**INTERNSHIP REPORT**



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Regards,

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**ABSTRACT**

This report summarizes my internship experience at Bosch Limited, where I worked in the Technical Engineering Functions (TEF-4) Department. The purpose of the internship was to gain practical experience in Data Analytics and to apply the theoretical knowledge acquired during my academic studies in real-world scenarios.

During my internship, I was involved in a project with respect to Heat Treatment Shop where in we are supposed to predict hardness values based on various input parameters like temperature data belonging to different phases like Prewasher, Preheating, Sealed Quench Furnace, Post Washer, Deep-freezing, Tempering and other values like Carbon potential, Methanol flow, LPG flow.by identifying the trend behind temperature data we want to predict for what standard temperature at various phases, for what amount of charge in, charge out time we can predict the hardness values.

During our internship, we analysed heat treatment data to identify patterns Scada generated excel files, focusing on product families, and stations where we could implement this. After cleaning the data, we found strong correlations between specific families and stations.

As part of our internship, we worked on Exploratory data analytics for correlation mapping. After conducting a line walk to understand the data flow, we identified key parameters like Sealed Quench Furnace data, Carbon potential, Tempering, Deep Freezer and Chain travel time by analysing correlations. Irrelevant parameters were filtered out to ensure clean, structured data. We then developed and tuned a machine learning model to predict hardness in line with customer requirements. The model was predicting mean values. It had a baseline accuracy since there not much variation in hardness data for the model to have a better learning curve

We also worked on getting more data for better prediction, we did a lot of data engineering for Data Mining Hackathon where our project was one of the chosen use cases. We used an extraction script to fetch messy data in a structured format and make it into a clean format for better processing, once the processing was done we found lots of missing important data wherein we required time series data which was not available during the time. Due to time constraints a azure pipeline was developed for further model development

In conclusion, the internship at Bosch Limited provided me with a unique opportunity to apply academic knowledge, hone professional skills, and explore potential career paths in software development and systems management

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**Chapter 1**

**ABOUT THE ORGANIZATION**

**1.1 Robert Bosch GmbH**

*Pioneering Innovation and Engineering Excellence*



Fig 1.1 Bosch Bidadi

Bosch, founded in 1886 by Robert Bosch in Stuttgart, Germany, is a leading global technology and engineering conglomerate. Over the years, the company has built a solid reputation for its commitment to innovation, quality, and social responsibility. With a diverse range of products and services, Bosch has left an indelible mark on numerous industries, playing a pivotal role in shaping the modern world.

Bosch's product portfolio spans a wide array of sectors, showcasing their versatility and expertise. In the Mobility Solutions sector, the company is a trailblazer in automotive technology, providing cutting-edge solutions for vehicles, including fuel injection systems, driver assistance technologies, and electric mobility solutions. Their Industrial Technology segment offers state-of-the-art automation and control systems, packaging technology, and cutting-edge factory solutions. Additionally, Bosch's Consumer Goods division produces high-quality power tools, home appliances, and security systems, elevating everyday life for consumers worldwide. The Energy and Building Technology sector focuses on creating smart and sustainable solutions for homes and buildings, including energy-efficient heating and cooling systems, security solutions, and building automation.

With a robust global presence, Bosch operates in over 60 countries, employing thousands of people. The company's wide-reaching impact can be seen in various industries and markets. Bosch has established an extensive network of subsidiaries, research centres, and manufacturing facilities, positioning itself as a pioneer in technological innovation across the globe.

Bosch's commitment to innovation is evident through its substantial investments in research and development. The company consistently seeks new technological frontiers, striving to enhance existing products and create innovative solutions that address emerging challenges. This dedication to cutting-edge research and engineering has allowed Bosch to stay ahead of the curve, setting new industry standards.

Embracing its responsibility as a global corporate citizen, Bosch places a strong emphasis on sustainability and environmental stewardship. The company actively pursues eco-friendly practices throughout its operations, focusing on energy efficiency, waste reduction, and responsible sourcing. Bosch is committed to reducing its carbon footprint and promoting sustainable development to create a more sustainable future for generations to come.

Throughout its long history, Bosch has earned the trust of consumers, businesses, and industries worldwide. The brand's name has become synonymous with reliability and high-quality products. From the automotive sector to consumer electronics, Bosch's innovations continue to impact and enhance lives.

Bosch's vision for the future centres on staying at the forefront of technological advancements and adapting to the changing needs of the world. The company envisions a future characterized by intelligent and sustainable solutions, contributing to the betterment of society and the preservation of the environment.

Bosch's journey from a small workshop to a global technology powerhouse is a testament to its visionary leadership, dedication to innovation, and commitment to social responsibility. With a diverse and innovative product range, Bosch remains at the heart of various industries, enriching lives and shaping the world for a brighter future. As the company continues to forge ahead, it remains an exemplar of engineering excellence and a beacon of hope for a more sustainable and connected world.

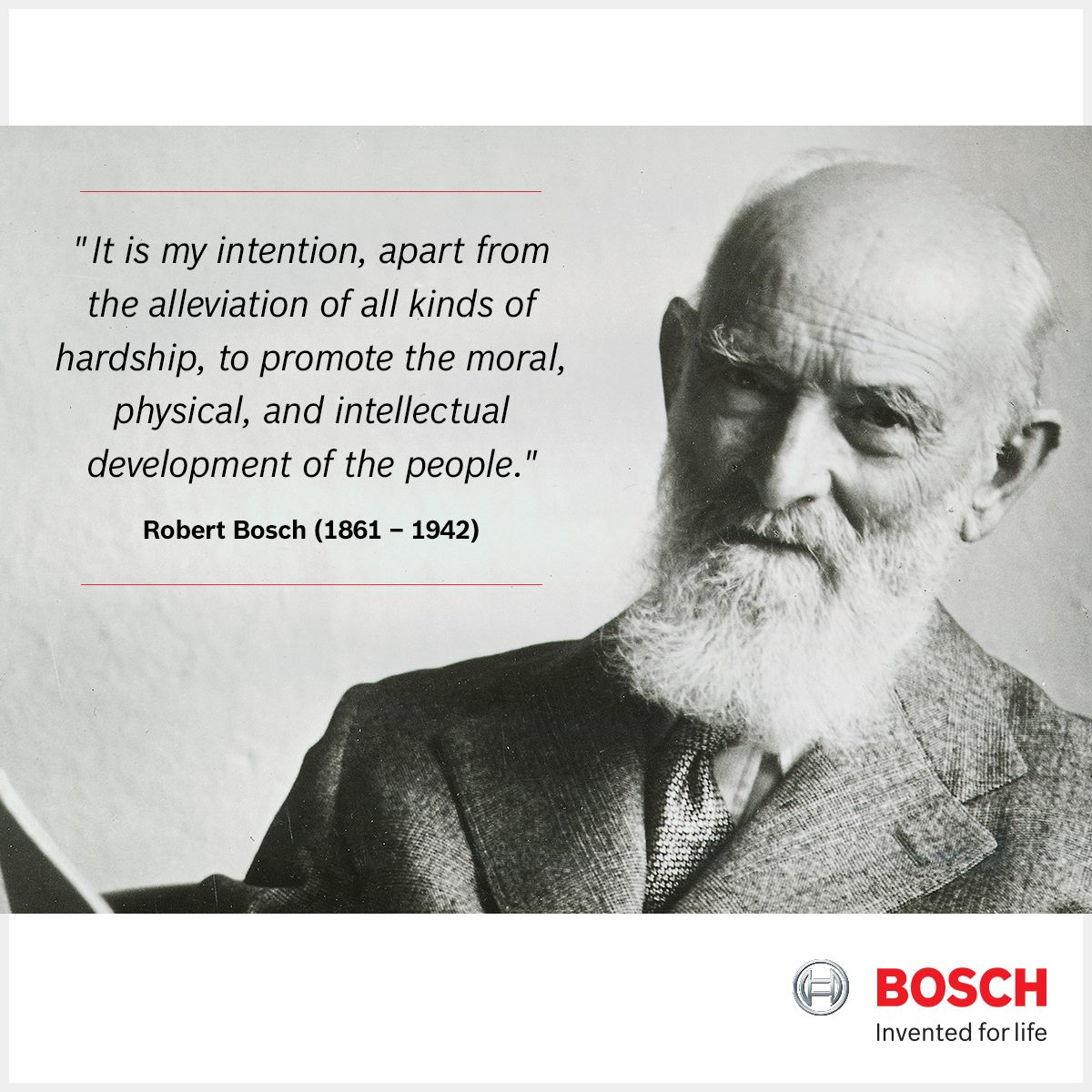
**1.2 The Founder: Robert Bosch**

Fig 1.2 Robert Bosch

Robert Bosch, the founder of Bosch, was a visionary entrepreneur and engineering pioneer whose legacy continues to shape the modern world. Born on September 23, 1861, in Albeck, Germany, Bosch's indomitable spirit and relentless pursuit of innovation laid the foundation for one of the world's most influential multinational corporations.

In 1886, at the age of 25, Robert Bosch founded the "Workshop for Precision Mechanics and Electrical Engineering" in Stuttgart, Germany. With a meagre initial investment, Bosch embarked on a journey that would change the face of technology forever. His early work focused on developing precision mechanics, such as the magneto ignition device for internal combustion engines, revolutionizing the nascent automotive industry.

From the very beginning, Bosch instilled a set of guiding principles into his business operations. He believed in the importance of responsibility and reliability, not only in the products but also in the treatment of employees and customers. These values formed the cornerstone of Bosch's business philosophy and laid the groundwork for the company's enduring success and reputation for quality.

Under Bosch's visionary leadership, the company quickly expanded beyond German borders. By the early 20th century, Bosch had established a global presence, with subsidiaries and manufacturing facilities across Europe and beyond. The company diversified its product range to include automotive technology, household appliances, industrial equipment, and cutting-edge innovations in various fields.

Robert Bosch was not only a brilliant engineer and businessman but also a philanthropist with a strong sense of social responsibility. He believed in giving back to society and invested in various initiatives aimed at promoting education, healthcare, and community development. To this day, the Bosch Foundation continues his legacy, supporting charitable and societal causes worldwide.

Robert Bosch's contributions to the fields of engineering and technology have had a profound and lasting impact on the world. His inventions and innovations have improved countless lives, from revolutionizing transportation to enhancing household comfort and industrial productivity. The company he founded, Bosch, remains at the forefront of technological advancements, continuously striving to shape the future through innovation and sustainability.

Robert Bosch, the founder of Bosch, was more than an entrepreneur and engineer; he was a visionary who laid the groundwork for a global technology empire. His commitment to excellence, social responsibility, and engineering innovation continues to drive Bosch's success and influence in the modern world. Robert Bosch's legacy serves as an inspiration to generations of engineers, entrepreneurs, and leaders, demonstrating the transformative power of a single individual's dedication to improving lives through innovation and responsible business practices.

**1.3 Bosch in India**

*Bosch in India: Driving Innovation and Transforming Industries*

Bosch, a global technology leader, has left an indelible mark on India's industrial landscape since its entry into the country in 1922. With a strong commitment to innovation, engineering excellence, and social responsibility, Bosch India has become a vital player in various sectors, positively impacting the lives of millions of people.

Bosch has been at the forefront of driving technological advancements in India. The company's substantial investment in research and development has paved the way for cutting-edge solutions tailored to meet the unique needs of the Indian market. From automotive technology to industrial automation, Bosch continues to introduce innovative products and services, elevating the nation's technological capabilities.

As a leading provider of automotive technology, Bosch plays a pivotal role in India's automotive sector. The company supplies a wide range of components and systems to automakers, contributing to the growth and development of the Indian automotive industry. Bosch's fuel injection systems, safety solutions, and engine management systems have significantly improved the performance, fuel efficiency, and safety of vehicles in the country.

Bosch's industrial technology solutions have been instrumental in enhancing productivity and efficiency across Indian industries. The company's automation and control systems, packaging technology, and energy-efficient solutions have helped manufacturers optimize their processes and remain competitive in the global market.

Environmental sustainability is a key focus for Bosch India. The company actively pursues eco-friendly practices, emphasizing energy efficiency, waste reduction, and responsible sourcing in its operations. Bosch India's commitment to sustainability aligns with the country's efforts to create a greener and more sustainable future.

Bosch India places significant emphasis on skill development and talent empowerment. The company offers training and development programs to equip the Indian workforce with the necessary skills and expertise to thrive in the ever-evolving technology-driven world.

Bosch India is dedicated to giving back to society through various corporate social responsibility initiatives. The company actively supports education, healthcare, environmental conservation, and community development projects, making a positive impact on local communities.

With multiple manufacturing facilities across the country, Bosch is deeply ingrained in India's industrial landscape. The company's wide network of service centres and authorized dealers ensures the availability of high-quality products and reliable services throughout the nation. At the same time, Bosch India's global connections and access to cutting-edge technologies enable it to bring the best solutions to the Indian market.

Bosch's presence in India epitomizes its commitment to engineering excellence, innovation, and social responsibility. Through its advanced solutions, the company has contributed significantly to the growth of the Indian automotive and manufacturing sectors while driving sustainability and social development initiatives. As Bosch India continues to empower industries, support communities, and pioneer transformative technologies, it remains a key driver of progress and a symbol of excellence in India's technology and engineering landscape.

Bosch has several manufacturing facilities and plants located across different regions in India. Here is a list of some of Bosch's major manufacturing plants in India:

**1.** **Adugodi Plant, Bengaluru:** This is one of Bosch's oldest plants in India, established in 1953. It produces various products, including automotive components and industrial equipment.

**2**. **Nashik Plant:** Located in Nashik, Maharashtra, this plant primarily manufactures automotive components and products.

**3**. **Jaipur Plant:** The Jaipur plant specializes in manufacturing starters and alternators for automobiles.

**4. Bidadi Plant, Karnataka:** This manufacturing facility is involved in the production of automotive components and products.

**5**. **Chennai Plant:** Located in Tamil Nadu, this plant is engaged in manufacturing various automotive components.

**6**. **Gangaikondan Plant:** Situated in Tamil Nadu, this plant focuses on the production of automotive components.

**7**. **Naganathapura Plant:** This facility, located in Bengaluru, Karnataka, is dedicated to manufacturing automotive components.

**8**. **Naganathapura Plant 2:** A newer addition to the Naganathapura facility, it is aimed at increasing production capacity.

**9**. **Coimbatore Plant:** Located in Tamil Nadu, this plant is involved in the production of automotive components.

**10**. **Ahmedabad Plant:** This plant, situated in Gujarat, focuses on manufacturing automotive components.

**11**. **Pune Plant:** Located in Maharashtra, this plant is dedicated to the production of automotive components.

**12**. **Gurugram Plant:** This facility in Gurugram, Haryana, is involved in the manufacturing of automotive components.

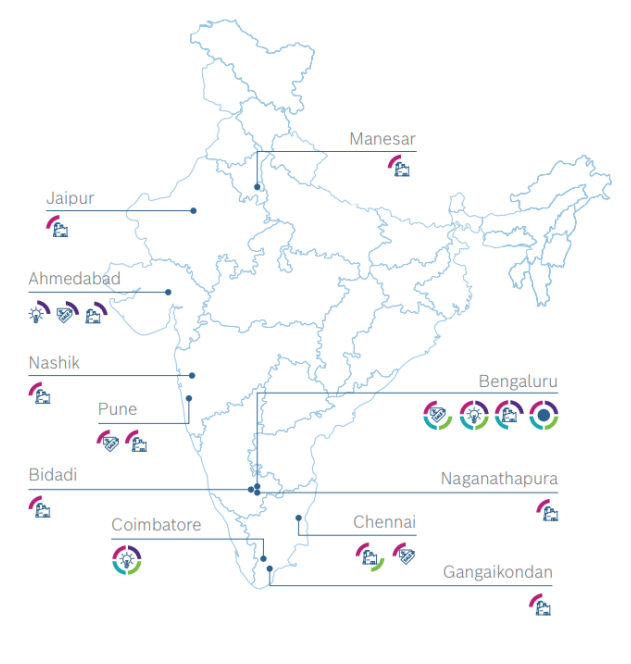


Fig 1.3 Comprehensive Map of Bosch Plants in India.

**1.4. Vision**

The target vision of Bosch Limited is “New Dimensions - Sustainability 2025” which is a sustainability strategy based on concrete objectives in all focus areas. They have been working consistently to realize the objectives stated below:

**Climate Action:**

Reducing CO2 Emissions: With more than 400 locations worldwide, the Bosch Group has been carbon neutral overall since 2020. Four levers were used to achieve carbon neutrality- increasing energy efficiency, generating our own energy from renewable sources, purchasing electricity from renewable sources, and as the last resort using carbon credits to offset residual CO₂ emissions.

**Water:**

Reducing absolute water withdrawal at company locations in regions with water scarcity by 25 percent by 2025: Since 2019, Bosch has launched more than 260 projects and reduced water withdrawal by 25.6 percent. In 2023, Bosch’s wastewater volume decreased to 15.46 million m³.

**Circular Economy:**

Improving materials efficiency and extending product life cycle: The activities of Bosch ranges from reusing products and their components to repairs and right through to remanufacturing, with the objective of extending product and component life cycles. Page 3 of 17 Internship Report

**Diversity:**

Equity and Inclusion: Bosch promotes equity and diversity by ensuring equal opportunities and increasing the proportion of female executives to 25 percent by 2030 and promoting inclusion at Bosch and in the communities around company locations.

**Human Rights:**

Responsibility and Transparency: Bosch ensures human rights are respected along the value chain by implementing due diligence obligations concerning human rights in their operational processes. At the same time, there is active demand for respect for human rights in their global supply chains as well and to take appropriate remedial action in the case of violations.

**Health:**

Occupational health and safety: Bosch aims to reduce the accident rate to 1.45 accidents per 1 million hours worked or less by 2025 and continuously upgrade materials data management.

**Mission**

The mission statement of Bosch Limited is “We are Bosch” where the primary motivation is the desire to develop products that are “Invented for life,” that spark enthusiasm, that improve quality of life, and that help conserve natural resources. The mission statement summarizes the company's values, strengths, and strategic orientation.

**1.5 Services**

Mobility: Bosch develops innovative solutions that facilitate new mobility offerings. Whether for private or commercial vehicles, multimodal transportation services, fleet management, or smart transport infrastructure, Bosch brings together vehicle technology, the data cloud, and services to offer complete mobility solutions.

At Home: Bosch Home Appliances is dedicated to providing intelligent, reliable, and appealing solutions to make life a bit easier every day. This underscores Bosch’s ambition to create technology that always serves a purpose: our products are there whenever people need them and harmonize with the home environment when they’re not — always supportive, never obtrusive.

Industry and Trades: Bosch offers drive and control technologies, energy and building solutions, engineering and business solutions. It is a globally active partner, with a one-of-a-kind portfolio for mobile applications, factory automation, and process plant engineering that features cutting-edge technology and matchless industry expertise. Bosch supplies connected and integrated solutions that increase security, efficiency, and comfort in industries and commercial buildings.

**Chapter 2**

**ABOUT THE DEPARTMENT**

**2.1. Introduction**

The Bosch Plant located in Bidadi, Karnataka, India, serves as a prominent illustration of engineering prowess and technological advancement. As one of Bosch's key manufacturing hubs in the nation, it plays an integral role in the company's endeavour to deliver state-of-the-art solutions across various industries.

Central to the operations at the Bidadi facility is the manufacturing of automotive components crucial for the efficient performance of contemporary vehicles. It epitomizes Bosch's dedication to innovation and research. With advanced machinery and technology at its disposal, the plant continually endeavours to pioneer new products and enhance existing ones. Research and development units collaborate closely with global experts and academic institutions, fostering a culture of perpetual learning and technological progression.

**2.2 Technical Engineering Functions (Tef-4) Department**

The TEF-4 department at Bosch Plant Bidadi, Karnataka, India, stands as a dynamic and critical unit responsible for spearheading digital transformation and embracing the principles of Industry 4.0. As the official 'Digital Transformation and Industry i4.0' department, it serves as the Information Technology (IT) backbone for the Technical Engineering Functions (TEF) within the plant. This diverse and innovative department plays a crucial role in ensuring seamless operations, enhanced efficiency, and cutting-edge technological solutions throughout the manufacturing process. Some of the tasks handled by TEF-4 are as follows:

**Enabling Cutting-Edge Technologies**

At the core of the TEF-4 department's mission is the deployment and management of cutting-edge technologies that enhance every aspect of manufacturing. With a multidisciplinary approach, the team collaborates to bring together expertise in various domains such as IT engineering, Data Analytics, and Machine Learning.

**Server Management and Connectivity**

TEF-4 undertakes the critical task of maintaining the servers that form the backbone of the entire plant's operations. By ensuring the servers are up-to-date, secure, and capable of handling the complex requirements of modern manufacturing processes, the department guarantees uninterrupted production cycles.

**Traceability and Database Management**

In the realm of manufacturing, traceability is of paramount importance. TEF-4 excels at providing comprehensive traceability of all parts throughout the production cycle. By maintaining meticulous databases, the department enables real-time monitoring, traceability, and analysis of production processes, ensuring superior quality control and compliance with industry standards.

**Smart Manufacturing Solutions**

TEF-4 is instrumental in conceptualizing, developing, and implementing smart manufacturing solutions. Leveraging advanced technologies such as the Internet of Things (IoT), Automation, and Artificial Intelligence, the department optimizes processes, automates tasks, and introduces intelligent systems to drive efficiency and productivity gains.

**Robotic Process Automation (RPA)**

Embracing the potential of Robotic Process Automation (RPA), the team focuses on automating repetitive and manual tasks, streamlining operations, and reducing human errors. By deploying robots to handle mundane tasks, TEF-4 liberates human resources for more complex and creative endeavours, fostering a more productive and agile workforce.

**Data Analytics and Machine Learning**

TEF-4 harnesses the power of Data Analytics to gain valuable insights from vast datasets generated in the manufacturing process. The team excels at leveraging Machine Learning, Deep Learning, and Computer Vision techniques to uncover patterns, identify inefficiencies, and make data-driven decisions, thereby optimizing operations and enhancing product quality.

**Web Development and Application Creation**

Recognizing the significance of user-friendly applications, TEF-4 takes charge of developing websites and applications tailor-made for the specific needs of the shop floor. These applications streamline processes, facilitate communication, and enhance overall efficiency, fostering a more connected and collaborative work environment.

**2.3 Centre for Digital Excellence (C4DE)**

Within the TEF-4 department, a standout competence centre known as the 'Centre For Digital Excellence' (C4DE) thrives. This centre serves as a knowledge hub and training facility for individuals across the plant. With a comprehensive curriculum covering IoT, Web Development, Robotic Process Automation, Data Analytics, and Machine Learning, anyone from the plant can access the C4DE and acquire valuable skills.

The C4DE is equipped with high-end workstations loaded with all necessary software, creating a conducive environment for hands-on learning and skill development. This initiative embodies Bosch's commitment to empowering its workforce with the latest technologies and skills, fostering a culture of continuous learning and professional growth.

The TEF-4 department, 'Digital Transformation and Industry i4.0,' at Bosch Plant Bidadi plays a pivotal role in driving innovation, excellence, and efficiency. From server management to smart manufacturing solutions, data analytics, and machine learning projects, the department embraces a comprehensive approach to digital transformation.

The Centre for Digital Excellence complements their efforts by empowering employees with essential digital skills, creating a workforce ready to embrace the challenges and opportunities of the future. Bosch Plant Bidadi's TEF-4 department exemplifies Bosch's commitment to excellence, technology, and continuous learning, solidifying its position as a global leader in the digital age. With a relentless pursuit of innovation, the TEF-4 department continues to redefine the boundaries of digital transformation and shape the future of manufacturing at Bosch Plant Bidadi.

**Chapter 3**

**INTERNSHIP DOMAIN: Generative AI & RAG**

**3.1 Introduction**

The modern industrial landscape, driven by **Industry 4.0** and the principles of **Digital Transformation**, necessitates intelligent and secure methods for managing critical enterprise information. Our internship, executed within the **Technical Engineering Functions (TEF-4)** department at **Bosch Bidadi Plant (BIDP)**, centered on a pivotal project in the emerging domain of **Generative Artificial Intelligence (AI)** and its application in **Retrieval Augmented Generation (RAG)**. This domain focuses on combining the creative power of Large Language Models (LLMs) with precise, verified data retrieval, making it ideal for information-heavy, sensitive applications.

The project’s focus was to address significant operational challenges concerning the retrieval, analysis, and visualization of highly **confidential HR data**, specifically **Long Term Settlement (LTS) documents**. In a large-scale corporate environment like Bosch, manually sifting through and synthesizing information from extensive, unstructured documents via traditional search methods is often inefficient, time-consuming, and prone to human error. Critically, these conventional methods lacked the necessary semantic understanding to provide contextual answers, which is vital for HR and management decision-making.

In response, the core objective was to architect and deploy an **intelligent, secure, and highly scalable RAG solution**. This system fundamentally **pivoted from traditional keyword-based search to a state-of-the-art Generative AI-driven approach**. The RAG framework was chosen specifically to leverage LLMs for generating insightful, human-like responses while strictly confining the answer source to the **confidential, verified LTS document corpus**. This dual-capability ensured two non-negotiable enterprise requirements were met: **high factual accuracy** by grounding the model in proprietary data, and absolute **data confidentiality** by preventing external data leakage and maintaining an auditable, secure data pipeline.

This intensive project provided profound domain expertise in the lifecycle of **production-ready LLM applications**. Our work transcended purely theoretical model-building; it involved practical aspects of data engineering for unstructured text, secure vector database management, fine-tuning retrieval mechanisms, and integrating the final system into a secure enterprise visualization layer. Ultimately, this Generative AI solution directly addressed a critical enterprise pain point by significantly modernizing the way management retrieves and analyzes sensitive historical HR data, thereby enhancing decision-making speed and data security compliance.

**3.2. Technologies Used**

|  |  |  |
| --- | --- | --- |
| **Category** | **Technology/Tool** | **Core Function in Project** |
| ***Core AI Framework*** | **Retrieval-Augmented Generation (RAG)** | The architectural backbone, used to ground the LLM's responses in internal, proprietary data, ensuring confidentiality and factual accuracy regarding LTS agreements. |
| ***LLM Orchestration*** | **LangChain Framework** | Utilized for managing the complex, multi-step RAG pipeline, including document loading, chunking, vector storage, context retrieval, and final response generation. |
| ***Large Language Model (LLM)*** | **Azure OpenAI GPT-4** | Served as the high-capability core model for complex reasoning, semantic understanding of queries, and synthesizing accurate answers from the retrieved confidential HR documents. |
| ***Embedding Model*** | **Embedding Gemma** | A state-of-the-art model used to generate vector embeddings of the confidential HR data, which is crucial for efficient and highly accurate semantic retrieval of context. |
| ***Data Processing*** | **Optical Character Recognition (OCR) Capabilities** | Integrated to successfully process and convert content from scanned PDF LTS documents into searchable text, ensuring all historical data could be indexed. |
| ***User Interface (UI)*** | **Streamlit** | Employed for rapid prototyping and deployment of a user-friendly, interactive web interface for the HR Smart Assistant. |

**3.3 TOOLS USED**

|  |  |
| --- | --- |
| Tool/Utility | Application in Project |
| On-premise Server | The production deployment environment, adhering to Bosch's strict internal security and data governance policies for confidential data. |
| Rate Limiter | Implemented for system stability and preventing resource abuse by managing the volume of concurrent user queries. |
| Logging Mechanisms | Essential for system monitoring, auditing access to confidential data, debugging, and tracking application performance and usage patterns. |
| Queuing System | Developed to manage and prioritize requests, ensuring system reliability and smooth operation under heavy load conditions. |
| Data Visualization Tools | Used for creating visualizations of the retrieved content (e.g., source document highlights, key data points) to provide transparency and build user trust in the RAG output. |
| [Git/Azure DevOps] | Used for version control, collaborative development, and managing the codebase for the modular assistant. |

### CHAPTER 4

### TASKS PERFORMED

#### **4.1 ABOUT THE PROJECT**

**Project: LTS CHATBOT**

**Task:**

Generative AI Smart Assistant for Confidential HR Data Retrieval (LTS Documents)

**Problem Statement:**

To design, build, and deploy a secure, RAG-powered application to analyze and query sensitive Long Term Settlement (LTS) documents, minimizing retrieval latency and ensuring factual accuracy.

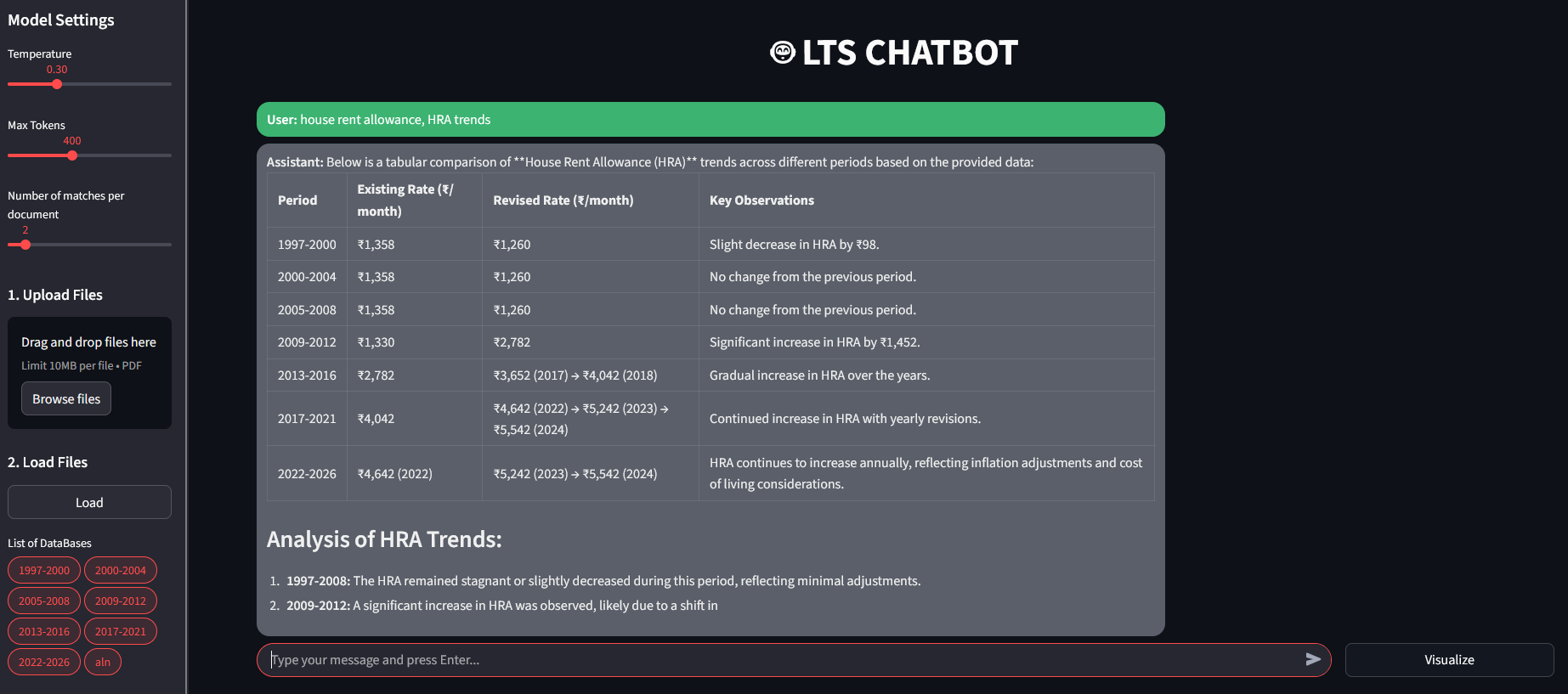
**Implementation:**

The team engineered a modular **Retrieval-Augmented Generation (RAG)** pipeline. This involved integrating **Optical Character Recognition (OCR)** for historical documents, vectorizing the resulting text using **Embedding Gemma**, securely storing the embeddings, and orchestrating the entire process with **LangChain**. The final application, hosted on an **on-premise server** via **Streamlit**, utilized **Azure OpenAI GPT-4** to generate grounded, context-aware answers to user queries, significantly modernizing data access for HR stakeholders. The architecture established a **closed-loop system**, ensuring the LLM's knowledge base was strictly confined to the proprietary, internal LTS corpus, thus guaranteeing **data confidentiality**. The implementation involved advanced **document chunking strategies** to optimize context size, balancing comprehensive information retrieval with prompt token limits. Rigorous **performance validation** demonstrated a high factual accuracy rate, a direct result of the RAG mechanism's ability to ground the generated response in source documents. The output delivered actionable insights, often including **direct citations and snippets** from the source LTS agreements to build user trust and transparency. Furthermore, robust **logging mechanisms** and a **rate limiter** were integrated into the on-premise deployment, addressing enterprise requirements for auditability and system stability under load.

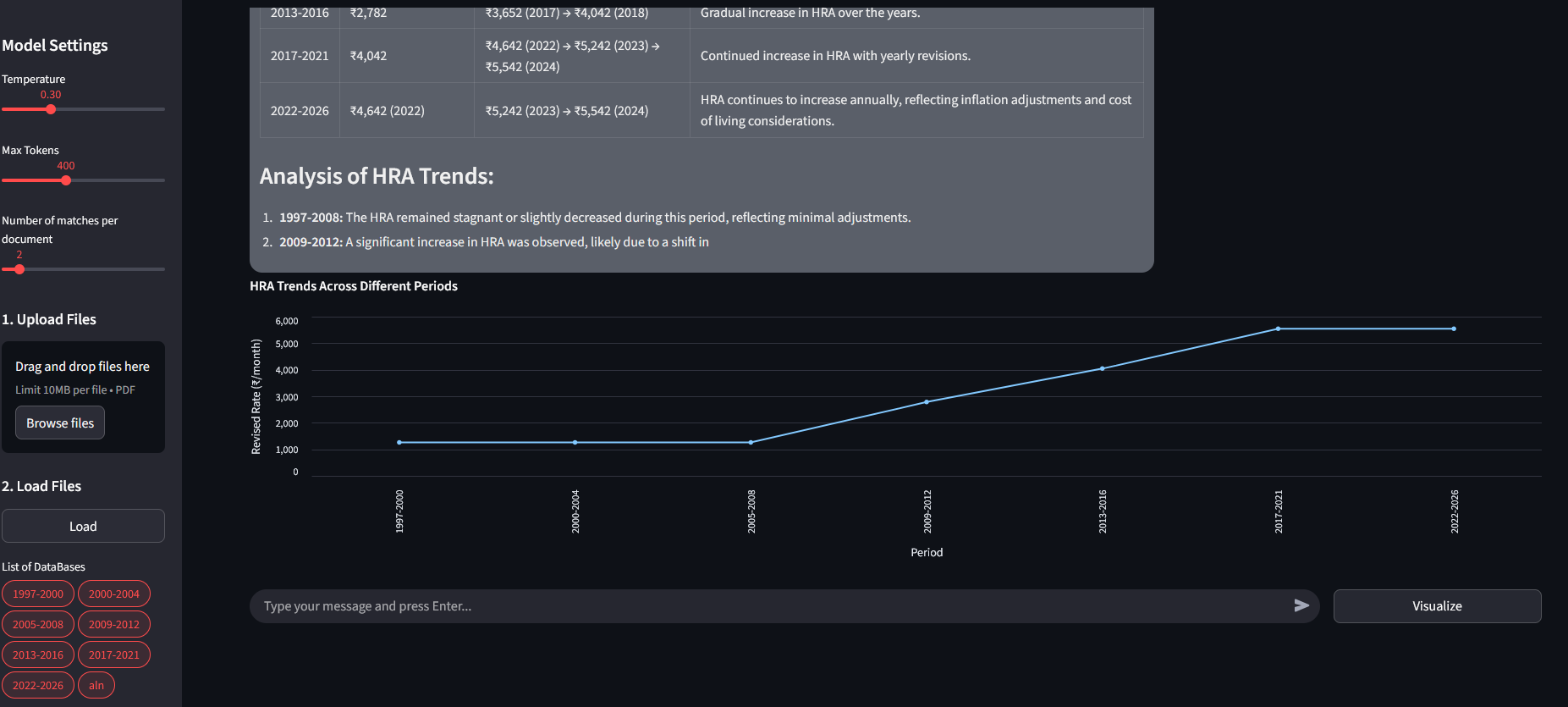
**4.2. STEP BY STEP PROJECT EXECUTION**

The development of the Generative AI Smart Assistant followed a rigorous, multi-phase execution methodology, prioritizing data security and system reliability from the outset.

1. **Requirement Elicitation and Security Audit:**
   * Collaborated with the **TEF-4** team and HR stakeholders to define precise functional requirements, focusing on the specific analytical needs for LTS documents (e.g., query types, desired output formats).
   * Established strict **data governance** protocols for handling confidential HR data, defining secure pathways for data ingestion and restricting model access to the internal data set via RAG architecture.
2. **Data Ingestion and Pre-processing Pipeline:**
   * Implemented an **Optical Character Recognition (OCR) pipeline** to convert scanned, unstructured LTS PDF documents into clean, machine-readable text. This was a critical step for indexing historical records.
   * Used Python and advanced text processing techniques to clean the OCR output, segment the large documents into smaller, semantically coherent text **chunks**, and prepare them for embedding.
3. **Vectorization and Retrieval Mechanism Development:**
   * Employed the **Embedding Gemma model** to transform the text chunks into high-dimensional numerical **vector embeddings**.
   * Integrated these embeddings into a secure **vector store**, establishing the knowledge base.
   * Developed and tuned the **retrieval mechanism**—the core RAG component—to efficiently and accurately fetch the most relevant text snippets (**context**) from the vector store based on a user’s query.
4. **RAG Chain Orchestration and LLM Integration:**
   * Utilized the **LangChain Framework** to build a robust, multi-step RAG pipeline that manages the flow: User Query $\rightarrow$ Retrieval $\rightarrow$ Context Injection $\rightarrow$ **Azure OpenAI GPT-4** Generation $\rightarrow$ Final Output.
   * Configured **Azure OpenAI GPT-4** as the core LLM, leveraging its strong reasoning capabilities to synthesize a concise, factual answer *only* from the provided retrieved context, thereby minimizing hallucination and ensuring data grounding.
5. **Deployment and Enterprise-Grade Hardening:**
   * Deployed the application prototype using **Streamlit** to create an interactive, user-friendly **UI** for rapid stakeholder feedback.
   * Implemented enterprise-level stability features, including a **Rate Limiter** to manage query volume, a **Queuing System** for load management, and comprehensive **Logging Mechanisms** for audit trails and performance monitoring on the **on-premise server** environment.
6. **Validation and Outcome Visualization:**
   * Conducted rigorous testing using known queries against the LTS documents to validate the **factual accuracy** and security of the RAG output.
   * Integrated **Data Visualization Tools** to display the source document excerpts and highlights alongside the generated answer, providing **transparency** and building user trust in the AI assistant’s grounding.



**4.1 User Interface**



**4.2 Visualization Trends**

### FUTURE SCOPE AND EXPANSION

The successful implementation of the Generative AI Smart Assistant for LTS documents establishes a robust foundation for integrating advanced AI capabilities across other critical organizational functions at Bosch. The future scope of this project can be categorized into three main areas: **Functional Expansion, Technical Enhancement, and Organizational Integration.**

**4.3.1 Functional Expansion**

* **Integration with Live HR Systems (HRIS):** The current system is primarily focused on querying historical, static LTS documents. The future scope involves integrating the RAG pipeline with live Human Resources Information Systems (HRIS) and other dynamic data sources. This would enable the assistant to answer real-time queries related to employee status, immediate policy changes, and personalized queries, moving from a pure document analyst to a comprehensive HR knowledge hub.
* **Multi-Document Type Analysis (Cross-Departmental RAG):** The model can be expanded to index and cross-analyze different types of confidential documents, such as internal regulations, legal contracts, or manufacturing standards (e.g., Quality Management System documents). This would require partitioning the vector store by document type to maintain data segregation and retrieval relevance.
* **Proactive Insights and Reporting:** Moving beyond reactive querying, the system could be developed to proactively generate reports or flag compliance risks. For example, it could analyze new policy changes against historical LTS agreements and automatically highlight areas of conflict or deviation for management review.

**4.3.2 Technical Enhancement**

* **Advanced Generation Capabilities (Function Calling):** The current model could be enhanced by implementing advanced **Function Calling** or **Tool Use** within the LLM. This would allow the model to not only answer questions but also perform actions, such as fetching related employee records from a secured API or drafting initial email summaries based on the generated answer.
* **Continuous Learning and Fine-Tuning:** While the RAG architecture is highly effective, the generation model (Azure OpenAI GPT-4) could be continuously fine-tuned on HR-specific language and LTS document style using **Reinforcement Learning from Human Feedback (RLHF)** derived from HR team interactions. This would further improve the quality and tone of the generated responses.
* **Hybrid Retrieval Methods:** To improve accuracy further, exploring hybrid retrieval methods that combine the current **semantic search** (vector-based) with traditional **keyword search** (sparse retrieval, e.g., BM25) could be beneficial, particularly for documents where specific names or dates are critical.

**4.3.3 Organizational Integration**

* **Personalized Access Control:** Enhancing the security architecture with fine-grained, **role-based access control (RBAC)** that dictates not just *who* can use the system, but *what* specific documents or sections of documents they are authorized to retrieve. This is essential for scaling the tool across different levels of HR and management.
* **Scalable Cloud Migration Strategy:** While currently hosted on-premise for security, developing a robust, secured migration strategy to a private cloud environment (e.g., Azure Private Endpoint) would be crucial for ensuring global scalability and resource optimization across other Bosch plants or departments.
* **Template Generation:** Implementing a feature that allows the system to generate policy-compliant document drafts or standard HR correspondence by using the LTS agreements as the authoritative template source.

**Chapter 5**

**INTERNSHIP OUTCOMES**

My internship at Bosch Limited has led to numerous technical and non-technical outcomes that have significantly contributed to my professional growth. These outcomes include:

* **Communication Skills:** Collaborating with my colleagues has greatly enhanced my ability to communicate effectively. I have gained valuable experience in engaging with teammates and higher authorities, ensuring the precise and clear exchange of ideas and information. This has improved my ability to articulate thoughts and contribute meaningfully to discussions.
* **Teamwork:** Teamwork has been a cornerstone of my internship, fostering an environment where diverse perspectives converged to solve problems and achieve common goals. Through collaboration, I was able to leverage the strengths of my colleagues, enhancing both individual and collective performance. Additionally, teamwork helped me develop essential interpersonal skills such as communication, adaptability, and conflict resolution.
* **Adaptability and Initiative:** Demonstrated the capacity to quickly learn and implement cutting-edge technologies (Generative AI, RAG) in a high-stakes corporate environment. This included taking the initiative to research and integrate best-practice solutions for challenges related to system stability and performance.
* **Problem-Solving in Enterprise Context:** Faced and successfully navigated real-world technical challenges, such as handling low-quality historical documents via **OCR post-processing** and optimizing retrieval mechanisms This experience significantly honed the ability to develop logical, efficient, and scalable solutions.
* **Data Security and Compliance:** Learned to prioritize and implement security-first design principles, ensuring all work on confidential HR data adhered to Bosch’s stringent **on-premise deployment** requirements and data governance policies.
* **Production-Ready LLM Development:** Gained practical skills in developing and hardening LLM applications for real-world enterprise use. This extended beyond model building to crucial components like implementing **Rate Limiters**, building **Queuing Systems**, and integrating robust **Logging Mechanisms** vital for system reliability and auditing

**Chapter 6**

**CONCLUSION**

The 13 weeks internship at Bosch Limited provided me with invaluable practical exposure to the industry, where I honed my skills in data analytics and strengthened my problem-solving and teamwork abilities. One of the challenges I faced was understanding the expectations and requirements of my superiors and developing logical solutions for the projects. I overcame this by proactively learning the necessary concepts to write efficient and effective code, which significantly enhanced my technical expertise.

In conclusion, this internship was a transformative experience that bridged the gap between theoretical learning and real-world application, deepening my understanding of data analytics. Collaborating with experienced professionals offered mentorship and insights into industry standards, contributing to both personal and professional growth.

Furthermore, the experience emphasized the importance of communication, adaptability, and collaboration in achieving project goals. Actively participating in team discussions, hackathons and incorporating feedback helped me refine my interpersonal skills and foster a collaborative work ethic.

This internship has solidified my passion for data analytics and shaped my career aspirations. I am grateful for the opportunities I received, and I am confident that the lessons learned, and skills acquired during this time will serve as a strong foundation for my continued growth and success in the field.

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[Fig 1.2. Retrieved from](https://www.google.com/search?q=robert+bosch+quotes&client=firefox-b-e&sca_esv=3c1a55819b6b7e41&udm=2&biw=1280&bih=793&ei=GxFZZ-6ZOeiZ4-EPhLSR4A8&oq=robert+bosch+quote&gs_lp=EgNpbWciEnJvYmVydCBib3NjaCBxdW90ZSoCCAAyBRAAGIAEMgUQABiABEi6JFDeBVigFXABeACQAQCYAaQBoAHVBaoBAzAuNrgBA8gBAPgBAZgCB6ACpQfCAhAQABiABBixAxhDGIMBGIoFwgIGEAAYBxgewgILEAAYgAQYsQMYgwHCAgoQABiABBhDGIoFwgIEEAAYHsICBhAAGAgYHpgDAIgGAZIHAzEuNqAHqRU&sclient=img#vhid=84kX7HxbjT4UAM&vssid=mosaic)