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Optimizing Manufacturing Line Efficiency

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Oraganization

The organization primarily offers soft drink products to its customers, with a current portfolio of five flavors: Orange, Lemon Lime, Cola, Diet Cola, and Root Beer. They distribute their products through various outlets, including Walmart, Co-op, and other major retailers. At present, they maintain a profit margin of up to 20%, with a significant portion of their expenditure allocated to marketing. Despite being a growing firm with good market opportunities, they face strong competition. Therefore, they are focused on maintaining high quality and continuously improving the taste and texture of their flavors. Given the scale of their business, a small sample of operators works on a single machine to manage production.

The soft drink production process involves several critical stages to ensure the beverage is safe, flavorful, and of high quality. It begins with water treatment, where the water undergoes coagulation, chlorination, sand carbon filtration, and micron filtration to remove impurities. UV treatment is applied to ensure microbial safety.

Simultaneously, sugar is dissolved, purified through carbon filtration, particle purification, and thermal treatment to ensure it meets the desired quality. Flavor concentrates and carbon dioxide (CO_2) are also prepared. CO_2 is vaporized and passed through multi-media filtration.

In the blending stage, purified water, sugar syrup, CO_2, and flavorings are mixed in precise proportions. This blend is then subjected to further filtration and transferred to filling machines, where it is bottled or canned, sealed, and prepared for distribution. The final product undergoes quality checks to ensure consistency in taste and safety before it reaches the consumer.

Goal And Purpose

- **Increase Manufacturing Efficiency**: Identify inefficiencies in the production process and take steps to optimize.
- **Reduce Downtime**: Understand the root causes of downtime and mitigate them.

OPEN-SOURCE DATA OF INTEREST:

The **Manufacturing Line Productivity** dataset is valuable for data science students due to its real-world relevance and potential for operational optimization. It includes diverse data types (efficiency, throughput, downtime factors, logs) that mirror industry challenges, allowing students to work with complex, multidimensional data.

By analyzing this dataset, students can identify inefficiencies, such as common downtime causes, and their impact on productivity. They can also explore relationships between product types and line throughput, gaining insights into how different factors affect manufacturing efficiency. Predictive models can be built for anticipating downtime or optimizing throughput.

This dataset provides a hands-on opportunity to apply key data science techniques like exploratory data analysis, predictive modeling, and data visualization. Students can create actionable insights in downtime patterns.

Ultimately, the dataset offers rich learning opportunities by combining time-series analysis, classification, and optimization techniques. It challenges students to think critically about real-world problems, making it a valuable project for improving both technical and industry-specific skills.

Key question on the dataset

• What are the primary reasons for downtime, and how do they differ across lines or products?

- Understanding the leading causes of downtime helps prioritize areas for improvement. By examining how these reasons vary between production lines or specific products, we can identify which is the prominent cause of failure and what action to be taken to rectify the issue

• Is there a correlation between downtime factors and specific products or production shifts?

- This question helps explore whether particular products or shifts experience more downtime. Analyzing downtime by shift can reveal patterns related to staffing or machine wear during specific hours.

• How does operator efficiency relate to production?

- By linking operator performance data with production outcomes, we can determine whether inefficiencies are linked to human factors, such as operator experience or training gaps.

• How does the performance of various products affect overall line productivity?

- Certain products may take longer to manufacture or cause more stoppages. Understanding how product characteristics influence line performance can guide adjustments in production planning, potentially improving overall throughput.

Metrics and KPIs:

To effectively track both operational and strategic objectives, the following **Key Performance Indicators (KPIs)** will be used for the Manufacturing Line Productivity project:

1. MTTR:

Definition: OEE measures the efficiency of the manufacturing process by combining availability, performance, and quality.

Purpose: Provides a comprehensive view of how well a production line operates compared to its full potential.

2. Rejection:

Definition: Rejection is the act of refusing or dismissing something that doesn't meet set standards or expectations.

Purpose: To maintain quality, promote improvement, and minimize risks. Whether in product quality, proposals, or job applications, rejection helps ensure that only viable, valuable, and suitable options are accepted.

3. Mean Time Between Failures (MTBF):

Definition: The average time between production failures or unplanned stops.

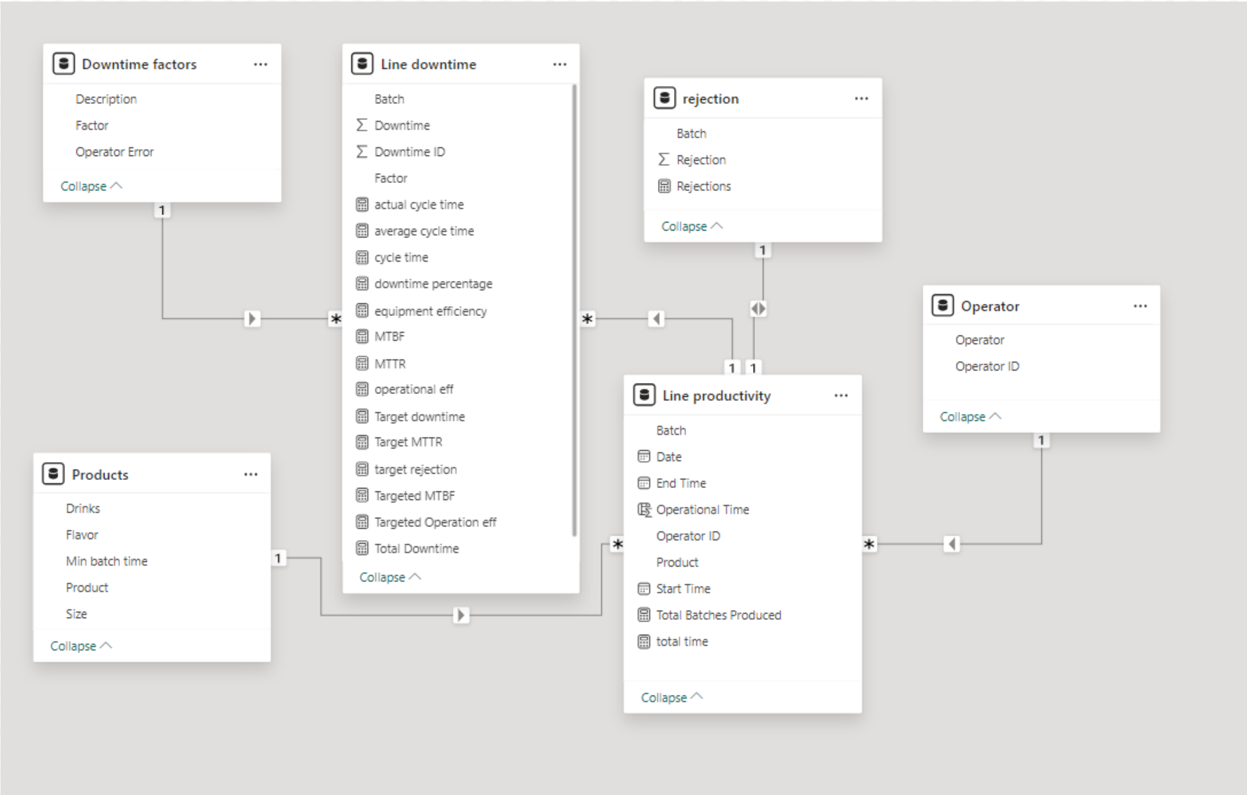
Purpose: Helps assess the reliability of equipment and predict when maintenance is required.

4. Cycle Time:

Definition: the time required to produce the single batch.

Purpose: Measures the productivity of the line, offering insights into the efficiency of product manufacturing.

Data model:



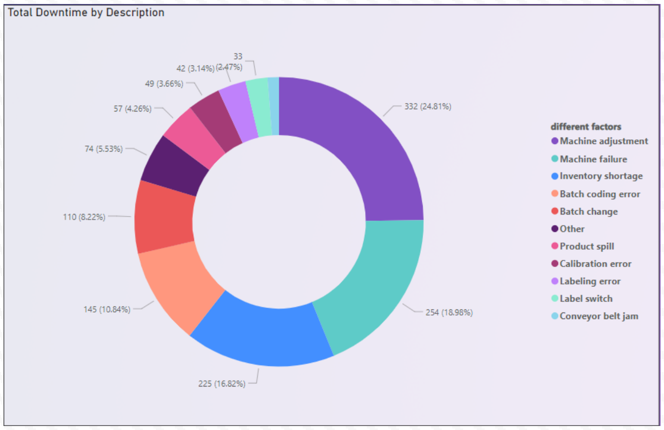
Breakdown Chart

The chart you provided shows the total downtime by description, where each segment represents a different cause for production downtime. The top three reasons for downtime are:

1. **Machine adjustment** (24.81%) – This seems to be the most significant cause, indicating a need for process optimization to reduce manual interventions or machine settings during production.

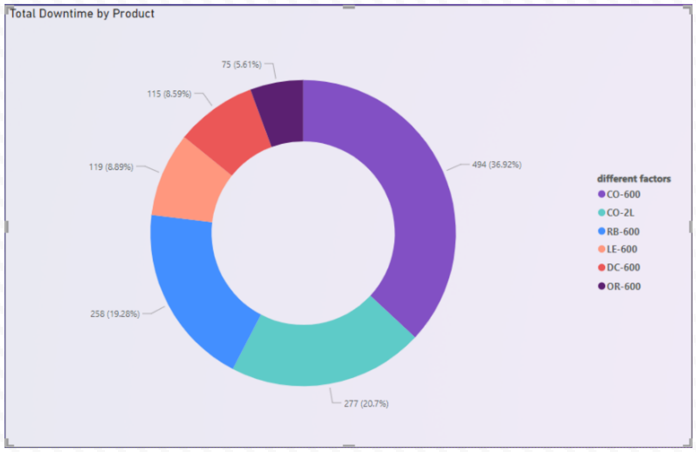
2. **Machine failure** (18.98%) – Regular maintenance and preventive strategies can help reduce this, potentially by implementing condition-based monitoring.

3. **Inventory shortage** (16.82%) – This issue could be addressed by improving inventory management practices to ensure consistent supply.



Other notable causes include **batch coding error**, **batch change**, and **conveyor belt jam**, each contributing between 10.84% and 3.66% of downtime.

The second chart illustrates the total downtime by product, showcasing how downtime varies across different product lines. Here are the key observations:



1. **CO-600** has the highest downtime (36.92%), suggesting that it may require the most attention regarding performance and reliability.
2. **DC-600** follows with 19.28%, indicating significant downtime as well and pointing towards potential issues specific to this product line.
3. **OR-600** and **RB-600** account for 20.7% and 8.59% of downtime, respectively, which are also noteworthy.

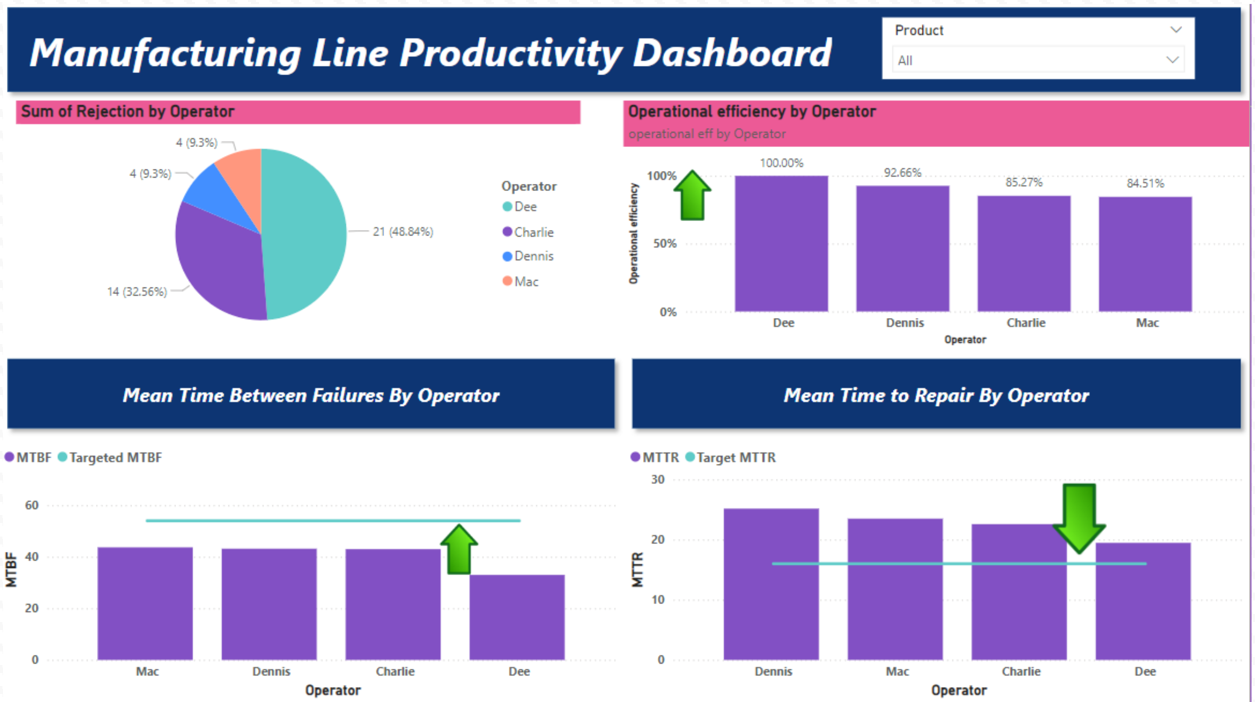
The other product lines, **CO-2L** (5.61%), **LE-600** (8.59%), and **CO-2L** (8.89%), have relatively lower downtime percentages but should still be monitored for consistent performance.

Actionable Insights

- **Prioritization:** Focus on the CO-600 line to understand the causes of downtime. Implement measures such as regular maintenance checks, process optimization, and staff training.
- **Comparative Analysis:** Analyze downtime reasons for CO-600 and DC-600 compared to the others. This could highlight specific operational weaknesses that can be targeted for improvement.
- **Consistent Monitoring:** For all product lines, maintain consistent monitoring to detect early signs of issues that could lead to increased downtime.

Operator DATA

In this dashboard, operator efficiency is directly related to production outcomes through the following metrics:



1. **Operational Efficiency by Operator**: This shows the percentage efficiency of each operator. Higher efficiency means less downtime and fewer production issues, indicating that the operator is effective in their role.
    - Example: Dee has 100% efficiency, which correlates with fewer rejections and smoother operations.
2. **Sum of Rejection by Operator**: This pie chart shows the number of rejected products per operator. If an operator has a higher number of rejections, it could indicate that operator efficiency is lower, negatively affecting production quality.
    - Example: Dee has the least rejections (9.3%), supporting their 100% operational efficiency.
3. **Mean Time Between Failures (MTBF) and Mean Time to Repair (MTTR)**: These two metrics reflect how often production line failures occur and how long it takes for operators to repair them. Operators with a higher MTBF and lower MTTR contribute more positively to production, as they maintain smooth operations with minimal downtime.
    - Example: Dee shows a good balance in both MTBF and MTTR, suggesting minimal downtime and quicker recovery from issues.

By analyzing these factors, you can link an operator's efficiency with overall production performance and identify where additional training or support may be needed.

To improve operator efficiency based on the output of the dashboard, consider the following suggestions:

1. Targeted Training Programs

- **Observation**: Dee has 100% efficiency, while Mac has the lowest efficiency (84.51%). This suggests variability in skill or experience.
- **Recommendation**: Provide additional training focused on operational tasks, particularly for operators like Mac and Charlie, who have lower efficiency. Training should address common causes of rejections and downtime.

2. Root Cause Analysis for Rejections

- **Observation**: Dee has the fewest rejections (9.3%), while Dennis and Mac have higher rejection rates (32.56% and 9.3%, respectively).
- **Recommendation**: Conduct a detailed root cause analysis for the rejections, focusing on the processes followed by Dennis and Mac. Introduce corrective actions and quality control measures that minimize operator errors, improving both quality and productivity.

3. Implement Standard Operating Procedures (SOPs)

- **Observation**: There is a difference in MTTR across operators, indicating inconsistent troubleshooting skills.
- **Recommendation**: Develop clear, concise SOPs for handling equipment failures and common production issues. Make sure all operators follow the same steps to reduce variability in repair times (MTTR).

4. Incentivize Performance

- **Observation**: Some operators outperform others in terms of operational efficiency and product rejection rates.
- **Recommendation**: Consider introducing performance-based incentives to encourage high efficiency and lower rejection rates. Reward operators who consistently meet or exceed efficiency targets, promoting a culture of excellence.

5. Cross-Training Operators

- **Observation**: Operators like Dee excel, while others underperform. This may be due to specific task familiarity.
- **Recommendation**: Implement a cross-training program so operators can handle various tasks on the line. This increases flexibility, improves overall operator skill, and reduces dependency on high-performing operators for specific tasks.

6. Regular Feedback and Coaching

- **Observation**: Variations in operator performance suggest some may not be aware of their performance gaps.

- **Recommendation**: Conduct regular performance reviews and coaching sessions with each operator, providing feedback based on data from the dashboard. Personalized guidance will help operators improve specific areas of weakness.

7. Optimize Workstation Layouts and Tools

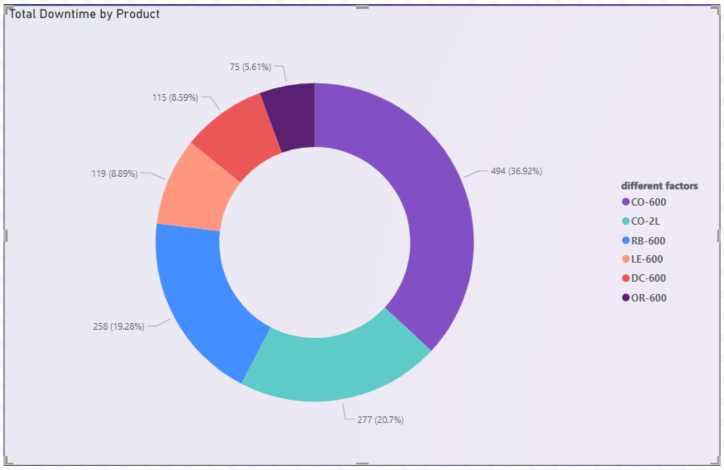
- **Observation**: Variability in MTTR (Mean Time to Repair) might indicate inefficiencies in workstation layouts or tool availability.
- **Recommendation**: Review the physical layout of workstations and ensure that tools and resources are easily accessible. Streamlining the layout can help operators work more efficiently and reduce repair times.

By implementing these suggestions, you can create a more consistent, skilled, and efficient operator team, which will improve overall production performance.

Product data chart

From the two charts provided, we can analyze how the performance of various products affects overall line productivity by focusing on **downtime** and **rejection rates**:

1. Total Downtime by Product

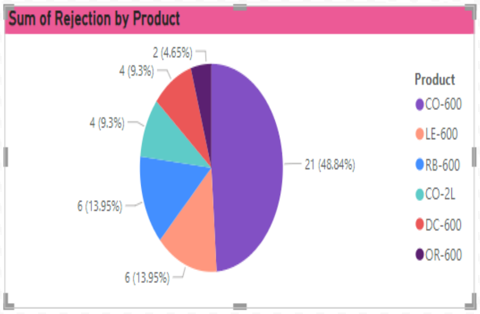


- **Key Observation**: The largest contributor to downtime is the **CO-600** product, accounting for 36.92% of total downtime, followed by **CO-2L** (20.7%) and **RB-600** (19.28%).
- **Impact on Productivity**: Since CO-600 is responsible for the majority of downtime, it heavily impacts the overall production line's throughput. The high downtime indicates frequent stoppages, slowing down the line and reducing overall productivity.
    - **Recommendation**: Investigate the causes of downtime specific to CO-600. This could involve machine maintenance, operator training, or revising the manufacturing process to reduce stoppages. Streamlining the production process for CO-600 can significantly improve overall productivity.

2. Sum of Rejection by Product

- **Key Observation**: The CO-600 product also leads in rejection rates, with 48.84% of all rejections. Other products such as LE-600, RB-600, and CO-2L have significantly lower rejection rates, around 13.95% each.

- **Impact on Productivity**: High rejection rates for CO-600 suggest issues in quality control or manufacturing, which further reduce productivity by wasting time and materials. Addressing these quality issues can improve line productivity and product yield.



  - **Recommendation**: Perform a root cause analysis to understand why CO-600 is experiencing high rejection rates. This could involve revising the manufacturing process, improving materials, or enhancing quality checks earlier in the production process.

Combined Analysis

- **CO-600** appears to be a major bottleneck for both downtime and rejections, affecting the overall productivity of the manufacturing line.
- **Other products (e.g., LE-600, RB-600)** cause fewer issues but still contribute to downtime and rejections. Balancing the production schedule by allocating more resources to high-performing products may help optimize overall throughput.

Suggestions for Improvement:

1. **Focus on CO-600**: Since it is responsible for the majority of both downtime and rejections, addressing the issues with this product will have the greatest impact on improving line productivity.
2. **Production Planning Adjustments**: For products with lower downtime and rejection rates (e.g., RB-600, CO-2L), consider increasing their production volumes to compensate for inefficiencies caused by CO-600.
3. **Enhance Maintenance and Monitoring**: Set up more frequent machine inspections and maintenance for processes involving CO-600 to reduce downtime.
4. **Improvement in Quality Control**: Implement stricter quality checks and review the manufacturing process of CO-600 to minimize defects and rejections.

By optimizing the performance of problematic products like CO-600 and leveraging the strengths of other products, the overall line productivity can improve significantly.

Conclusion:

The analysis of the Manufacturing Line Productivity dataset provides valuable insights into the key drivers of inefficiency and downtime. The dataset reveals that the most significant downtime causes include machine adjustment (24.81%), machine failure (18.98%), and inventory shortages (16.82%). These findings highlight areas for immediate action, such as enhancing machine maintenance protocols and optimizing inventory management. Additionally, the product CO-600 is a notable bottleneck, contributing to 36.92% of the total downtime and 48.84% of all rejections, making it a primary focus for process improvements.

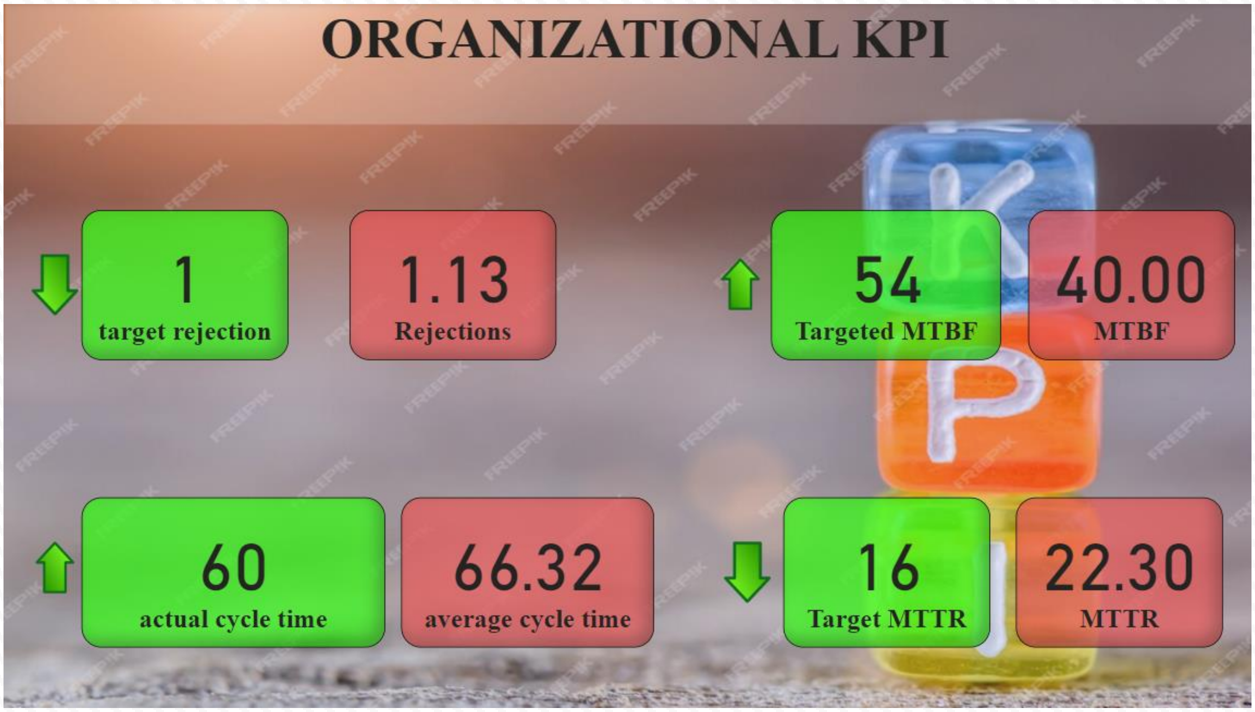
Operator efficiency also plays a critical role in production performance. Metrics like Mean Time Between Failures (MTBF), Mean Time to Repair (MTTR), and rejection rates show that variations in operator efficiency significantly impact downtime and product quality. Operators with higher efficiency, such as Dee, contribute to smoother operations, while others may require targeted training and support.

By addressing the root causes of downtime, optimizing operator performance through training, and focusing on the CO-600 product's quality issues, the manufacturing line’s overall efficiency can be significantly improved. These actionable insights set the stage for increased throughput, reduced downtime, and a more efficient manufacturing process.

Power BI

Appendix

Dash board Presentation:



The following image outlines the key performance indicators (KPIs) we are aiming to improve. We have identified rejection rates as our primary target, as we believe they are a significant factor contributing to potential business failure. While our target for per-batch rejection is achievable, we need to focus on minimizing these rejections and setting a new benchmark closer to zero.

Next, we look at the KPI for **MTBF (Mean Time Between Failures)**. To explain, imagine a vehicle driven for 6 hours, breaking down twice. To calculate the MTBF, we divide the total driving hours by the number of breakdowns, which gives a result of 3 hours per failure. Similarly, in our scenario, MTBF is calculated by dividing total operational time by the number of downtime events. A higher MTBF value indicates better performance, and we aim to maximize this.

The next KPI we have chosen is **Cycle Time**, with a benchmark set at 60 minutes. Currently, we are at 66.32 minutes, indicating that the target is achievable with focused efforts. By improving this cycle time, we can enhance the overall **OEE (Operational Efficiency)** and further boost operator efficiency.

Lastly, we are targeting an **MTTR (Mean Time to Repair)** of 16 minutes. While this target is challenging, we are committed to achieving it. At present, we've reached 22.30 minutes, showing significant progress, but there is still room for improvement.