1. Executive Summary

This project focuses on analyzing manufacturing downtime to uncover the key factors affecting production efficiency. Using Python, SQL, Excel, and Tableau, the study identified high-downtime machines, critical shifts, operator-related issues, and machine failures. A forecasting model was also developed to predict next-day downtime and support production planning. The insights generated aim to help management reduce downtime, improve productivity, and optimize operational decision-making.

2. Business Problem

Manufacturing downtime directly impacts production output, delivery schedules, and operational costs. Excessive downtime leads to lower machine utilization, increased labor waste, and reduced profitability. The business needed clear, data-driven insights to understand why downtime occurs, which machines or operators are responsible, and how to proactively mitigate future disruptions.

3. Project Objectives

The project was designed to achieve the following goals:

- Identify machines and shifts with the highest downtime.

- Analyze the root causes of downtime (machine failures vs. operator-related issues).

- Answer 23 targeted analytical questions to understand downtime behavior.

- Build a forecasting model for predicting next-day downtime.

- Create a clear and interactive Tableau dashboard presenting all major insights.

4. Dataset Description

The dataset included manufacturing downtime records captured over a specific time.

- **Columns Included:** Shift, Operator, Downtime Duration, Downtime Category, Date, etc.

- **Data Types:** Numeric, categorical, timestamps

- **Data Quality:**

    - No missing values
    - No duplicates
    - Clean and ready for analysis

During the project, we attempted to integrate expanded historical data for deeper insights. However, the extended dataset produced inconsistent and illogical results. Therefore, we reverted to the original dataset to maintain accuracy and reliability.

5. Tools & Technologies Used

- **Python** – Data cleaning, analysis, forecasting

- **Excel**– Quick analysis and validation

- **Tableau** – Building dashboards and visualizing insights

6. Methodology

6.1 Data Understanding & Review

- Reviewed data structure and fields

- Validated correctness of machine logs and downtime durations

6.2 Data Cleaning

- Checked for missing values (none found)

- Verified duplicates (none found)

- Standardized date formats and categories

6.3 Exploratory Data Analysis (EDA)

- Distribution of downtime across machines

- Downtime per shift

- Common root causes

- Operator performance analysis

6.4 Analysis Questions Phase

- Defined 23 key questions

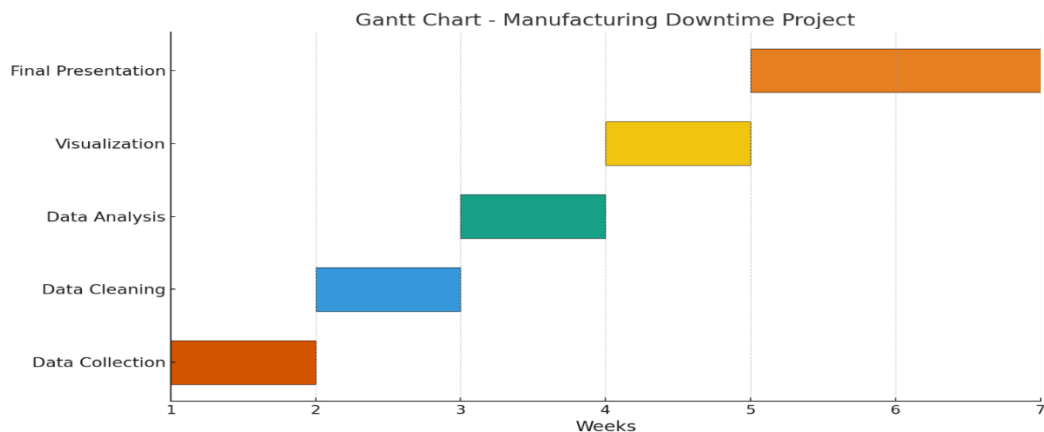- Solved them using SQL, Python, and Excel Pivot Tables

6.5 Forecasting Model

- Used Python to predict next-day downtime

- Suggested production batch adjustments

- Forecast visualizations were generated to support planning

6.6 Dashboard & Reporting

- Built an interactive Tableau dashboard

- Summarized insights in a structured presentation

7. Weekly Progress Summary

Gantt Chart - Manufacturing Downtime Project

8. Key Findings

8.1 KPI Summary (Overall Production Performance)

- Total Production Time: 3,668 minutes
- Total Downtime: 1,388 minutes
- Actual Production Time: 2,280 minutes
- Minimum Batch Time: 398 minutes

8.2 Shift Performance

- Morning shift experienced higher downtime.
- Possible reasons: operator fatigue, workload, or scheduling issues.

8.3 Root Causes of Downtime

- Mainly due to machine-related issues.
- Operator errors or delays contributed as well.

8.4 Operator Insights

- Some operators consistently showed higher downtime.
- Training or supervision may be needed.

8.5 Forecasting Results

- Downtime for the next day was successfully predicted.
- Help with planning the expected number of production batches.

9. Forecasting Approach

The forecasting model used Python to analyze downtime trends. While simple, it provided useful next day estimates and highlighted expected deviations.

- Suitable for short-term planning

- Accuracy can improve with more historical data

10. Tableau Dashboard Overview

The dashboard visualized:

- Total downtime

- Downtime by machine

- Downtime by shift

- Top reasons for downtime

- Forecast trends

- Key KPIs for decision-makers

This allowed stakeholders to explore insights interactively.

11. Project Limitations

- Limited historical data reduced forecasting accuracy

- Operator skill levels or maintenance logs were not included

- External factors (e.g., power issues) were not tracked

12. Recommendations

Operational Recommendations:

- Focus maintenance on high-downtime machines

- Provide targeted operator training

- Improve scheduling for high-downtime shifts

Strategic Recommendations:

- Collect more detailed data (maintenance logs, environment conditions)

- Automate downtime logging for higher accuracy

- Implement preventive maintenance routines

13. Conclusion

This project successfully analyzed downtime patterns, identified key inefficiencies, and developed forecasting insights to support better production planning. The findings offer practical guidance for optimizing machine performance, reducing downtime, and improving overall manufacturing efficiency. With enhanced data and ongoing monitoring, the system can evolve into a more accurate and automated decision-support tool.