

GenAI-Powered OEE Analysis Tool for Biscuit Packaging

Welcome to the NTT Data Internship case study presentation. My name is Smaran Rangarajan Bharadwaj from RV University, and today I will present a cutting-edge solution designed to enhance operational efficiency in biscuit packaging plants by leveraging Generative AI technology. This tool calculates and displays Original Equipment Effectiveness, or OEE, providing valuable insights for manufacturing optimization.

This presentation will cover problem definition, data characteristics, formulae, system design, and key outcomes with a focus on real-world application and scalability.



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Problem Statement

Objective

Develop an interactive Generative AI web application featuring a ChatGPT-style conversational interface that analyzes OEE of biscuit packaging devices.

Input & Filters

The application processes IoT sensor data in .xlsx format from 2024 to 2025, allowing filtering by Device ID, Location, and Month for targeted analysis.

Output

OEE percentages are delivered through natural language responses, making complex manufacturing data accessible and actionable.

Data Format & Assumptions

Key Data Fields

- Unit_ID: unique package identifier
- Timestamp: completion time per unit
- Device_ID: machine identifier
- Location: plant or floor
- Production_Time: packaging duration
- Ideal_Cycle_Time: target time per machine
- Result: quality status ("Accepted" or "Rejected")

Assumptions

- Downtime definition thresholds based on time gaps exceeding twice the ideal cycle time
- Ideal_Cycle_Time is fixed per device, e.g., DEV_A1 = 1.8s, DEV_C3 = 2.0s
- Data presumed to be accurate and continuous within selected time frames

Formulae to Calculate the OEE

Availability (%)

Downtime is detected via gaps in sensor timestamps exceeding twice the ideal cycle time.

$$\text{availability} = (\text{actual_run_time} / \text{planned_time}) * 100$$

Performance (%)

Ratio of ideal cycle time times units produced over actual run time, reflecting production speed efficiency relative to the ideal.

$$\text{performance} = (\text{ideal_cycle_time} * \text{total_units} / \text{total_production_time}) * 100$$

Quality (%)

Percentage of accepted units out of total produced, measuring the yield of conforming products in the batch.

$$\text{quality} = (\text{accepted_units} / \text{total_units}) * 100$$

Overall Equipment Effectiveness

OEE combines all three metrics as Availability × Performance × Quality ÷ 10,000, providing a holistic operational efficiency metric.

$$\text{oeo} = (\text{availability} * \text{performance} * \text{quality}) / 10000$$

Sample Dataset Rows

Index	Unit_ID	Timestamp	Device_ID	Location	Production_Time	Ideal_Cycle_Time	Result
4057	PKG2024_004058	2024-01-01 00:10:04	DEV_A1	Plant_3	1.58	1.8	Accepted
3641	PKG2024_003642	2024-01-01 01:37:56	DEV_A1	Plant_1	1.72	1.8	Accepted
80	PKG2024_000081	2024-01-01 03:24:32	DEV_C3	Plant_3	1.92	2.0	Accepted
4040	PKG2024_004041	2024-01-01 03:47:03	DEV_A1	Plant_3	1.83	1.8	Accepted
197	PKG2024_000198	2024-01-01 03:58:11	DEV_B2	Plant_1	1.97	2.2	Accepted

System Architecture: Data Flow and GenAI Integration

Data Ingestion

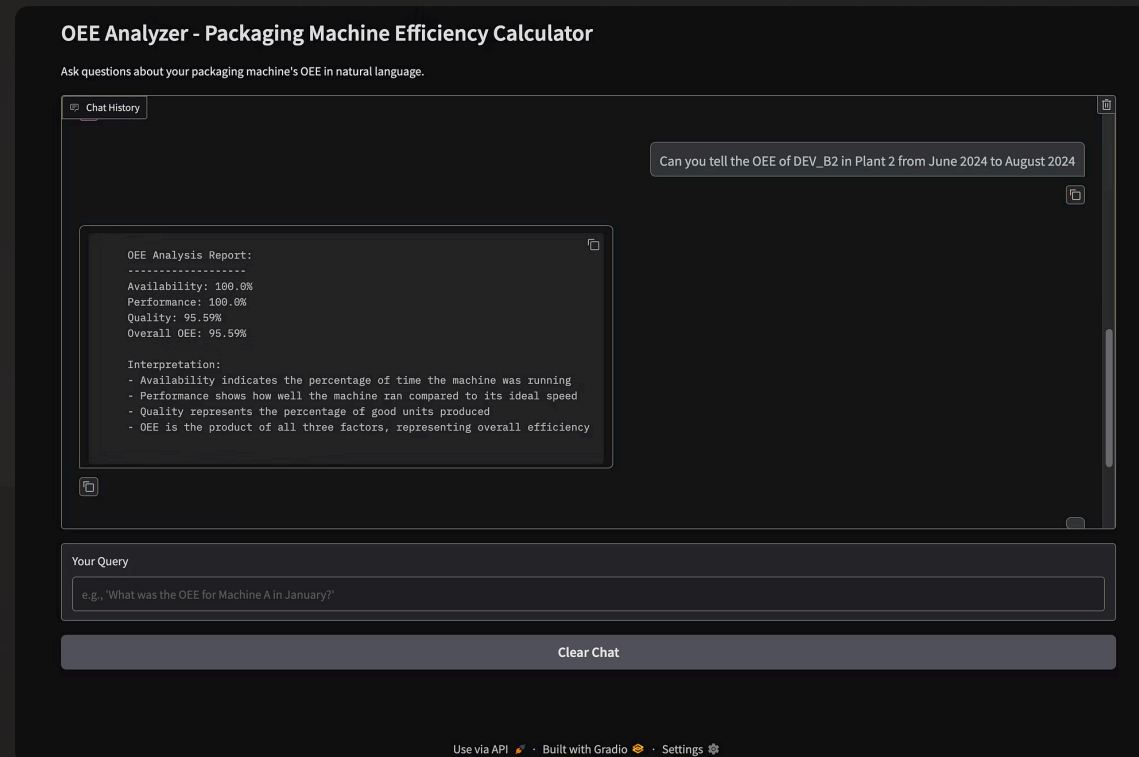
IoT sensors continuously feed production data into a centralized data lake storing .xlsx files for historical and real-time analysis.

Agentic Framework

- QueryAgent extracts user parameters using AI-powered natural language understanding.
- DataAgent manages data loading, validation, and filtering based on query.
- OEEAgent performs calculations, generates reports, and validates metrics before output.

User Interface Preview:

The GenAI-powered web interface enables intuitive conversation with the system, where users ask about device efficiency by specifying parameters like device ID or time periods.



Responses include detailed OEE metrics presented in clear natural language, enhancing accessibility for operators and engineers alike.

Code Repository: https://github.com/smaranrb/oeo_analyzer_biscuit_packaging_git

Missing inputs?

It can also handle missing query parameters if the user hasn't entered them in the prompt:

OEE Analyzer - Packaging Machine Efficiency Calculator

Ask questions about your packaging machine's OEE in natural language.

Chat History

Analysis Report:

Availability: 93.88%
Performance: 97.04%
Quality: 97.3%
Overall OEE: 88.64%

Interpretation:

- Availability indicates the percentage of time the machine was running
- Performance shows how well the machine ran compared to its ideal speed
- Quality represents the percentage of good units produced
- OEE is the product of all three factors, representing overall efficiency

How about DEV_C3 in plant 3 through June 2026

An error occurred: No data found for the specified time period.

Your Query

e.g., 'What was the OEE for Machine A in January?'

Clear Chat

Use via API · Built with Gradio · Settings

Technology Stack Powering GenAI OEE Tool



Python Ecosystem

Pandas and OpenPyXL for robust data processing and Excel file manipulation.



Gradio UI

Enables dynamic conversational interface resembling ChatGPT for seamless user queries.



GenAI Models

Mixtral-8x7B-Instruct and LLaMA 3 provide natural language understanding and agentic control.

Key Benefits of the Agentic Framework

Modular Design

Allows independent development and easy maintenance of discrete agents handling specific tasks.



Independent Testing

Enables thorough validation of each agent ensuring reliability and system robustness.



Clear Responsibility

Each agent focuses on a defined domain: query processing, data management, or OEE calculation, reducing errors.



Scalability

Supports growing data volumes and new device integrations with minimal system disruption.





Conclusion: GenAI Driving Efficiency and Innovation

This GenAI-powered OEE analysis tool exemplifies how AI can transform manufacturing by providing real-time actionable insights and predictive analytics.

It offers a scalable solution that enhances operational efficiency, reduces downtime, and supports continuous improvement. This tool equips manufacturing teams with the information needed to maintain a competitive advantage through innovation and data-driven decision-making.