Term paper
Wiesmann Automotive Group - “Practical Studies Industry 4.0”

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Development of an Industry 4.0 concept

Step 1: company description

The company I chosen for this paper is Wiesmann Automotive Group. The company was founded by Martin and Friedhelm Wiesmann brothers. The company is located in Dülmen, Germany. The main aim of the company is to design, manufacture, and markets hand-crafted, high-performance vehicles. In addition to their vintage-contemporary design, company vehicles have exceptional engineering and bespoke customization options. The company's automobile are designed with the specific requirements of automotive enthusiasts in mind, who place a high value on exclusivity, workmanship, and superior driving experiences. As a result, the company's vehicles cater to a niche market.

The Wiesmann Automotive Group manufactures luxury sports vehicles that is combination of aesthetics with modern technology. For instance MF4 and MF5. The company provides a variety of such roadster and variants of such models. These cars are powered by robust BMW engines, making sure excellent power, torque, and driving dynamics. The key to success of each vehicle of Wiesmann is that, its hand-built to the client's specifications, provides various configurations for interior, exterior designs and enhancement of performance. [2]

The company assure to incorporate cutting-edge technology into its vehicle design and manufacturing processes. The company's core focus emphasize on innovations in chassis design, aerodynamics and weight reduction. Moreover, company is engaged in exploring the integration of hybrid and electric powertrains to evolve automotive trends and to fulfill environmental standards.

The feature that make the company stand out from its competitors is its approach to bespoke manufacturing process, that is because each vehicle is hand-craft by skilled craftsmen. Having spoken about this distinct feature, it's also true that it effect their large scale manufacturing due to the amount of time and resource they have to invest in manufacturing each vehicle. Moreover, the company's luxury sports vehicle attract sport vehicle enthusiasts from Europe, North America and even from Asia. [1]

Step 2: industry 4.0 concept

The specific business process targeted for implementation in acceptance of Industry 4.0 concept in this paper is the enhancement of manufacturing efficiency. The primary goal is to convert existing manufacturing plants into smart, efficient and adaptive production environments (a smart factory). This thesis suggests implementation of Industrial Internet of Things (IIoT) devices, robotics integration, and Human-Machine Interaction (HMI) systems for efficient operations, manual workload reduction, and precision and quality enhancement.

To increase the efficiency, quality, and safety this thesis suggests to create both automated and manual Vehicle manufacturing assembly lines. As Figure 2.1 shows that the assembly line is IIoT integrated. Production line is divided into multiple stations. Each station has MasterPC that has all the data coming from different sources like (IIoT device and sensors, client's description etc). Human-Machine Interface (HMI) will provide real-time monitoring, and data visualisation and control. Displays matrics like temperature, torque, pressure and alignment etc. The stations that have robotic arms are connected to MasterPC and getting instructions from the production manager through MasterPC. Except that, the Figure 2.1 on the right side also illustrates a Human Worker at Station 3, emphasising the collaborative nature of the assembly line.

By devising such a production line will not only ensure enhancement in performance and quality but also kept Wiesmann's key differentiators that is bespoke manufacturing processes intact. So, by leveraging the production line with integration of state-of-the-art technologies company can scale its assembly while also allows customers to tailor their vehicles to their exact preferences. This is a win-win situation for the company.

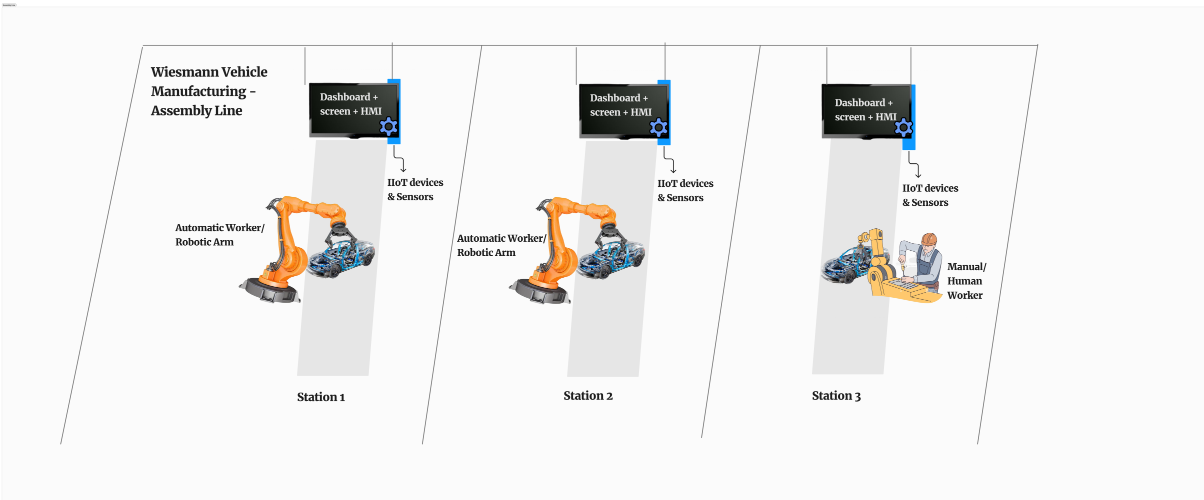

Figure 2.1: Implementation Plan for Wiesmann Vehicle Assembly Line

As shown in Figure 2.2, in order to implement Industry 4.0 in Wiesmann's production processes, this thesis suggests a strategic plan consist of several steps. First of all, initial assesment and planning need to be done to evaluate the existing production process. That will not only allow the company to enhance the efficiency, quality, and safety but also leverage them to integrate industry 4.0 practice to streamline tasks, real-time monitoring and inspection. Eventually, the integration of Industrial Internet of Things (IIoT) that refers to integration of IoT technologies within industrial environments, and manufacturing. And robotics to ensure that these technologies are compatible with and seamlessly integrated into existing infrastructure. In the end, its important to develop intuitive Human-Machine Interface (HMI) system that is specifically developed to fulfill operational requirements with focus on usability, reliability, and safety. Furthermore, company has to conduct trainings and seminars from industrial tech experts to train and adapt their employees from continuous improvement and for positive feedback from the clients.

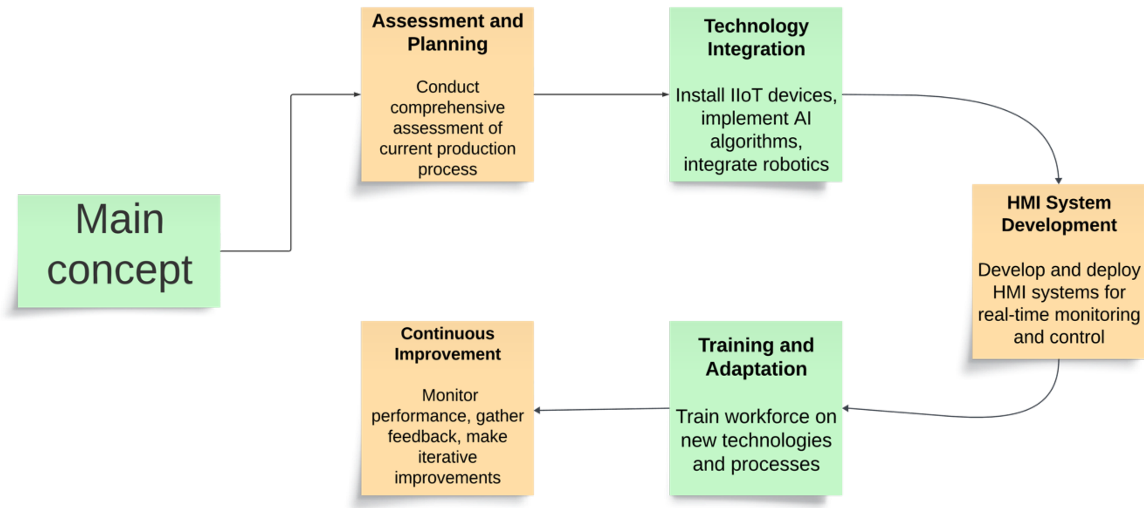

Figure 2.2: Implementation Plan

Step 3: benefits of the project

In today’s era of technology, it’s important to stay up-to-date otherwise your competitor will outclass you in all the departments. Prior to the integration of IIoT technologies, company encountered difficulties in term of efficiency, quality insurance, and most import sustainability and scalability within their manufacturing processes. Company’s policy to rely on traditional manufacturing processes was short lived as they could not automate the flow and huge amount of time and resources were invested for production of vehicle only by craftsmen. These decisions resulted in number of adverse effects, including delays in production, inefficiencies, and inconsistent quality.

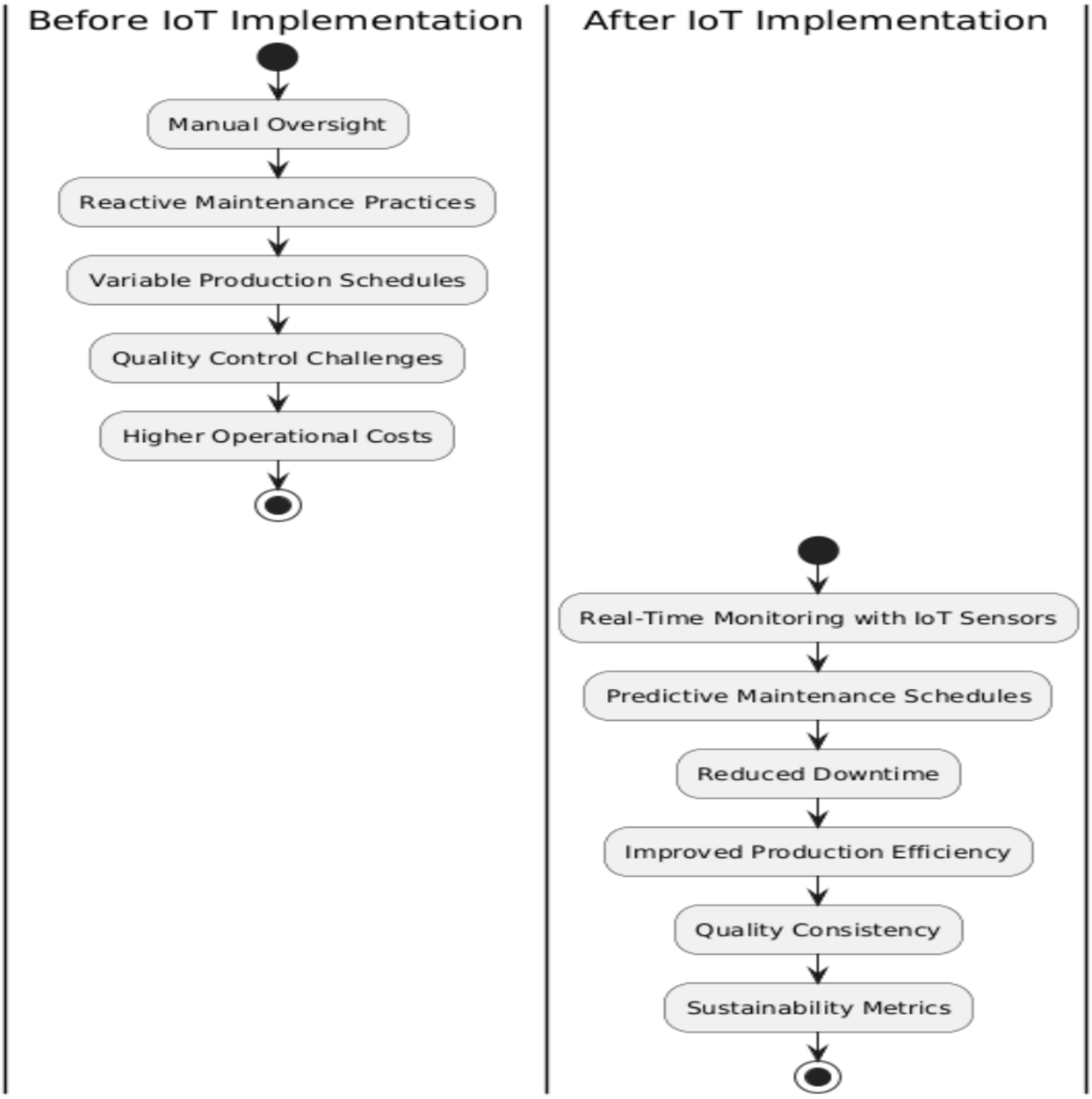

Figure 3.1: Transformation in Production Line

The integration of IIoT devices and technologies has resulted in significant and transformative enhancements to Wiesmann’s manufacturing operations. The implementation of IIoT-enabled sensors facilitated the real-time monitoring of machine performance and operational parameters, thereby enabling predictive maintenance practices that reduced machine downtime and enhanced the predictability of production schedules. This technological advancement resulted in cost savings through the optimization of machine utilization and a reduction in maintenance requirements. Moreover, the implementation of IIoT-driven quality control systems ensured the maintenance of consistent product quality through the prompt detection and resolution of any deviations. The enhanced data insights facilitated optimized energy usage and waste reduction, which aligns with Wiesmann’s commitment to sustainability and reduced the company’s environmental footprint.

The adoption of IIoT technologies by Wiesmann Automotive GmbH has resulted in enhanced operational efficiency and product quality, as well as notable cost savings and advancement in the company's sustainability objectives. The transition from traditional manufacturing practices to IIoT-driven smart factory operations represents a pivotal advancement, reinforcing Wiesmann's position as a leader in the luxury sports car market while contributing to a more sustainable future.

Step 4: business process

The one business process that we consider for this thesis is Smart Manufacturing Process Flow, it integrates a range of advanced technologies, including the IIoT, robotics, human-machine interfaces (HMI), and customer preference data with the objective of transforming production efficiency, flexibility, and quality. As illustrated in Figure 4.1, the process starts with the **Data Acquisition & Monitoring**, where IIoT sensors gather real-time data on the machinery and production metrics. This data is then provided to **Robotic Automation & Collaborative Robots (Cobots)** where welding, painting, and assembly is handled by advanced robotics whereas collaborative robots work under human guidance to achieve precision and safety.

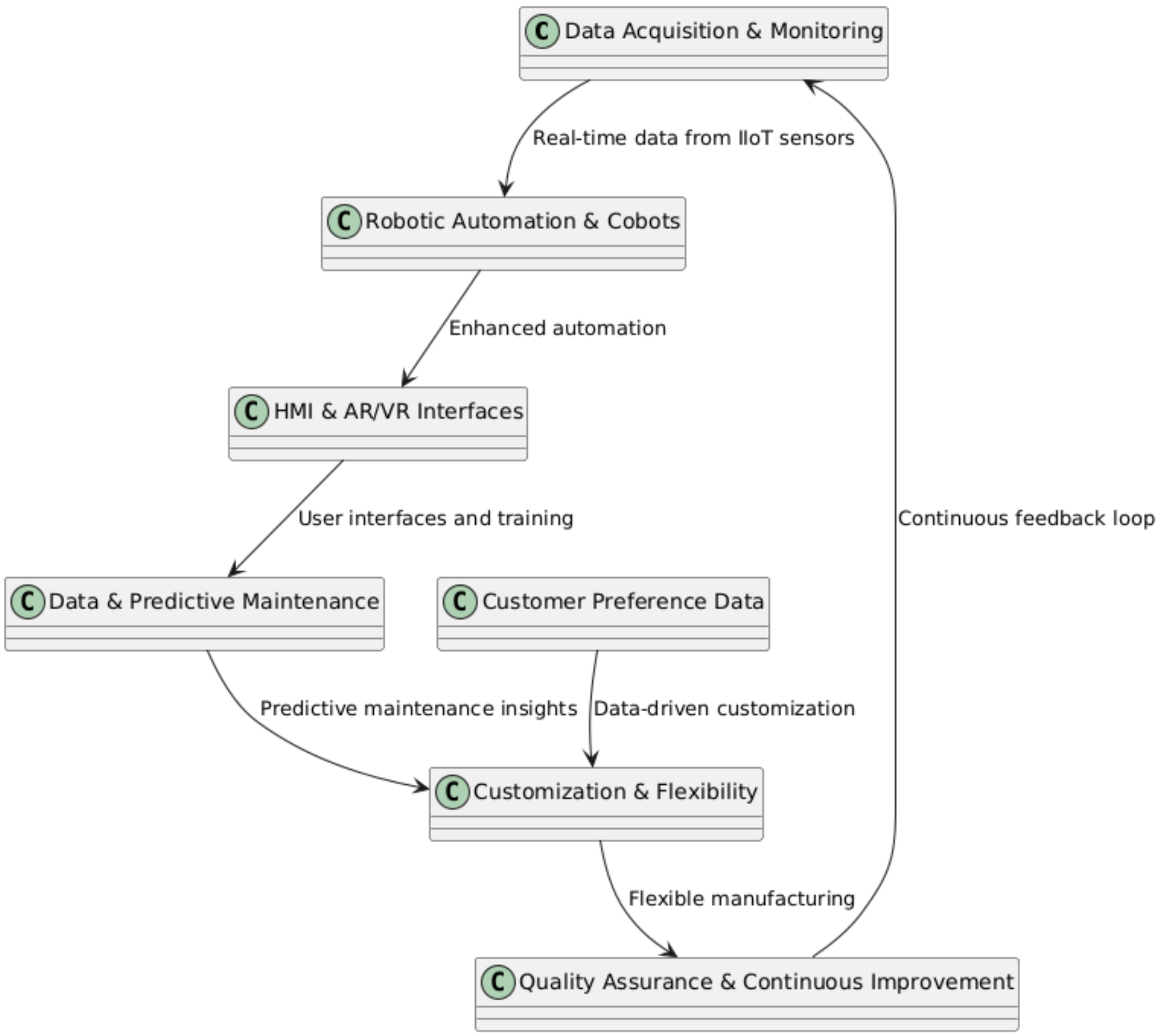

Figure 4.1: Smart Manufacturing Process Flow

Going further, next comes **HMI & AR/VR Interfaces**, which facilitate intuitive controls and interactive training tools through human-machine interfaces which enables efficient operations and maintenance. Data that came from precious step is analyzed in **Data & Predictive Maintenance** stage. In this stage, data is used to do predictive analytics to forecast potential equipment failure and optimized maintenance schedules, hence decrease downtime and extend the operational life of the equipment. Except that, **Customer Preference Data**, some data that is coming from customer for vehicle customization as per requirement is also analyzed and both data stream are passed to next stage.

In **Customization & Flexibility** stage, the manufacturing system uses insights from customer preference data to offer highly personalized vehicle configurations. This integration enables rapid adaptation to varying customer needs and market demands, ensuring that production remains agile and responsive. The final stage, **Quality Assurance & Continuous Improvement**, focuses on maintaining high product standards through automated quality inspections and continuous feedback loops. This ongoing evaluation drives iterative improvements in the manufacturing process, ensuring that the production system remains efficient and capable of delivering the highest quality products.

Overall, this smart manufacturing process flow enables the Wiesmann Automotive Group to achieve a more advanced, data-driven approach to production that increases operational efficiency, meets diverse customer preferences and maintains rigorous quality standards.

Step 5: data requirements

As we know automotive manufacturing/ production line highly rely on input and output data to take decisions. In this step of thesis, we try to address data requirement for Smart Manufacturing Process as detailed as possible. Data requirement is further categorized into 6 major indicators. Note that this section mostly mention the data that is new due to industry 4.0 integration and data that will be change in the process of integration.

1. IIot Data Types: This section focus more on data required by different devices that are linked together at production line. This data type emphasize on real-time and predictive data associated with equipment and environmental conditions, necessary for monitoring and maintaining operational excellence. Table 5.1 show such data types.

No.	Indicator	Data Types
1	**IIoT Data Types**	
1.1	Machine Health Data	Wear & Tear, Pressure, Vibration, Temperature
1.2	Production Metrics	Throughput, Production Rate, Time, Cycle
1.3	Environmental Conditions	Humidity, Air Quality, Ambient Temperature
1.4	Energy Consumption	Energy efficiency, power usgae
1.5	Failure Prediction Data	Failure probabilities, maintenance alerts

Table 5.1

2. HMI Data Types: This type of data is affliated to user interaction and training rounds, which helps more in training and interface experience along with learning outcome and AR/VR. Table 5.2

illustrates HMI Data types.

No.	Indicator	Data Types
2	**HMI Data Types**	
2.1	User Interaction Data	Usage Patterns, Error Rates, Operator Feedback
2.2	Training Effectiveness Data	Performance Metrics from AR/VR Training, Learning Outcomes

Table 5.2

3. Data for Acquisition & Monitoring: This included real-time and historical data both because this data is important for trend analysis and detailed monitoring. Table 5.3 shows data requirement for Acquisition and Monitoring.

No.	Indicator	Data Types
3	**Data for Acquisition & Monitoring**	
3.1	Real-Time Monitoring Data	Live Machine Health Data, Production Rates
3.2	Historical Data	Historical Performance Data, Past Maintenance Logs
3.3	Sensor Data	Sensor Readings (e.g., temperature, vibration)

Table 5.3

4. Data for Robotic Automation & Cobots: Includes data required for performance metrics, also contains data necessary for integration to produce effective operations and robotic system's collaboration. Table 5.4 shows data requirement for Robotic Automation and Collaborative Robots.

No.	Indicator	Data Types
4	**Data for Robotic Automation & Cobots**	
4.1	Robotic Performance Data	Speed, Accuracy, Task Completion Rates
4.2	Operational Integration Data	Task Allocation, Robot-Human Interaction Efficiency
4.3	Error and Fault Data	Error Logs, Fault Reports, Debugging Information

Table 5.4

5. Customer Preference Data: This contains data for design selection and feature preference to cater customer requirement, that magnify personalization and user satification. Table 5.5 show Data for customer requirements.

No.	Indicator	Data Types
5	**Customer Preference Data**	
5.1	Customization Requests	Design Choices, Feature Preferences, Special Requirements
5.2	Market Demand Data	Sales Trends, Customer Feedback

Table 5.5

6. Quality Assurance Data: Data contains defect rates, quality matrix for to assure that vehicle meets quality standards and also data like quality checks by feedback and suggestion to continous improve the vehicle quality. Table 5.6 show Quality Assurance data.

No.	Indicator	Data Types
6	**Quality Assurance Data**	
6.1	Inspection Data	Defect Rates, Quality Metrics, Compliance Records
6.2	Continuous Improvement Data	Feedback from Quality Checks, Improvement Suggestions

Table 5.6

Step 6: technology requirements

In order to implement the Smart Manufacturing Process Flow for Wiesmann Automotive Group, it is necessary to create a focused and integrated technology stack comprising a selection of advanced technologies. This stack is capable of supporting the various stages of the manufacturing process, from data acquisition to quality control. The following technology stack was used for implementation of industry 4.0 process:

1. **Connectivity and Data Management**
   The implementation of smart manufacturing is facilitated by **Siemens MindSphere**, which serves as the core platform for IIoT. This enables the interconnection of machines and devices for the purpose of data collection and analysis. The platform facilitates the real-time monitoring of machine health, production metrics, and environmental conditions, which is a fundamental aspect of predictive maintenance. The incorporation of data analytics and AI through **IBM Watson** further optimizes this configuration, facilitating advanced data processing and predictive insights, thereby enhancing both maintenance schedules and overall production efficiency.

2. **Automation and Human-Machine Interaction**
   The automation sector is primarily driven by two industry-leading companies: **ABB Robotics** and **Universal Robots**. These companies specialize in the provision of industrial robots and collaborative robots (Cobots), respectively. These companies provides technologies that facilitate the automation of complex and repetitive tasks, such as assembly and painting, while simultaneously ensuring operational flexibility and safety. The **Siemens SIMATIC HMI system** provides operators with intuitive interfaces, thereby enhancing control and interaction with machinery. Furthermore, **Microsoft HoloLens** enables the implementation of augmented

reality solutions for the purposes of immersive training and maintenance, thereby enhancing operational readiness and efficiency.

3. **Customization and Quality Assurance:**
   In order to facilitate the production of bespoke products, **Dassault Systems' DELMIA** integrates customer preference data into the manufacturing workflow. **Cognex Vision Systems** facilitates quality control through the implementation of automated inspection techniques, which enable the real-time detection of defects and the maintenance of high-quality standards. The integration of customization systems and quality control technologies ensures that the Wiesmann Automotive Group is able to offer bespoke products while maintaining excellence in manufacturing processes.

Step 7: project success

The implementation of a smart manufacturing process at Wiesmann Automotive GmbH can be effectively evaluated through the utilization of a wide range of key performance indicators (KPIs) that are aligned with the project's stated objectives. The following section provides a comprehensive account of the manner in which these KPIs can be employed to gauge the success of the project. Note that KPI were measured after industry 4.0 implementation in month of April, 2024.

1. Production Efficiency

Overall Equipment Effectiveness (OEE): This measure quantifies the proportion of productive time in production processes, evaluating the availability, performance, and quality of the processes in question. A higher OEE is indicative of enhanced operational efficiency and a reduction in downtime. Figure 6.1 shows Overall Equipment Effectiveness rate almost doubles after March.

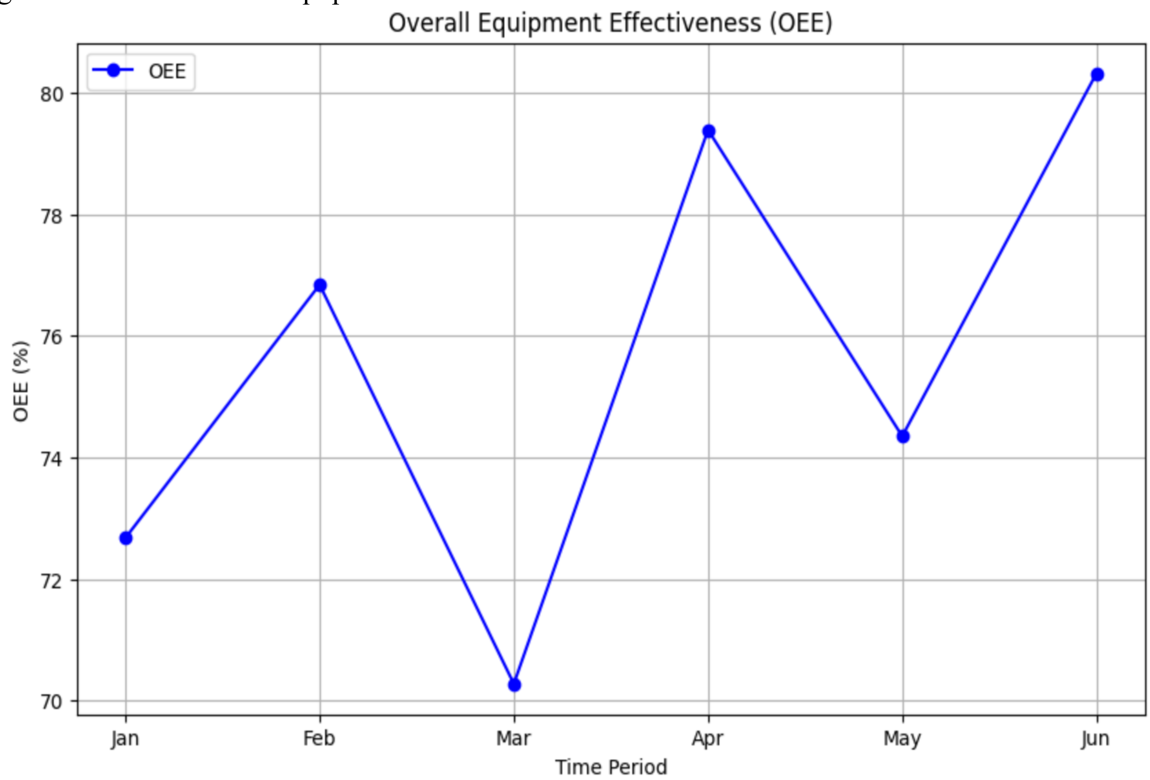

Figure 6.1

2. Quality Control

Defect Rate: This metric monitors the proportion of products that fail to meet the established quality standards. A reduction in the incidence of defects is indicative of enhanced quality control and an increase in the reliability of the product. Figure 6.2 shows that defect rate dramatically decrease after industry 4.0 implementation.

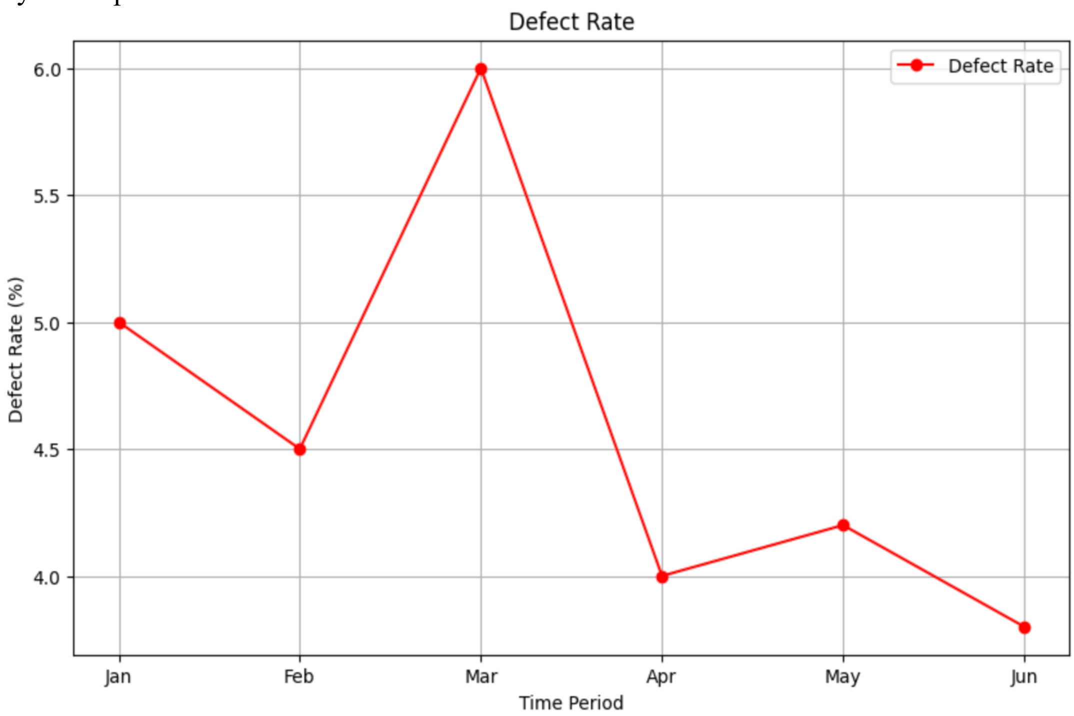

Figure 6.2

3. Customization Accuracy

On-Time Delivery of Custom Orders: The objective is to assess the percentage of bespoke orders that are delivered in accordance with the specified schedule and customer requirements. High rates indicate effective management of bespoke orders and responsiveness to customer requirements. Figure 6.3 show that after the month of March On-Time Delivery of Custom Orders is hyped.

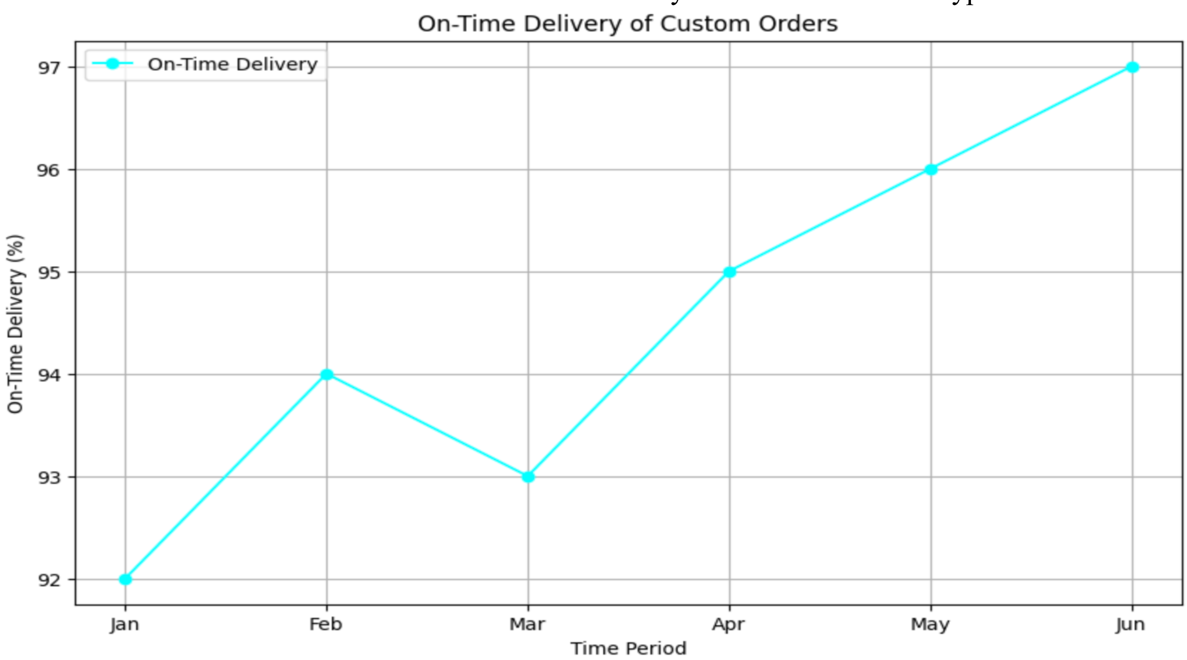

Figure 6.3

4. Data Utilization

Data-Driven Decision Rate: This indicator quantifies the extent to which decisions are informed by data analytics insights, as opposed to relying on more traditional methods. A higher rate is indicative of the effective utilization of data analytics and AI for strategic and operational improvements. Figure 6.4 shows constant increase in data-driven decision rate.

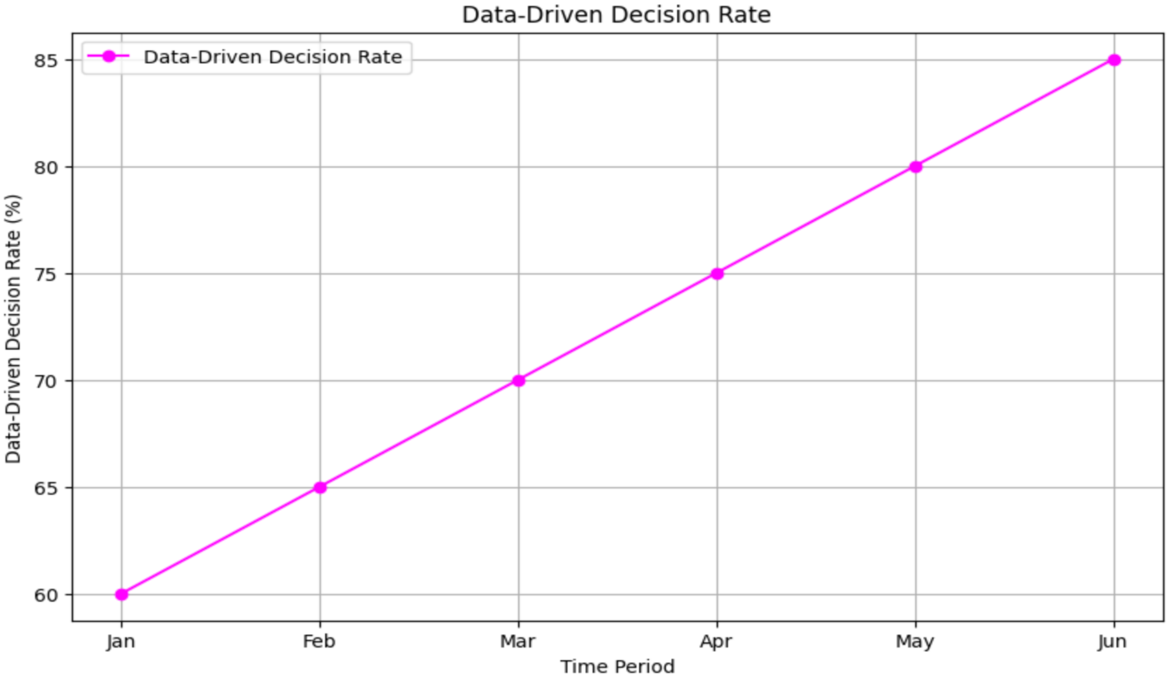

Figure 6.4

Bibliography

1. Wikipedia: https://en.wikipedia.org/wiki/Wiesmann_GmbH
2. Wiesmann Official Website: https://wiesmann.com/pages/homepage
3. Dun & Bradstreet: https://wiesmann.com/pages/corporate
4. Jupyiter lab (All Plots)
5. Lucidchart (All diagrams)

Declaration of Authenticity

I hereby declare that I have prepared the thesis without the assistance of others and without using any sources other than those indicated, and that the work has not been submitted in the same or similar form to any other examination authority. All the explanations of the work, taken literally or meaningfully, are marked as these.

Freising, 26/07/2024, Saad
Location, Date, Signature

Before you Submit

Please check your answers against the requirements of the project:

- Each section is written clearly and is concise.
- The word limit of each section is kept.
- The content of each section matches the task description.
- All references are marked as those.