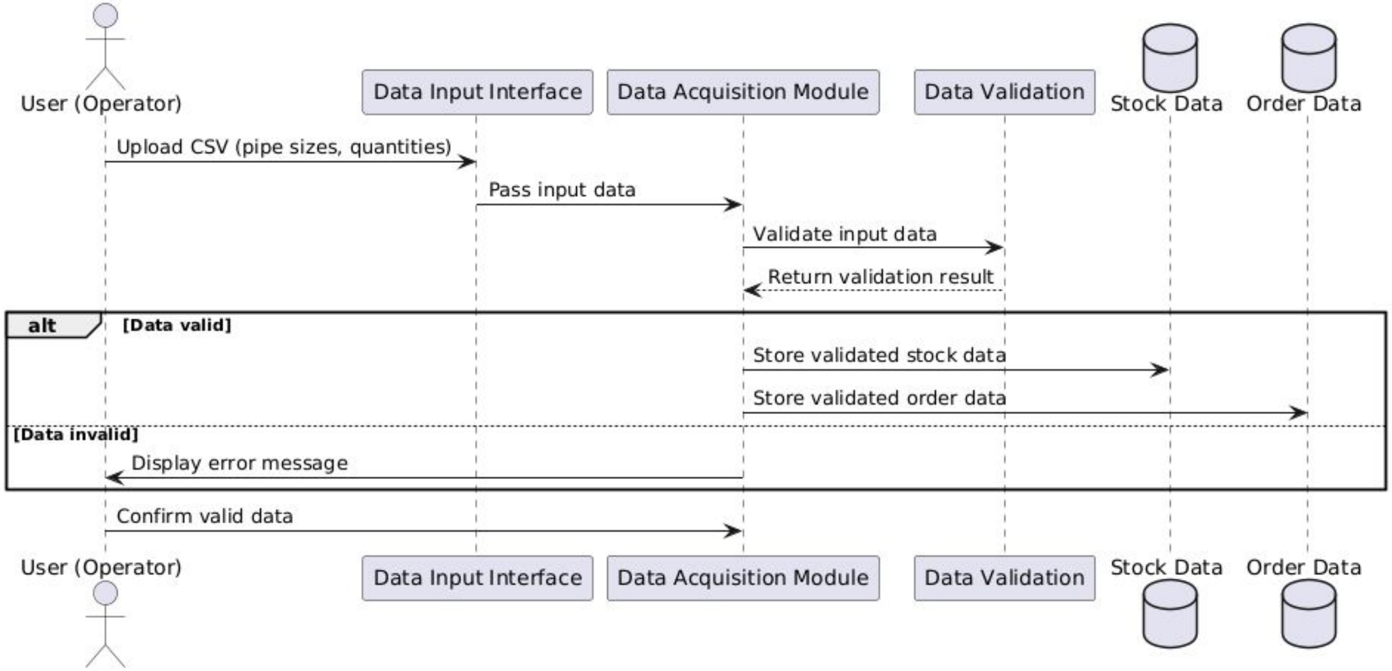
Data Acquisition Module

Main Purpose: Collect and validate the input data required for pipe-cutting optimization.

Key Components:

- **Data Input Interface**: Users upload data (e.g., pipe sizes and quantities) via CSV.
- **Data Validation**: Ensures the data is complete and correct before processing.

Data Acquisition Module



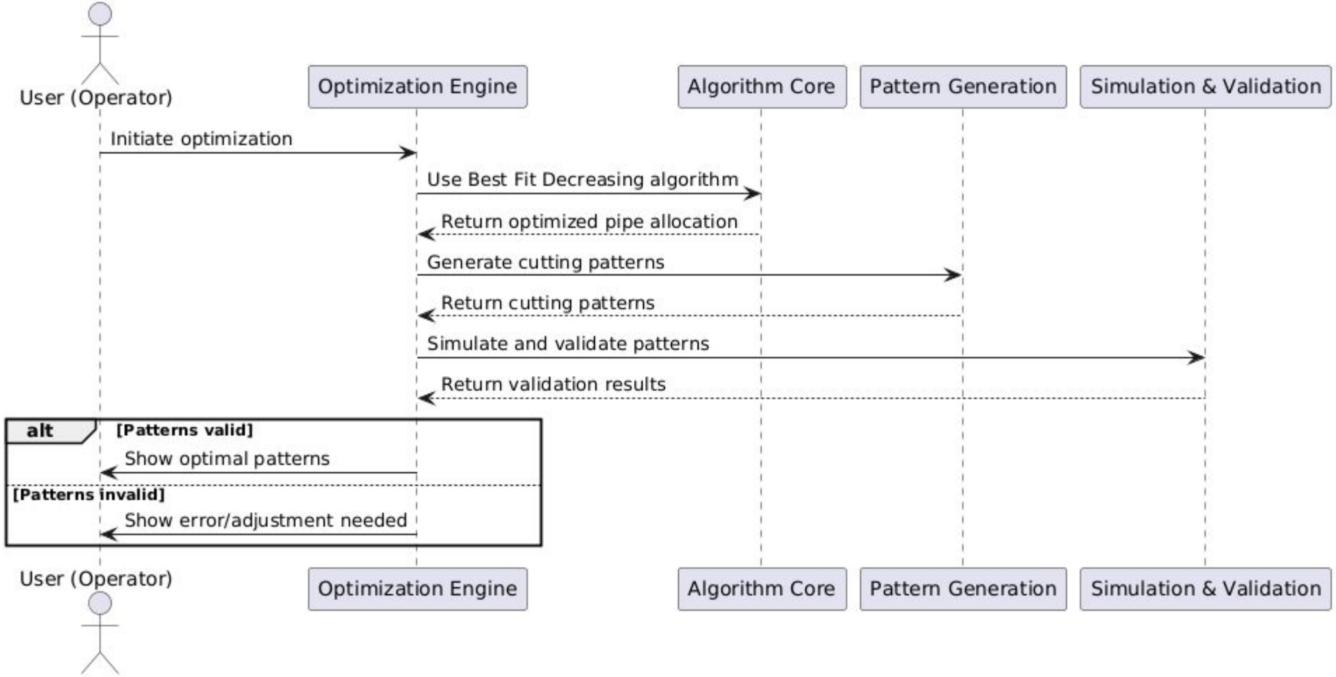
Optimization Engine

Main Purpose: Generate optimal cutting patterns to minimize waste and maximize efficiency.

Key Components:

- **Algorithm Core**: Uses the Best Fit Decreasing algorithm to allocate pipes based on the available lengths.
- **Pattern Generation**: Creates cutting patterns for pipes.
- **Simulation & Validation**: Tests the patterns in a simulated environment to ensure practicality.

Optimization Engine



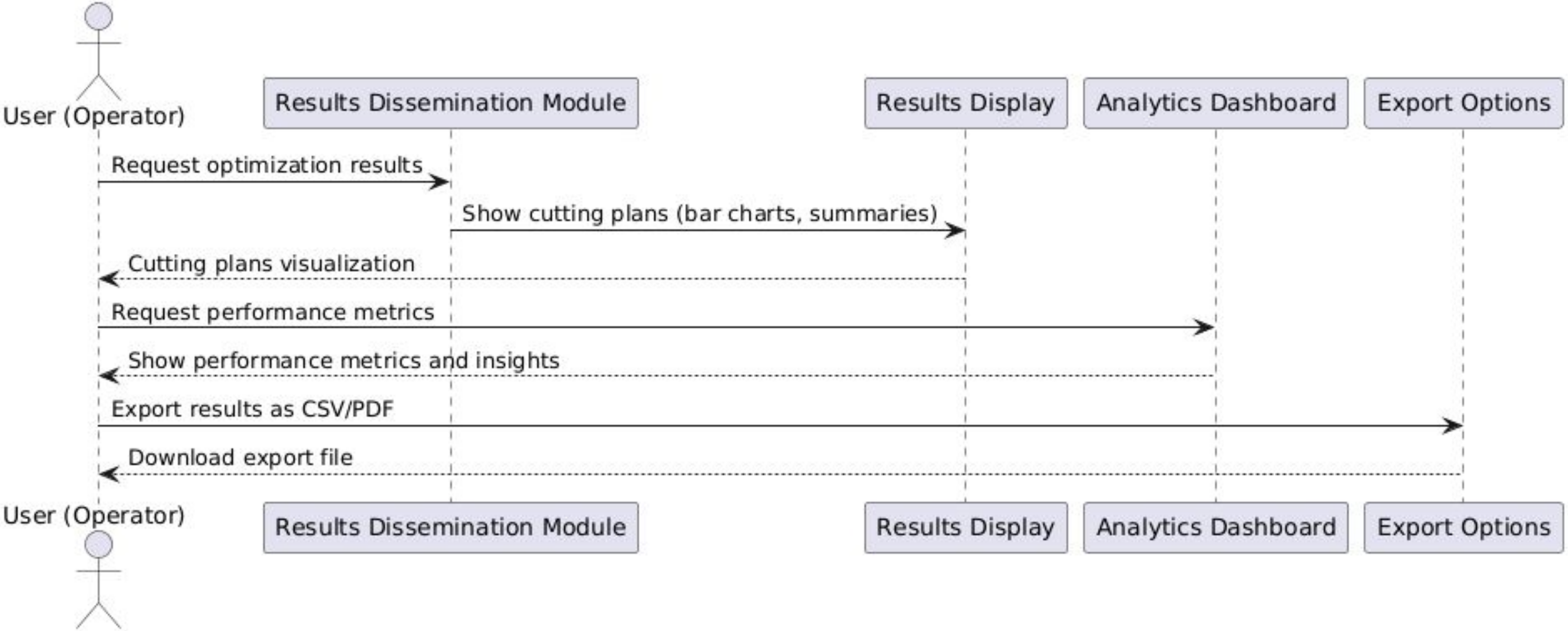
Results Dissemination Module

Main Purpose: Present the results of the optimization process.

Key Components:

- **Results Display**: Visualizes the cutting plans using bar charts and pipe usage summaries.
- **Analytics Dashboard**: Provides performance metrics and waste reduction insights.
- **Export Options**: Allows users to export the results in different formats like CSV or PDF.

Results Dissemination Module



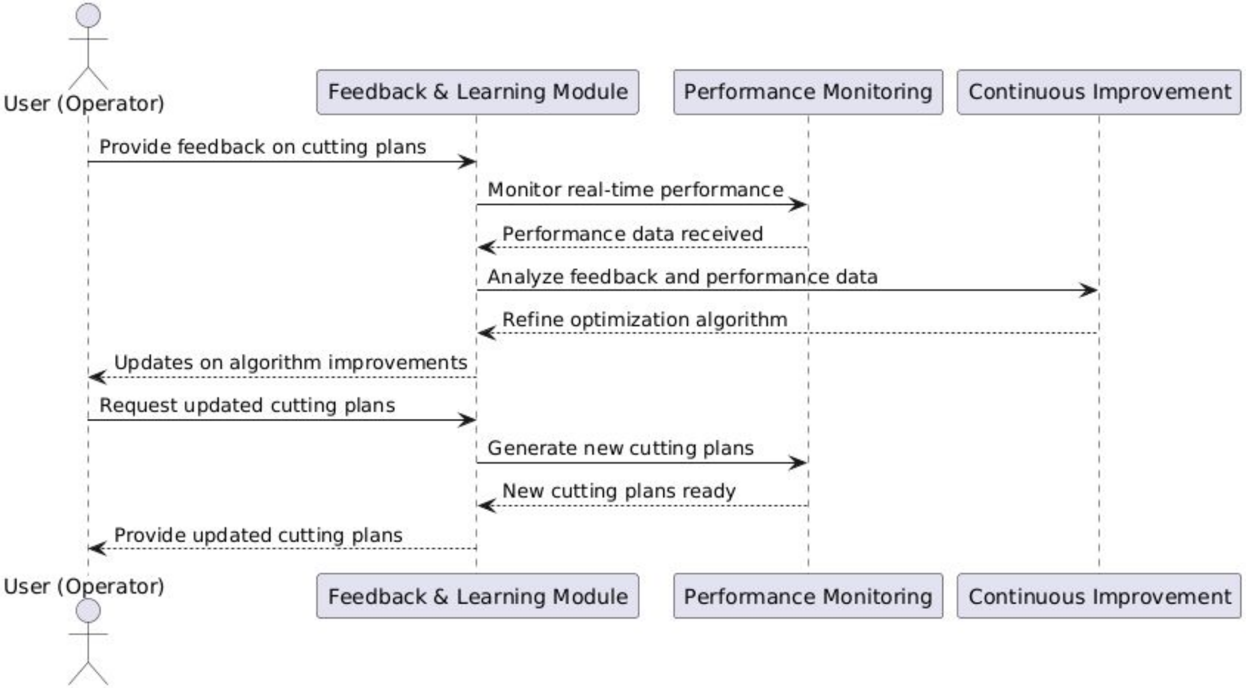
Feedback & Learning Module

Main Purpose: Continuously improve the optimization process by learning from past data.

Key Components:

- **Performance Monitoring**: Tracks real-time performance of the cutting plans.
- **Continuous Improvement**: Uses feedback to refine the algorithm for better future results.

Feedback & Learning Module



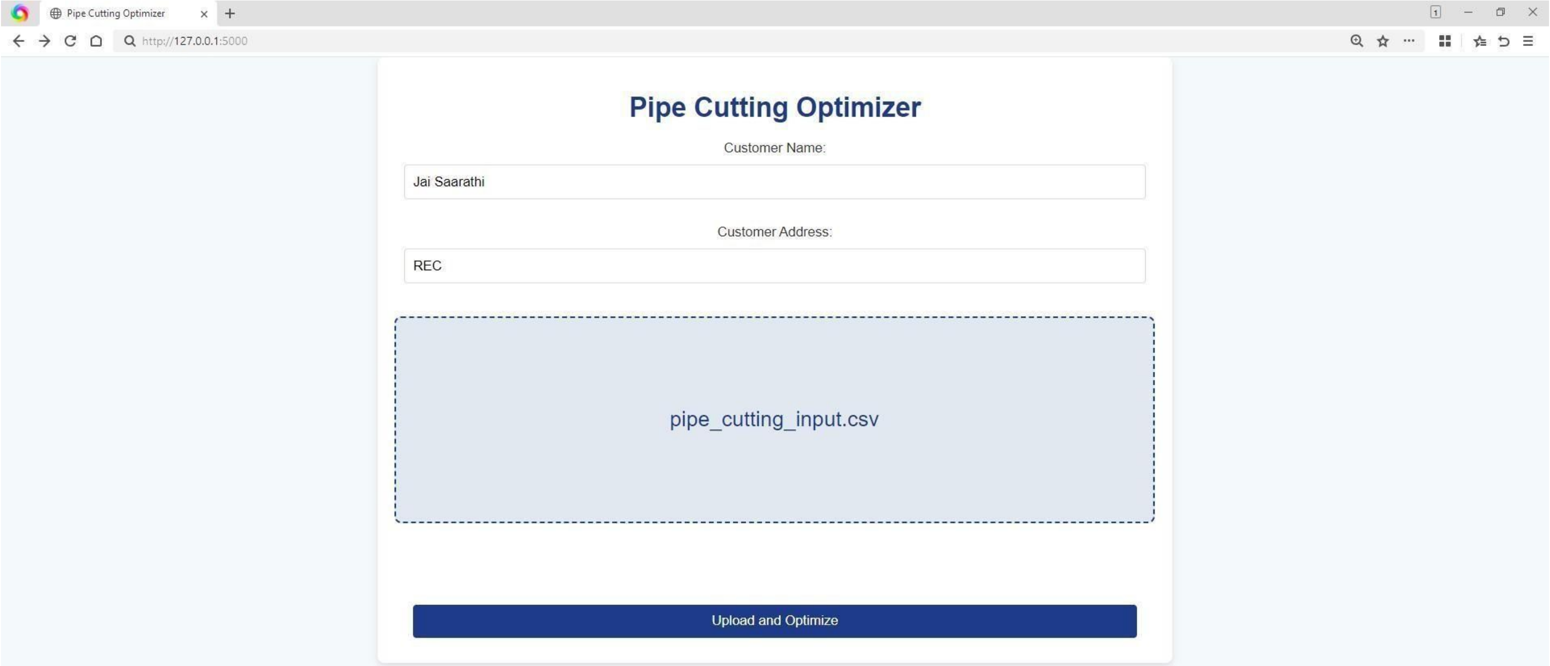
Result and Discussion

Main Purpose: Continuously improve the optimization process by learning from past data.

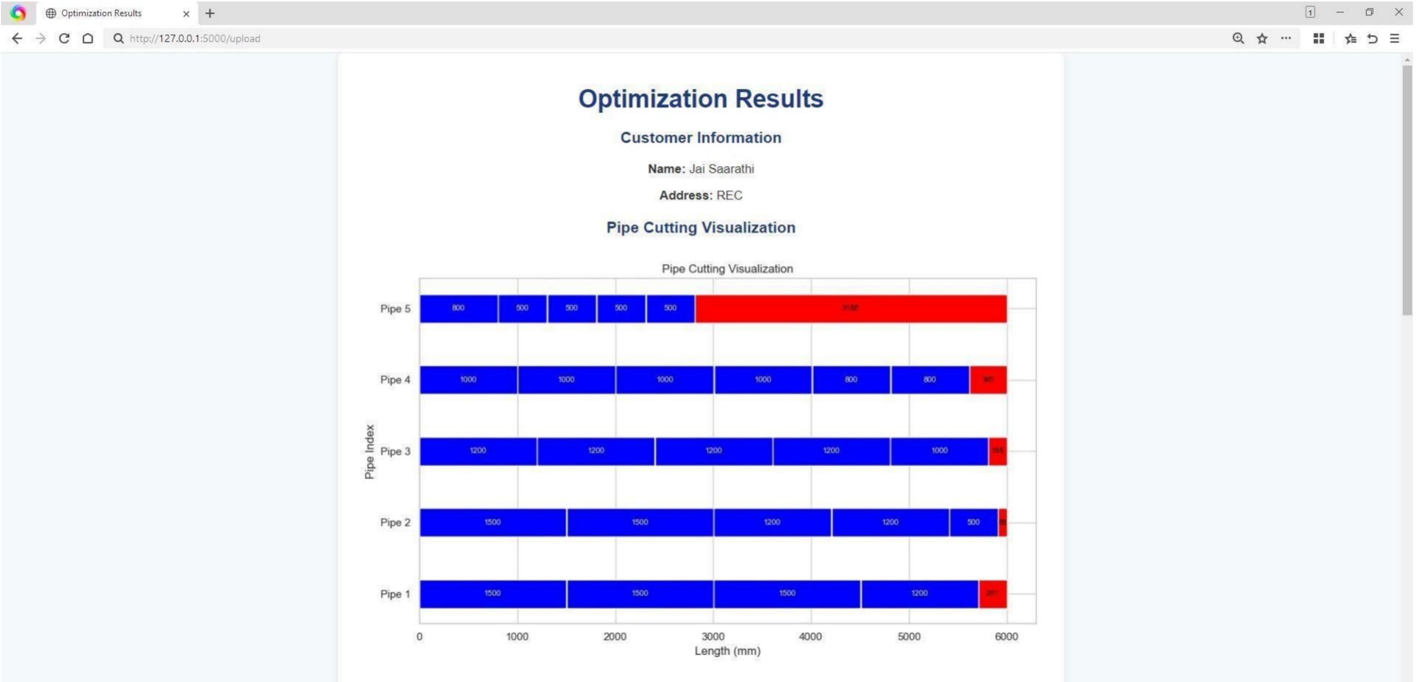
Key Components:

- **Performance Monitoring**: Tracks real-time performance of the cutting plans.
- **Continuous Improvement**: Uses feedback to refine the algorithm for better future results.

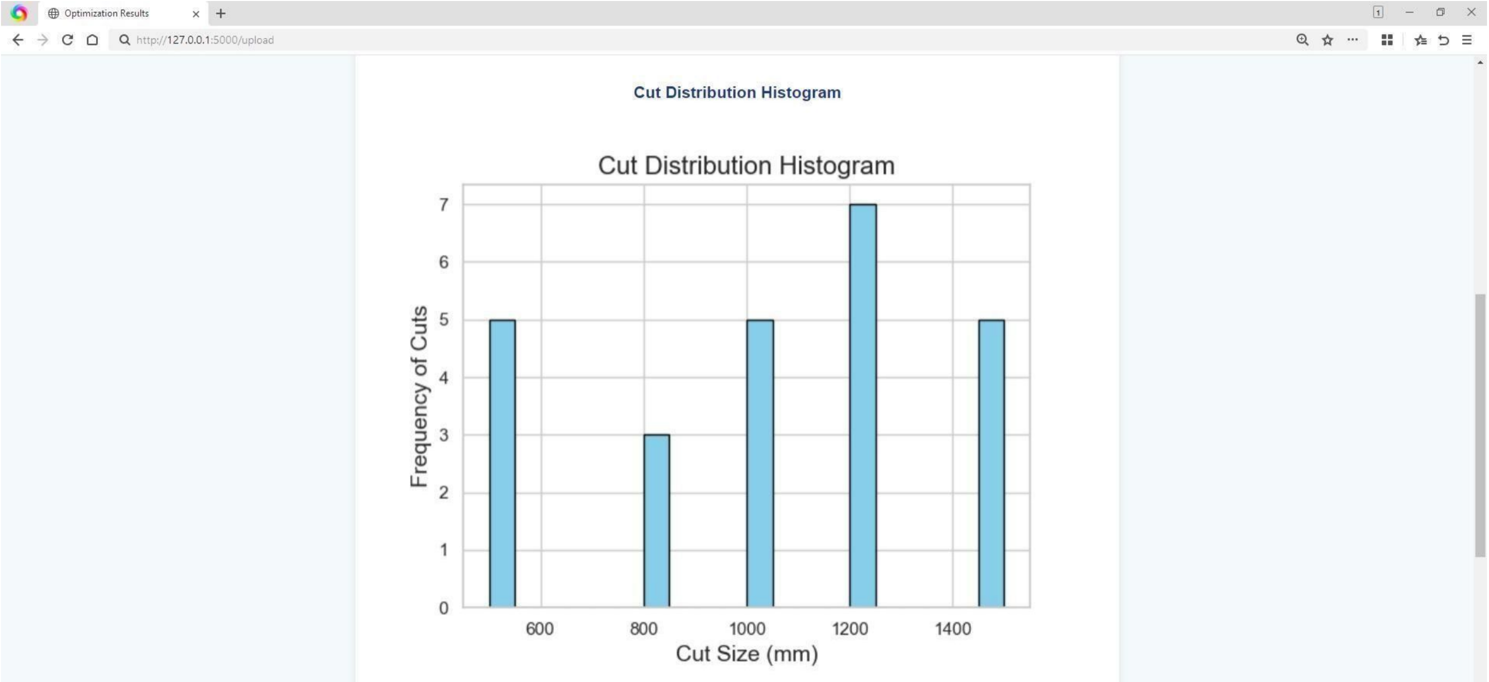
Output


Pipe Cutting Optimizer
http://127.0.0.1:5000
Pipe Cutting Optimizer
Customer Name:
Jai Saarathi
Customer Address:
REC
pipe_cutting_input.csv
Upload and Optimize

Output

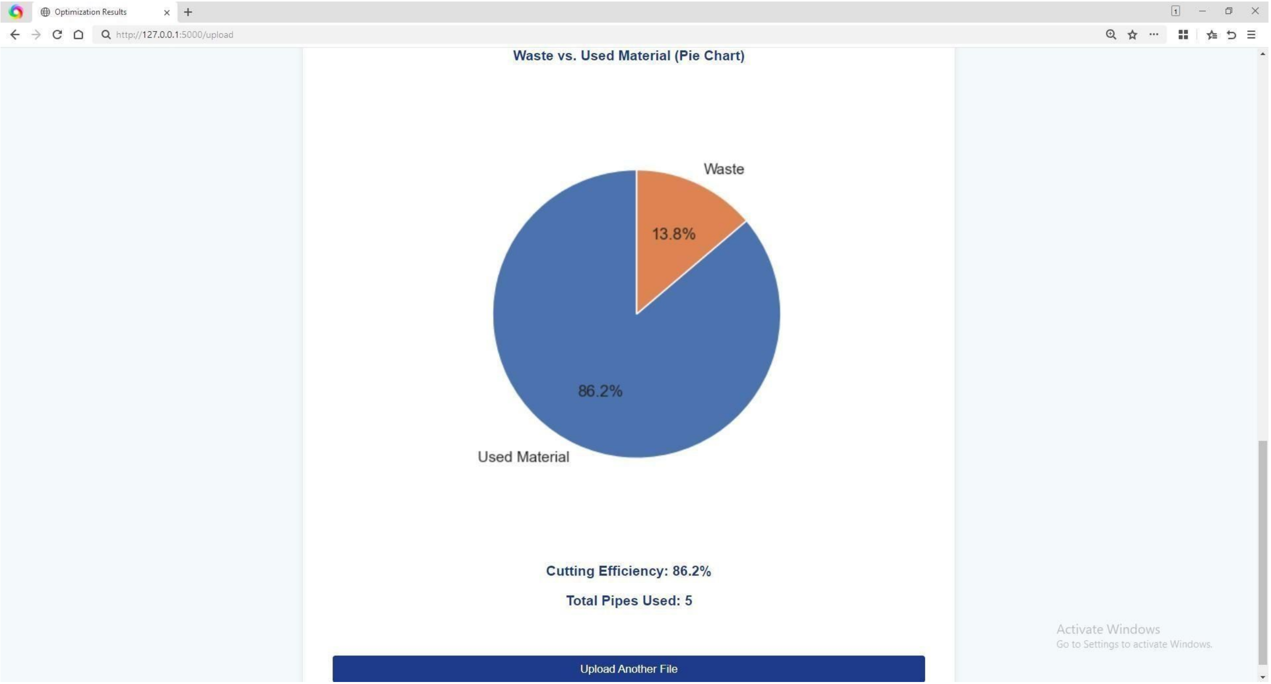

Optimization Results
http://127.0.0.1:5000/upload
Optimization Results
Customer Information
Name: Jai Saarathi
Address: REC
Pipe Cutting Visualization
Pipe Cutting Visualization
Pipe 5
Pipe 4
Pipe 3
Pipe 2
Pipe 1
Pipe Index
0
1000
2000
3000
4000
5000
6000
Length (mm)

Output



Optimization Results
http://127.0.0.1:5000/upload
Cut Distribution Histogram
Cut Distribution Histogram
Frequency of Cuts
0
1
2
3
4
5
6
7
600
800
1000
1200
1400
Cut Size (mm)

Output


Optimization Results
http://127.0.0.1:5000/upload
Waste vs. Used Material (Pie Chart)
Waste
13.8%
86.2%
Used Material
Cutting Efficiency: 86.2%
Total Pipes Used: 5
Upload Another File
Activate Windows
Go to Settings to activate Windows.

References

- **A. Kumar, D. Verma, and A. Kumar, "A Review of Cutting Stock Problem Solutions with Metaheuristics: Recent Trends and Future Directions,"** *IEEE Access*, vol. 11, pp. 59342-59364, 2023, doi: 10.1109/ACCESS.2023.3275412.
- **Y. Li, H. Wang, and Z. Liu, "An Adaptive Genetic Algorithm for the Cutting Stock Problem with Multiple Patterns,"** *IEEE Transactions on Evolutionary Computation*, vol. 27, no. 1, pp. 123-136, Feb. 2023, doi: 10.1109/TEVC.2022.3180709.
- **J. K. Lee and J. K. Kim, "Enhanced Integer Programming Approaches for Large-Scale Cutting Stock Problems,"** *IEEE Transactions on Automation Science and Engineering*, vol. 20, no. 2, pp. 320-331, April 2023, doi: 10.1109/TASE.2023.3205361.

Thank You