EDA / Descriptive Statistics

## Introduction:

Manufacturing industries generate vast amounts of operational data daily, but when recorded manually, it becomes difficult to analyze and utilize effectively. The client currently maintains all manufacturing records in logbooks, which leads to inefficiencies, data inaccuracies, and limited insights into production performance. Our project focuses on digitizing this data and developing interactive dashboards that provide clear, real-time insights into key manufacturing metrics. These dashboards will help monitor process efficiency, track errors, and evaluate productivity trends, ultimately supporting data-driven decision-making. By implementing this digital solution, the organization aims to maximize operational efficiency, reduce manual errors, and achieve measurable growth in profitability and revenue.

## Overall design strategy

The manufacturing data extracted for analysis contains extensive records of daily production activities, operator performance, and process efficiency. To ensure meaningful insights, the data was organized and structured into multiple dashboards focusing on key manufacturing metrics such as production output, error rates, and efficiency trends. Since the data is captured at the activity level, an additional data connection was created to aggregate information at the machine and operator levels for specific visualizations. Both the raw data and SQL-based aggregated datasets were used to build a comprehensive analytical view.

For visualization, consistent color coding was applied **—** green representing successful or error-free operations and red indicating process deviations or failures. The font Trebuchet MS was used for all titles and subtitles to maintain a professional appearance, while Cambria Math (size 8) was used for numerical axes and Calibri (size 8) for textual labels. A light blue background was selected for the dashboards to provide a clean and calm visual appeal, and light green backgrounds were used for titles to enhance readability. Emphasis in tooltips and key metrics was achieved through the use of contrasting colors to highlight important trends and insights effectively.

## Data Overview

Data for this analysis is collected from the client’s manufacturing operations and historical production records. While the primary dataset is captured manually in logbooks, it is extracted and digitized into text files for analysis. Key reference datasets, such as machine details, operator information, and quality checks, are also collected, over all 52586 operator demographic data.

Once uploaded into Power BI, all files are joined using defined keys to create a unified dataset. Additionally, a custom SQL extract is used to summarize data at the team or production line level, enabling efficient visualization of overall manufacturing performance, trends, and key metrics.

## Users

Users of the visualization dashboard will be:

* Printer Operators: Can use the dashboards to monitor printing output, track sheet usage, and identify errors in the printing process for better efficiency.
* Chip/Embedding Operators: Can track chip embedding performance, detect errors, and ensure all chips are functioning correctly to reduce defective cards.
* Personalization Operators: Can analyze personalization accuracy, laser engraving quality, and monitor trends over time to improve precision.
* Quality Control Staff: Can review quality metrics across printing, embedding, and personalization stages to identify issues and ensure overall product quality.

## Questions

Questions which will be answered by this visualization:

### ****For Printer Operators:****

* Which machines or shifts have the highest printing errors?
* How many sheets/cards were printed per batch or per day?
* Are there trends in ink or paper type issues affecting print quality?
* Can I filter data by operator or date to analyze performance?

### ****For Chip/Embedding Operators:****

* How many chips failed during embedding in a given period?
* Which machines or operators have the most embedding errors?
* Can I track chip serial numbers for defective cards?
* How effective are alignment and functionality checks across batches?

### ****For Personalization Operators:****

* How many cards had personalization errors per batch?
* Can I see which operators or machines had the most laser engraving issues?
* How accurate is data entry for personalized information?
* Can I compare performance across shifts or production lines?

### ****For Quality Control Staff:****

* What is the overall rejection rate across printing, embedding, and personalization?
* Which stage of production has the highest defects?
* Can I drill down to see specific batches with recurring errors?
* How are defect trends changing over time, and which operators are involved?

## Describe Visualization and how it answers the questions

**Printer Operators:**

* **Which machines or shifts have the highest printing errors?**
* This visualization displays the error rate per machine and per shift, allowing operators to identify the periods with the most printing defects.
* It helps in planning maintenance schedules and optimizing manpower allocation.
* **How many sheets/cards were printed per batch or per day?**
* A time-series chart shows the total cards printed daily or per batch, helping track productivity trends and detect any drops in production performance.
* **Are there trends in ink or paper type issues affecting print quality?**
* The dashboard links print quality metrics with ink and paper type, helping identify which material combinations lead to higher rejection rates or color mismatches.
* **Can I filter data by operator or date to analyze performance?**
* Interactive filters allow users to view production performance by operator, date, or machine to support operator-level performance reviews and accountability.

**Chip/Embedding Operators:**

* **How many chips failed during embedding in a given period?**
* KPI charts show the count of embedding failures and their frequency over time, helping identify defective chip batches or machine malfunctions.
* **Which machines or operators have the most embedding errors?**
  + A comparative bar chart highlights embedding errors by operator or machine, enabling management to identify areas for skill improvement or maintenance.
* **Can I track chip serial numbers for defective cards?**
  + Drill-down functionality allows users to trace each defective card back to its chip serial number for easier recall, warranty tracking, or supplier feedback.
* **How effective are alignment and functionality checks across batches?**
* Line charts display alignment accuracy and chip functionality success rates per batch, ensuring that embedding quality remains consistent across production runs.

**Personalization Operators:**

* How **many cards had personalization errors per batch?**
* A summary view shows the total number of personalization rejections per batch, helping identify problem trends in laser engraving or data entry.
* **Can I see which operators or machines had the most laser engraving issues?**
* Visual comparisons show error counts by machine and operator, helping pinpoint where engraving quality control needs improvement.
* **How accurate is data entry for personalized information?**
* A quality metric visualization displays data accuracy rates across different operators, ensuring customer-specific information is correctly engraved.
* **Can I compare performance across shifts or production lines?**
* Side-by-side bar graphs compare productivity and error rates across different shifts or production lines to identify top-performing teams.

**Quality Control Staff:**

* **What is the overall rejection rate across printing, embedding, and personalization?**
* A consolidated dashboard visualizes total rejection percentages across all manufacturing stages to track process efficiency and product quality.
* **Which stage of production has the highest defects?**
* A stage-wise breakdown identifies whether defects are most common in printing, embedding, or personalization, helping prioritize improvement actions.
* **Can I drill down to see specific batches with recurring errors?**
* Drill-through reports allow QC teams to identify batches with repeated issues and trace them back to responsible operators or machines.
* **How are defect trends changing over time, and which operators are involved?**
* A trend line graph shows defect rate fluctuations over weeks or months, with filters for operator or shift, helping assess improvement after corrective actions.

## Conclusion

It is very difficult to analyze the card manufacturing data, which contains thousands of records collected from multiple production stages such as printing, embedding, and personalization. Even after aggregating this data, traditional reports only provide summarized figures and fail to show the detailed connections between processes, operators, and quality outcomes. Visualizing this data with various parameters such as operator performance, material type, and defect trends enables quicker insights and supports better decision-making.

With the implementation of digital tracking technologies and machine-level monitoring, there is a strong opportunity to build advanced dashboards that provide real-time visibility into manufacturing efficiency and product quality, helping improve overall operational performance.