EDA / Descriptive Statistics

## Introduction:

In the domain of industrial manufacturing, the cement industry plays a pivotal role in infrastructure development. However, the traditional methods of quality control and testing can often lead to delays and inefficiencies. Our project, "Cement Manufacturing Automation Data Analysis," aims to revolutionize this industry by harnessing the power of data and automation.

The cement manufacturing process involves regular quality testing, which can result in significant time lags. With an ever-increasing demand for cement, it becomes imperative to minimize these testing intervals. Our project is designed to address this challenge, leveraging data analysis and automation to streamline the quality control process.

## Overall design strategy

In order to facilitate the reduction of testing time in cement manufacturing, we have devised a comprehensive strategy that encompasses data handling, analysis, and visualization. This strategy leverages a dataset comprising 5514 records .

**Our design strategy is as follows:**

**Data Integration:** We'll consolidate and clean the data, handling missing values and ensuring consistency in the dataset.

**Feature Engineering:** We'll derive additional relevant features from the existing data columns to better understand the manufacturing process.

**Statistical Analysis:** We'll perform statistical analysis to identify patterns, correlations, and outliers, which can provide valuable insights into the manufacturing process.

**Visualization:** We'll design interactive dashboards that provide a visual representation of key metrics. Color-coding, similar to the NBA project, will be employed to highlight crucial aspects of the data.

**Font and Style Consistency:** For dashboard uniformity, we'll use consistent fonts, colors, and background themes. This will ensure that users can quickly interpret and navigate through the visualizations.

**Testing Time Reduction:** Through analysis and insights from the dashboards, we aim to optimize and streamline the testing intervals, thereby reducing the overall testing time in cement manufacturing.

## Data Overview

The dataset encompasses a total of 5514 records, collected between June 1, 2022, at 7:24 AM, and April 30, 2023, at 11:27 PM. This dataset is essential for analyzing and optimizing various aspects of the cement manufacturing process. Key columns in the dataset provide valuable insights:There are total 28 columns. There are No duplicates records. All records are in float datatype.

Date & Time: This column records the date and time of each data point, enabling precise temporal analysis of manufacturing processes.

Mill TPH: It represents the total feed of the mill in tons per hour, offering insights into the milling process efficiency.

Clinker TPH: This column tracks the rate of the clinker weigh feeder in tons per hour, aiding in the analysis of clinker production.

Gypsum TPH: It reflects the rate of the gypsum weigh feeder in tons per hour, contributing to gypsum utilization analysis.

DFA TPH: Dried Fly Ash in tons per hour provides valuable data for optimizing fly ash processing.

WFA TPH: Wet Fly Ash in tons per hour data aids in understanding wet fly ash processing.

Mill KW: The power consumption of the mill in kilowatts allows assessment of energy efficiency.

Mill I/L Temp: Temperature at mill inlet is crucial for monitoring the temperature profile within the mill.

Mill O/L Temp: Temperature at mill outlet is essential for understanding the material's temperature as it exits the mill.

Mill O/L BE Amp: This column records the mill outlet bucket elevator current/load, aiding in elevator performance assessment.

Mill Vent Fan RPM: Mill ventilation fan speed, essential for assessing the ventilation process's efficiency.

Mill Vent Fan KW: The power consumption of the mill ventilation fan in kilowatts, facilitating energy efficiency analysis.

Mill Vent BF I/L Draft: Draft pressure at the mill ventilation fan inlet, important for optimizing draft conditions.

Mill Vent BF O/L Draft: Draft pressure at the mill ventilation fan outlet, another key parameter for draft system analysis.

Reject: The amount of material rejected by the separator, crucial for quality control.

Sep RPM: Separator speed in revolutions per minute, a vital metric for separator performance analysis.

Sep KW: Separator power consumption in kilowatts, helping to assess separator efficiency.

Sep Amp: Separator ampere reading, providing insights into separator current or load.

CA Fan RPM: Circulating air (CA) fan speed, crucial for understanding the efficiency of air circulation.

CA Fan KW: The power consumption of the circulating air (CA) fan in kilowatts, necessary for energy efficiency analysis.

Mill Folaphone: The mill fill level noise reading, which is essential for monitoring mill fill levels.

Mill I/L Draft: Draft pressure at the mill inlet, crucial for optimizing draft conditions.

Mill O/L Draft: Draft pressure at the mill outlet, another key parameter for draft system analysis.

Sep. Vent I/L Draft: Draft pressure at the inlet of the separator ventilation system, aiding in separator ventilation optimization.

Sep. Vent O/L Draft: Draft pressure at the outlet of the separator ventilation system, another vital parameter for separator ventilation analysis.

Sep.Vent bag filter fan KW: Power consumption of the separator ventilation system bag filter fan in kilowatts, helping assess filtration efficiency.

Sep.Vent bag filter fan RPM: The speed of the separator ventilation system bag filter fan in revolutions per minute, essential for monitoring filtration efficiency.

Residue: This column denotes the target quality, specifically the % residue retained on a 45-micron sieve, crucial for quality control and product standards.

This dataset provides a comprehensive foundation for analyzing and optimizing the cement manufacturing process, with a focus on reducing testing time and improving overall efficiency..

## Users

Users of the visualization dashboard will be:

* Quality Control Teams: Quality control teams aim to ensure the quality of the cement produced. They would be concerned with data related to residue levels, which represent the quality of the final product. A dashboard could focus on tracking and visualizing residue levels and ensuring that they meet target quality standards.
* Production Teams: Production teams focus on maximizing cement output. They would benefit from dashboards that show data related to mill throughput (Mill TPH), as well as fan speeds (Mill Vent Fan RPM, CA Fan RPM) that can impact production efficiency. Insights into separator performance can also be useful for optimizing production processes.
* Plant Managers: Plant managers are responsible for optimizing the cement manufacturing process. They would be interested in dashboards that provide real-time data on key operational metrics such as Mill TPH, power consumption, and temperature profiles. Insights on process efficiency, material rejection rates, and separator performance would help them make data-driven decisions to improve production.

## Questions

Questions which will be answered by this visualization:

**Quality Control Teams:**

* How does the clinker production (Clinker TPH) vary over time? Are there any patterns or trends that could indicate potential quality issues?
* What is the distribution of clinker residue (45μ) over the observed period? Are there any outliers that may indicate a need for quality control measures?
* Can we identify any correlations between mill operating conditions (e.g., Mill I/L Temp, Mill O/L Temp) and clinker quality (Clinker TPH)?
* Is there a relationship between the reject rate and the clinker production rate? How does this impact product quality?

**Production Teams:**

* How can we optimize mill operation (Mill KW, Mill TPH) to achieve higher production output (Clinker TPH) while maintaining product quality and energy efficiency?
* Are there specific time periods when the mill vent fan operates at higher or lower efficiency (Mill Vent Fan RPM and KW)?
* Is there a significant relationship between Separator Vent Efficiency and the reject rate ,does the efficiency of the separator vent impact reject rates ?
* What is the quarterly trend in clinker production (Clinker TPH) over the analyzed period?
* Can we identify any patterns or relationships between the rates of processing DFA (DFA\_TPH) and WFA (WFA\_TPH) with the clinker production rate (Clinker\_TPH)?

**Plant Managers:**

* Can we review historical data on power consumption (Mill KW) and find instances where lower energy consumption coincided with reduced testing time, thus highlighting energy-efficient modes of operation?
* Are there temperature profiles (Mill I/L Temp, Mill O/L Temp) that, when monitored, can lead to faster testing without compromising product quality?
* Can draft pressure data (Draft values) at various points in the system be used to streamline testing processes and minimize downtime during testing?

## Describe Visualization and how it answers the questions

**Quality Control Teams:**

**Clinker Production Over Time:**

Visualization: Line Chart showing Clinker TPH over time.

Answer: This visualization allows us to track how clinker production varies over time. Any unusual patterns or fluctuations could indicate potential quality issues that need investigation.

**Clinker Residue Distribution:**

Visualization: Histogram or Box Plot of clinker residue (45μ) over the observed period.

Answer: The distribution chart helps identify the typical range of residue values. Outliers in the data may indicate a need for quality control measures.

**Correlation Between Mill Conditions and Clinker Quality:**

Visualization: Scatter Plots correlating Mill I/L Temp and Mill O/L Temp with Clinker TPH.

Answer: By visualizing these correlations, we can determine if mill operating conditions affect clinker quality, providing insights for quality control.

**Reject Rate vs. Clinker Production:**

Visualization: Scatter Plot comparing Reject Rate and Clinker TPH.

Answer: Examining this plot helps understand the relationship between the reject rate and clinker production rate, revealing how it impacts product quality.

**Production Teams:**

Mill Operation Optimization:

Visualization: Line Chart or Area Chart showing Mill KW, Mill TPH, and possibly Clinker TPH on the same graph.

Answer: Overlaying these metrics helps find the balance between achieving higher production output while maintaining product quality and energy efficiency.

**Efficiency of Mill Vent Fan:**

Visualization: Line Chart showing Mill Vent Fan RPM and KW over time.

Answer: Analyzing these charts reveals specific time periods when the mill vent fan operates at higher or lower efficiency, helping optimize fan settings.

**Separator Vent Efficiency vs. Reject Rate:**

Visualization: Scatter Plot comparing Separator Vent Efficiency (e.g., Sep Vent Fan KW/RPM) and Reject Rate.

Answer: This plot determines whether the efficiency of the separator vent impacts reject rates, which is crucial for maintaining product quality.

**Quarterly Clinker Production Trend:**

Visualization: Bar Chart or Line Chart showing quarterly trends in Clinker TPH.

Answer: This chart illustrates the quarterly variations in clinker production, aiding production planning and optimization.

**Patterns in Aggregate Processing:**

Visualization: Scatter Plots correlating DFA\_TPH and WFA\_TPH with Clinker TPH.

Answer: These plots help identify any patterns or relationships between the rates of processing different aggregates and clinker production.

**Plant Managers:**

Energy-Efficient Modes:

Visualization: Line Chart showing Mill KW and Testing Time on the same graph.

Answer: Overlaying these metrics helps identify instances of lower energy consumption coinciding with reduced testing time, highlighting energy-efficient modes of operation.

**Temperature Profiles for Faster Testing:**

Visualization: Line Chart displaying Mill I/L Temp and Mill O/L Temp.

Answer: By monitoring temperature profiles, we can identify conditions that lead to faster testing without compromising product quality.

**Draft Pressure for Streamlined Testing:**

Visualization: Multiple Line Charts showing draft pressures at various points in the system.

Answer: Analyzing draft pressure data helps streamline testing processes and minimize downtime during testing, improving overall efficiency.

## Conclusion

The implementation of data visualization tools plays a pivotal role in optimizing the efficiency of cement quality assessments. These visualizations offers valuable insights into process bottlenecks and recurring patterns, equipping decision-makers with the knowledge needed to make informed choices. This streamlined process not only enhances productivity but also underscores the profound impact of data-driven decision-making in the realm of industrial optimization.