CHAPTER 1

INTRODUCTION

This chapter gives brief introduction to custom application for Product Lifecycle Management, project description, company profile and Dissertation organization.

The Product lifecycle Management (PLM) application is software solution intended to transform the way businesses manage the whole lifecycle of their goods. Effective PLM practises are essential for businesses to maintain competitiveness, shorten time to market, and streamline product development processes in today's changing business climate. With the help of our Custom application, organisations can improve communication, streamline processes, and get more insight across the whole product lifecycle.

PLM application's central platform functions as a thorough repository for all data pertaining to products. This comprises the manufacturing documents, bills of materials, specs, and design files. Our solution offers straightforward access, version control, and effective communication across cross-functional teams by centralising and organising this data. This encourages fluid communication, enhances decision-making, and lowers the possibility of mistakes or inconsistencies across the course of the product lifetime.

Workflow automation is one of the main components of PLM platform. Businesses may automate operations and streamline product development workflows by developing and implementing standardised standards. This lessens manual labour requirements and human error rates while simultaneously accelerating time-to-market. Teams may work together more productively with automated alerts, approvals, and job assignments, guaranteeing a seamless transition from product concept to production.

Communication and collaboration are essential to effective PLM procedures. Strong tools are included in Custom application to provide smooth information sharing and real-time communication across stakeholders. Users may quickly assign tasks, exchange updates, annotate designs, and monitor progress.

PLM platform integrates analytics and reporting features to allow data-driven decision-making. It makes use of data gathered throughout the course of the product lifetime to offer insightful

information on the performance of the product, resource use, and market trends. Organisations may make wise judgements, spot opportunities for development, and stimulate innovation by analysing this data.

1.1 Project Description

The goal of the ambitious PLM (Product Lifecycle Management) application project is to provide a software solution that is specifically designed to answer the problems that organisations experience while managing their product lifecycles. Effective PLM practises are essential for organisations to optimise their operations, shorten time-to-market, and ensure successful product launches in an era of rapid technical breakthroughs and escalating market rivalry.

- project's main goal is to develop a complete, centralised platform that will act as a single hub for all information, procedures, and data pertaining to products.
- Design data, specifications, bills of materials, production instructions, and quality control records will all be combined into a single, user-friendly interface by our proprietary PLM programme.
- There is seamless access, version control, and cooperation across many teams and departments made possible by this consolidation, the full product lifecycle will be supported by effective communication and well-informed decision-making.

Workflow streamlining is one of our PLM application's main areas of focus. Intelligent automation elements that standardise and automate repetitive jobs, approval processes, and change management procedures will be created and put into place. Our solution will quicken product development cycles, optimise resource allocation, and boost operational effectiveness by minimising manual labour and human error.

The effective deployment of PLM depends critically on cooperation and communication. To promote efficient teamwork and information exchange among heterogeneous teams, our Custom application will include cutting-edge collaboration tools and capabilities. Throughout the product lifecycle, smooth information interchange, collaborative work, and stakeholder

alignment will be supported through real-time document sharing, version control, annotation tools, and integrated communication channels.

A key component of PLM application is to ensure quality control and compliance. PLM will provide solid components that make it easier to define and implement industry best practises, legal requirements, and quality standards. The solution will assist organisations in maintaining consistent product quality, adhering to compliance standards, and improving customer satisfaction through integrated quality checkpoints, inspections, and audit trails.

PLM programme will make use of sophisticated analytics and reporting features to offer insightful data on product performance, market trends, and resource usage. Businesses may get actionable insight, make data-driven choices, spot bottlenecks, and spot possibilities for innovation and continuous improvement by analysing data gathered from various phases of the product lifecycle.

The objectives of the custom application for PLM are.

- Gathering the requirement for development of application, designing the system, and designing the architecture.
- Applying the Agile approach for developing the core module
- Integration of the module and managing the data.
- Testing the application and deployment

1.2 Company Profile

Koch Business Solutions India

Koch Business Solutions India is a subsidiary of Koch Industries, a global conglomerate. It operates as a shared services organization, providing strategic support and services to Koch Industries' business units. The company offers a range of solutions in areas such as IT, procurement, finance, human resources, and legal and compliance. With a focus on enhancing operational efficiency and optimizing business processes, Koch Business Solutions India plays a vital role in driving innovation and supporting the growth of Koch Industries' businesses.

History

Koch Business Solutions India is a subsidiary of Koch Industries, one of the largest privately held companies in the world. Koch Industries was founded in 1940 by Fred C. Koch and has grown into a diversified conglomerate with interests in various industries, including energy, chemicals, manufacturing, and technology. Koch Industries' commitment to long-term value creation and innovative solutions has propelled its growth and established it as a global leader.

Brands

- Guardian
- INVISTA
- Molex
- Flint Hills Resources
- Koch Ag & Energy Solutions
- Koch Engineered Solutions
- Koch Minerals
- Koch Fertilizer
- Koch Methanol
- Koch Carbon

Services

Koch business solutions India provides various services such as

- IT Solutions and Support
- Procurement and Supply Chain Management
- Finance and Accounting Services
- Human Resources Support
- Legal and Compliance Services
- Research and Development
- Strategic Planning and Consulting
- Risk Management and Insurance Services
- Environmental, Health, and Safety Services
- Process Engineering and Optimization
- Energy Trading and Marketing

- Logistics and Transportation Services
- Manufacturing and Production Support
- Project Management and Execution
- Data Analytics and Business Intelligence
- Innovation and Technology Development
- Sustainability and Corporate Responsibility Consulting
- Market Research and Analysis
- Asset Management and Investment Advisory
- Customer Relationship Management and Support

1.3 Dissertation Organization

The entire report is divided into nine fragments In Chapter Two, there will be details about existing systems or projects that are relevant to backend services, as well as which frameworks are best suited to the problems. The third chapter focuses on software requirement specifications, particularly functional and non-functional requirements. The system design, or how the clusters are created, is discussed in Chapters four and five, as well as the project's overall flow. Chapter Six focuses on the project's implementation in terms of the pseudocodes and procedures used in the project.

The software testing specifications and various types of unit testing that are required for efficient development and debugging are covered in Chapter Seven. Chapter Eight focuses on summarizing conclusions Finally, the chapters include the project's future scope and closing remarks with the references.

CHAPTER 2
LITERATURE REVIEW

This chapter gives an overview of the inferences from the literature survey, existing proposed system of the project, Tools and Technologies that are used and Hardware software requirements of the project.

2.1 Literature Survey

The authors A. Smith et al. in [1] have proposed a framework for customizing PLM systems specifically to enhance support for engineering change management processes. It discusses the key components of the framework and provides insights into the customization techniques and challenges involved in achieving effective change management within PLM systems.

The authors B. Johnson et al. [2] has focuses on customizable PLM solutions tailored for small and medium-sized enterprises (SMEs). It explores the benefits, challenges, and considerations of implementing customizable PLM systems to meet the specific needs of SMEs and discusses the various customization options available.

The authors C. Lee et al. [3] have presented an adaptive and agile customization approach for PLM systems. It emphasizes the importance of flexibility and adaptability in customizing PLM solutions to accommodate changing business requirements and discusses strategies for agile customization to ensure efficient and effective PLM system deployment.

D. Brown et al. [4] addresses the integration challenges and solutions when integrating custom applications with PLM systems. It explores different integration techniques, discusses the potential issues that may arise during integration, and provides insights into effective integration strategies to ensure seamless communication between custom applications and PLM systems.

The authors E. Wang et al. [5] have provided a comprehensive review of different customization approaches employed in PLM systems. It discusses the pros and cons of various customization techniques, such as configuration, extension, and modification, and highlights the key

considerations in selecting an appropriate customization approach based on specific business requirements.

The authors F. Chen et and al. [6] have given case study that explores the user-centric customization of PLM interfaces. It presents a real-world example of how user-cantered design principles and methodologies can be applied to customize PLM interfaces to improve user experience, usability, and productivity.

The authors in [7] proposes a customization framework for PLM systems based on a modular architecture. It introduces the concept of modular customization and presents a framework that allows for flexible and efficient customization of PLM systems by assembling and configuring modular components.

The authors H. Zhang et al. [8] have focused on evaluating the performance of custom PLM applications. It discusses the metrics and benchmarks that can be used to assess the performance of custom PLM applications, enabling organizations to measure and optimize the efficiency and effectiveness of their customized solutions.

I. Davis et al. [9] addresses the integration challenges between customized PLM applications and enterprise resource planning (ERP) systems. It explores the strategies and considerations for effectively integrating these two critical systems to ensure seamless data exchange and process synchronization.

The study in [10] presents a comparative analysis of custom PLM solutions and off-the-shelf systems. It evaluates the advantages, disadvantages, costs, and risks associated with both options, providing insights for organizations to make informed decisions when selecting between customized PLM solutions or pre-built off-the-shelf systems.

The authors K. Anderson et al. [11] have shared lessons learned from industry projects on the agile development of custom PLM applications. It discusses the benefits and challenges of adopting an agile approach in the development process, highlighting best practices and key considerations for successfully implementing agile methodologies in custom PLM application projects.

This paper [12] explores the use of custom PLM applications for supply chain collaboration in global manufacturing settings. It discusses the benefits and challenges of implementing customized PLM solutions to enable effective collaboration, information sharing, and coordination across geographically dispersed supply chain partners.

M. Johnson et al. in [13] have given a systematic review focuses on data integration challenges encountered in custom PLM solutions. It identifies common data integration issues, such as data formats, data consistency, and data synchronization, and provides insights into strategies and approaches to overcome these challenges for seamless data integration in customized PLM systems.

The authors N. Wilson et al. [14] has investigated the benefits and challenges associated with cloud-based custom PLM applications. It discusses how cloud computing technologies can enable flexible, scalable, and cost-effective solutions, while also addressing concerns such as data security, privacy, and integration with existing on-premises systems.

The authors P. Thompson et al. [15] have explored the factors influencing user acceptance of customized PLM systems. It examines user perceptions, attitudes, and behavioural intentions toward customized PLM solutions, identifying key factors that influence user acceptance and providing insights for successful user adoption and system implementation.

Q. Davis et al.: [16]has addressed the security and privacy considerations in custom PLM applications. It discusses the potential security and privacy risks associated with customized PLM solutions, presents best practices for implementing robust security measures, and highlights the importance of safeguarding sensitive data throughout the PLM lifecycle.

The economic analysis of customization options in PLM implementations is proposed [17] .It explores the costs, benefits, and return on investment associated with various customization approaches, providing insights for decision-making on cost-effective customization strategies in PLM projects.

The authors S. Turner et al. [18] have highlighted the role of custom PLM applications in product data visualization and simulation. It discusses how customized PLM solutions can

enable advanced visualization techniques and simulation capabilities to enhance product design, development, and validation processes.

The authors T. Mitchell et and al. [19] have examined the impact of custom PLM applications on organizational processes and workflows. It explores how customized PLM solutions can improve process efficiency, collaboration, and information sharing within organizations, ultimately leading to enhanced productivity and innovation.

The authors by V. Patel et al. in "Integration of AI and Machine Learning in Custom PLM Solutions: Current Trends and Future Directions" [20] have explored the integration of artificial intelligence (AI) and machine learning (ML) in custom PLM solutions. It discusses current trends and applications of AI and ML in custom PLM, highlighting their potential to enable intelligent decision-making, predictive analytics, and automation in the PLM domain.

Summary of Literature survey

- The survey looks at several ways to adapt PLM systems for objectives, such improving engineering change management, addressing the demands of small and medium-sized businesses (SMEs), and facilitating supply chain communication in global manufacturing environments.

- It shows the advantages and difficulties of using modular customisation techniques and emphasises the significance of flexibility and adaptability in tailoring PLM systems to meet shifting business requirements.

- To enable seamless communication and data sharing, the study covers integration problems between bespoke applications and PLM systems and offers insights into practical integration techniques.

- The merits and cons of various customisation strategies, such as configuration, extension, and modification, are explored and assessed in light of particular business requirements.

- To enhance the usability, productivity, and user experience of PLM interfaces, user-centric design ideas and approaches are investigated.

- The study discusses measures and standards to evaluate efficiency and effectiveness while looking at the performance of bespoke PLM solutions.

- It examines how machine learning (ML), and artificial intelligence (AI) are used in bespoke PLM systems, emphasising the potential for these technologies to support deft judgement and predictive analytics.

- The discussion includes user acceptability factors for customised PLM systems as well as security and privacy issues about customised PLM applications.

- Insights into economic analysis are provided by the survey, which compares the expenses, advantages, and returns on investment of various customisation choices for PLM deployments.
- To illustrate the possibilities for enhancing productivity and innovation, the function of bespoke PLM systems in product data visualisation, simulation, and their influence on organisational procedures and workflows are also investigated.

2.2 Existing and Proposed System

Lack of Flexibility: Some PLM systems might only offer a little amount of customisation freedom. They might have been created with established procedures or data models that are difficult to change or adapt to specific organisational needs.

Complexity: PLM systems can be difficult for users to master because of their complexity. The intricacy may make it difficult for users to adapt the system and result in inefficient usage of all its features.

Integration Challenges: It can be difficult and time-consuming to integrate PLM systems with other business systems, such as ERP or CAD software. The smooth transmission of information

and the automation of workflows might be hampered by system incompatibilities or issues with data synchronisation.

Costly Customization: Certain PLM system customizations may come at a substantial cost, both in terms of development time and ongoing maintenance. The requirement for considerable customisation might lengthen project schedules and cost more money.

Scalability Issues: Some PLM systems may have trouble scaling to handle rising data volumes, user numbers, or additional features when organisations develop or undergo structural changes.

User Interface Limitations: Existing PLM systems' user interfaces cannot always be simple or user-friendly, making it challenging to navigate, enter data, or access certain functions. Poor user experience can impede productivity and user adoption.

Version Control and Collaboration: In some PLM systems, collaborative features including version control, document sharing, and real-time collaboration may be constrained or lacking in substantial capabilities. This may affect how effectively and accurately team members collaborate.

Upgrade Challenges: It can be difficult to update current PLM systems to more recent versions because of potential data transfer concerns, customisation compatibility issues, and disruptions to ongoing operations during the upgrade process.

Proposed System

The document management module will give Specifications, drawings, and manuals for products may all be efficiently stored, arranged, and retrieved thanks to the document management module. Users will be able to quickly search, manage versions, and collaborate on documents, expediting the documentation process and guaranteeing that all stakeholders can access the most recent versions.

The popular CAD programme will be smoothly integrated with the CAD integration module, enabling users to import, manage, and associate CAD files inside the PLM system. Through this interface, designers and engineers will be able to work quickly with CAD models, keep

track of design modifications, and guarantee accurate and current product data throughout the product lifetime.

For managing quality procedures, such as quality planning, inspections, non-conformance management, and corrective measures, the quality management module will offer thorough tools. Organisations will be able to do things like set quality standards, check on product quality, and take remedial action when problems are found. Real-time warnings and alerts will guarantee prompt solutions to quality issues, encouraging ongoing development and consumer satisfaction.

The reporting and analytics module will provide sophisticated reporting and data analytics features. Users will be able to create reports that are fully configurable, view important performance indicators, and draw conclusions from the gathered data. With the help of this module, decision-makers will be better equipped to analyse data, spot patterns, and streamline the process of creating new products.

The suggested solution would offer a single platform on which all modules will be fully integrated, facilitating smooth information flow and removing data silos. User adoption will be facilitated by the user-friendly interface and straightforward processes, and organisations will be able to customise the system to meet their unique needs thanks to the customisation choices. Sensitive data will be protected by data security measures, and frequent system upgrades and support services will be offered to keep the system current and in line with changing business needs.

2.3 Tools and Technologies Used

This section gives an overview of the tools and techniques used to implement the project. The PLM application is developed using java which provides the foundation for its backend logic, services, and APIs. It runs on application server known as Apache Tomcat which handle the deployment, management, and execution of the PLM application. PLM supports database of Microsoft SQL Server for storing and managing product data and related information. PLM integrates with CAD software known as AutoCAD. PLM uses Java Server Faces (JSF) and Java Servlets web development frameworks to build its web-based user interface.

Java: The Java programming language was mostly used to construct the PLM application. It is a robust, versatile object-oriented language with platform independence and a sizable, welcoming community. Java gives the framework for developing the backend logic, services, and APIs of the PLM system, making it a viable choice for building big and scalable systems.
Apache Tomcat: The PLM application is deployed, managed, and executed using Apache Tomcat, an application server. Open-source application server Tomcat is well-known for being simple to operate, light in weight, and supporting Java web applications. It serves as the runtime environment for the PLM application, handling user requests, managing resources, and ensuring that users can access the programme.

Microsoft SQL Server: Microsoft SQL Server serves as the PLM application's database management system. Relational databases like SQL Server, which provide superior data storage, retrieval, and administration capabilities, are reliable and frequently used. Assuring data integrity, security, and scalability, it is highly suited for managing massive amounts of product-related data and associated information.

AutoCAD: PLM interfaces with the AutoCAD computer-aided design (CAD) programme. For developing, revising, and sharing 2D and 3D drawings, engineers and manufacturers frequently utilise the well-known CAD programme AutoCAD. Through smooth data transmission between the PLM system and the CAD programme made possible by the interface with AutoCAD, effective collaboration and design management are made possible.

Java Server Faces (JSF) and Java Servlets: PLM builds its web-based user interface using Java Server Faces (JSF) and Java Servlets, two web development frameworks. The JSF framework, which is built on components, makes it easier to create dynamic web pages by offering reusable UI components. On the other hand, Java Servlets manage user requests and provide communication between the user interface and backend services. Together, these frameworks make it easier to handle user interactions, produce web pages effectively, and combine user interface and backend functionality.

2.4 Hardware and Software Requirement

Hardware Requirement

Table 2.1: Hardware Requirement

Hardware	Requirement
Disk Space	9GB Minimum to 32Gb Maximum
Memory (RAM)	16GB Maximum to 32GB Maximum
Screen Resolution	1920 x 1080
Video RAM	2GB Minimum to 6GB Maximum

The above table describes the installation of the customised PLM programme necessitates a minimum of 9GB of disc space and a maximum of 32GB of available space. A 1920 x 1080 pixel screen resolution is advised. To guarantee effective data processing and lag-free operation, the system's RAM should be at least 16GB, expandable up to 32GB. Additionally, to handle graphics-intensive operations and provide a fluid user interface, a least of 2GB and a maximum of 6GB of Video RAM are required.

Software Requirement

Table 2.2: Software Requirement

Software	Requirement
Operating System	Windows 10 or later
Browser	Google Chrome, Microsoft Edge

The above table describes the compatibility and best performance, the custom PLM application has certain software needs. It is made to work on Windows 10 or later operating systems, giving users a comfortable and well-liked platform. Additionally, the programme is prepared for usage with common web browsers like Google Chrome and Microsoft Edge, guaranteeing easy access and interaction. The bespoke PLM application may efficiently handle product data, procedures, and collaboration by satisfying these software criteria, resulting in a user-friendly experience that supports simplified product development and increased productivity inside the company.

CHAPTER 3
SOFTWARE REQUIREMENT SPECIFICATION

This chapter provides a detailed description of the existing and proposed system. The system's definitions, general product description and functions, user characteristics, functional and non-functional requirements, and system limitation constraints are all included in the specification.

3.1 Introduction

Software requirements specification (SRS) is a document that contains a detailed description of how the system should function. The Software Requirement Specification (SRS) stage of software development is where the requirements of the system under consideration are written down to lay the groundwork for the software development activities. Correctness, completeness of all essential requirements and their definitions, unambiguity, and consistency are all characteristics of a good SRS document.

Definitions, Acronyms and Abbreviations

Table 3.1: Abbreviations

Abbreviation	Explanation
PLM	Product Lifecycle Management
CAD	Computer-aided design
ERP	Enterprise Resource Planning
JSF	Java Server Faces

This table provides a quick reference to the abbreviations along with their corresponding explanations. It is commonly used in technical contexts where these abbreviations frequently appear, allowing users to easily understand the meaning of each abbreviation without the need for additional research.

3.2 General Description

An organization's specific needs for storing product data, optimising workflows, and promoting team communication are met by a Custom application for Product Lifecycle Management (PLM), which is a customised software solution. This software has capabilities including document management, CAD integration, change management, quality control, supply chain management, and reporting/analytics, all of which are tailored to fit the organization's particular processes and data models. Organisations may increase productivity, strengthen data integrity, promote cross-functional communication, and make wise decisions across the whole product lifecycle by utilising this unique PLM application.

3.2.1 Product Description

A complete software solution, PLM application is made to optimise product lifecycle management. Document management, CAD integration, quality management, and reporting/analytics are its four key elements. The software simplifies CAD integration to improve design workflows, guarantees stringent quality control procedures, and offers extensive reporting and analytics capabilities. It also enables effective document storage, collaboration, and version control. Organisations may successfully manage product data, enhance team collaboration, uphold high standards, and make data-driven choices for successful product development and management with the help of our specialised PLM application.

3.2.2 Product Function

Document Management: Organise and safely keep papers pertaining to the products. Use version control to keep track of document updates and preserve a history. Enable document retrieval and search for simple access. Encourage team members to collaborate on and share documents. To maintain data security, establish access control and permissions.

CAD Integration: Integrate seamlessly with CAD applications for effective administration of CAD files. Import CAD models, then link them to pertinent product information. Allow direct CAD model modification and viewing within the PLM system. Keep data synchronised and track CAD design changes. Encourage cooperation between designers and engineers using CAD models.

Quality Management: Establish and enforce quality standards and regulations. Conduct quality checks and keep a record of the findings. Control non-conformance problems and start remedial measures. Create high-quality metrics and reports for tracking and analysing. Keep a database of certificates and papers relevant to quality.

Reporting and Analytics: Create reports that may be customised depending on user-defined criteria. Visualise metrics and key performance indicators (KPIs). analyses product data to find trends and new information. integrate with external business intelligence systems or analytics solutions. Give decision-makers useful information so they can make wise choices.

3.2.3 User Characteristics

When creating a Custom PLM application, user attributes are crucial factors to consider. The application can be tailored to meet the unique requirements and preferences of users by carefully considering user roles, technical proficiency levels, functional requirements, collaboration needs, data access and security preferences, mobile accessibility requirements, and the need for training and support. An intuitive user interface, tailored processes, useful collaboration tools, strong data protection safeguards, seamless mobile accessibility, and extensive training materials are all ensured by this user-centric approach. The Custom PLM application becomes a priceless tool that allows users across diverse roles and proficiency levels to efficiently manage the product lifecycle, streamline procedures, foster cooperation, and achieve the best outcomes by considering these human characteristics.

3.3 Functional Requirement

This project is built in four modules. The description of the modules is given below:

Module 1: Document Management

The Document Management module in Custom PLM focuses on managing documents related to product development, such as specifications, drawings, manuals, and technical documents.

- **Input:** The input for the Document Management module includes various types of documents created during the product development process
- **Function:** The module facilitates document collaboration by providing capabilities for comment tracking, markups, and review workflows. It also includes search functionality, allowing users to locate documents based on attributes, keywords, or metadata.
- **Output:** The module also generates document change notifications, approval records, and access logs, providing an audit trail of document-related activities.

Module 2: CAD Integration

The CAD Integration module in Custom PLM enables seamless integration between Teamcenter and various computer-aided design (CAD) tools.

- **Input:** The input for the CAD Integration module includes CAD files and associated metadata created and modified using CAD software, such as AutoCAD.
- **Function:** The module provides capabilities for managing CAD file relationships, associating CAD files with product structures, and synchronizing design changes between Teamcenter and the CAD software. It also supports visualization of CAD data, allowing users to view, interrogate, and analyze 3D models and drawings.
- **Output:** The module generates CAD-related reports, visualizations, and metadata, supporting collaboration and decision-making during the product development process.

Module 3: Quality Management

The Quality Management module in Custom PLM focuses on managing product quality throughout its lifecycle.

- **Input:** The input for the Quality Management module includes quality requirements, specifications, inspection plans, and non-conformance data.
- **Function:** The Quality Management module allows users to define quality plans and requirements for products. It supports the creation and management of inspection plans, defining the criteria, methods, and frequency of inspections.

- **Output:** The module generates quality reports, performance metrics, and audit records, enabling organizations to monitor and continuously improve their quality processes.

Module 4: Reporting and Analytics

The Reporting and Analytics module in Custom PLM provides capabilities for generating comprehensive reports, performance metrics, and analytics dashboards.

- **Input:** The input for the Reporting and Analytics module includes data from various modules and sources within PLM Application, such as change management, quality management, manufacturing processes, or requirements management.
- **Function:** The Reporting and Analytics module enables users to define and generate custom reports, tailored to specific requirements and key performance indicators (KPIs). It provides data visualization tools, including charts, graphs, and dashboards, to facilitate data analysis and interpretation.
- **Output:** The module enables data-driven decision-making, supports process optimization, and provides a basis for continuous improvement initiatives.

3.4 Non-Functional Requirements

Performance

The PLM system needs to be optimized from an application standpoint in order to provide effective and quick performance. It should be able to manage a lot of data without slowing down or losing responsiveness. Quick execution of tasks like finding, retrieving, and updating data is required to give consumers a seamless and easy experience. Techniques for performance tweaking and optimization should be used to guarantee the system's effectiveness even under a strong demand.

Scalability

The PLM solution must be scalable since it must be able to handle growing data and user loads over time. Scalability should be considered while designing the system so that it can expand and change to meet changing business requirements. Scalable architectures, distributed computing, and load balancing techniques may all be used to

accomplish this. The PLM system should scale effortlessly as the user base and data volume increase to maintain peak performance.

Security

As a PLM application deals with sensitive and private product-related information, security is of the highest significance. To protect data and prevent unauthorized access, the system must apply strict security measures. To make sure that only authorized users have access to certain data and capabilities, user authentication systems, role-based access control, and data encryption should be put into place. To identifying and addressing any security issues, regular security audits and vulnerability assessments should also be carried out.

Reliability

The PLM system must have excellent uptime and data retention standards, guaranteeing minimal downtime. The system's ongoing availability is essential for uninterrupted communication and product development. The application should be designed using fault-tolerant design concepts and redundancy to ensure dependability. Mechanisms for disaster recovery and data backup should be in place to prevent data loss in the case of system malfunctions. Additionally, proactive monitoring and performance management should be used to find and fix possible problems before they have an influence on the dependability of the system.

3.5 Design constraints

To ensure its efficacy and smooth integration into the organization's product development ecosystem, the custom PLM application must be created considering several crucial design limitations. To enable seamless data interchange and system integration, the application must, first and foremost, be compatible with the current technological infrastructure, including operating systems and databases. Strong measures are required to protect sensitive product data and stop unauthorised access since data security and privacy are of the utmost importance. The programme should also have outstanding speed and scalability, able to manage large data volumes and user loads without sacrificing effectiveness. Intuitive and user-friendly user interfaces maximise usability and shorten users' learning curves.

For businesses working in regulated industries, compliance with industry norms and regulations is crucial. The project requires effective resource management and project planning to be accomplished within the given time and financial limits. Furthermore, the application's dependability and data integrity are crucial, necessitating backup and recovery techniques to guarantee uninterrupted operations. To encourage user adoption, adequate user training and acceptability testing should be carried out. The application's flawless operation across many platforms means that it can be used by users on computers, laptops, tablets, and smartphones. By addressing these design limitations, the organization's product lifecycle management procedures will be able to execute the bespoke PLM application successfully, improving productivity, quality, and competitiveness.

CHAPTER 4

SYSTEM DESIGN

System design provides an overview of the system's architecture, including how the system is connected internally, how workflows within the system, and the concept of complete system components.

4.1 System Perspective

Problem Specification

The exact problems and inefficiencies within each of the modules (document management, CAD integration, quality management, and reporting/analytics) that the custom PLM application seeks to solve are listed. Understanding these difficulties will enable the application's designers to provide solutions that are specifically targeted, speeding workflows and improving overall product lifecycle management.

The absence of a centralised repository in the existing document management procedure makes it challenging to store, arrange, and retrieve product-related documents. This causes lengthy searches and the potential loss of important information. When handling document modifications, the absence of version control procedures causes confusion and mistakes. It becomes difficult to keep track of updates, preserve document history, and guarantee the correctness of the most recent information. Limited capacity for collaboration Effective cooperation and information sharing are hampered by the absence of comprehensive collaboration tools.

Manual Data transmission because the PLM and CAD software integration process is currently fragmented, manual data transmission is necessary. This influences design workflows and general efficiency by causing mistakes, delays, and inconsistent data. synchronisation difficulties The PLM system's and CAD software's ability to synchronise data is hampered by a lack of seamless connection. As a result, accuracy and coordination may suffer when design modifications made in CAD do not reflect correctly in the PLM system. Design workflows are interrupted by ineffective CAD integration, which results in inefficiencies and the possibility of rework. Effective collaboration between engineers and designers becomes more difficult, which causes misunderstandings and delays. Document Management: Ineffective Document Storage:

The absence of a centralised repository in the existing document management procedure makes it challenging to store, arrange, and retrieve product-related documents.

Quality planning, inspections, non-conformance management, and remedial measures are inconsistent due to the present quality management systems' lack of standardisation. This may result in inconsistent quality standards, more rework, and unhappy clients. The inability to track and monitor quality-related activities is caused by the lack of a systematic approach to quality management. This restricts access into quality measurements, making it difficult to pinpoint problem areas and adopt preventative actions.

The current PLM system lacks robust analytics and reporting tools. As a result, it is difficult to see important patterns and insights that may be used. Without access to personalised reports and real-time data, making decisions becomes difficult. It is challenging to understand and convey complicated product data in the absence of data visualisation tools. Analytics insights are not adequately communicated, making it difficult to spot trends, patterns, and opportunities for development.

Block Diagram

This section gives an overview of Product Design process.

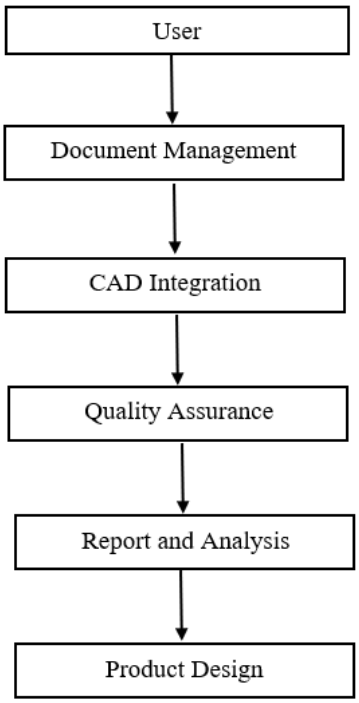

Figure 4.1: Block Diagram

The above block diagram explains the flow of the modules and explains the modules. In this the user will add a new document for designing a product. The management of the massive quantity of data and documents related to the product development process is covered in the document management. Various sorts of data, including project requirements, design specifications, and regulatory papers, are gathered and organised at this stage, which serves as the input stage. All stakeholders will have access to the most recent information This facilitates effective communication and information exchange among team members by centralising and organising crucial project materials.

The document management stage's input is used in the CAD Integration module to develop intricate product designs with computer-aided design (CAD) software. CAD tools may be used by engineers and designers to produce 2D and 3D models of the finished product, visualise the design, and run simulations and analyses. The PLM application and the CAD software can transmit data seamlessly thanks to the CAD connection, which also ensures that updates and modifications to designs are automatically synchronised with the document management system. The design process is streamlined by this integration, which also improves communication between the engineering and design teams.

The quality assurance is crucial to the process of creating a product. It entails evaluating and comparing the product design to numerous standards and quality criteria. Features like design rule checks, simulation analysis, and tolerance analysis might be included in this module. Performing thorough quality checks throughout the design phase enables possible problems and errors to be found and fixed before they have a chance to become costly mistakes or need further labour.

The custom PLM application focuses on producing reports and carrying out in-depth evaluations of the product development process. This module makes use of information gathered throughout the course of the product's lifecycle and offers insightful information on the project's development, effectiveness, and room for improvement. Stakeholders may use it to detect bottlenecks, optimise the product development process for next projects, and make data-driven choices.

4.2 Context Diagram

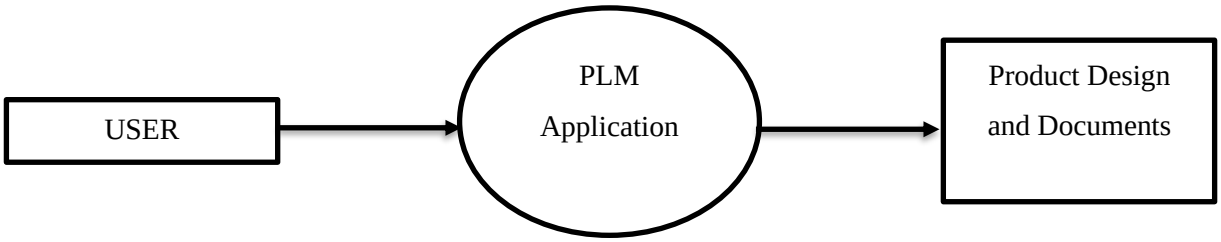

Figure 4.2: Context Diagram

The above context diagram explains the application flow, the people or groups participating in the creation of the product are represented by the term "User". Engineers, designers, project managers, executives, vendors, and other team members who are involved in the product lifecycle might be among these users. To enter and retrieve data, handle documents, and carry out other product development activities, the user interacts with the PLM programme.

The main computer programme that enables and controls the full product lifecycle is known as the "PLM Application." It acts as the central management and storage platform for all information, documents, and data pertaining to the product. Document management, CAD integration, quality assurance, reporting and analysis, collaboration tools, and workflow management are just a few of the features and functions that the PLM programme offers. It serves as the major hub for all product-related data and offers users a fluid environment for effective teamwork, product design, analysis, and management.

The output and supporting papers created throughout the product development process are referred to as "Product design and documents". The product design, design requirements, engineering drawings, simulation results, reports, and other pertinent documentation can all be represented in CAD files. Authorized users have access to these product-related outputs that are developed and controlled within the PLM application for collaboration, review, and validation.

CHAPTER 5
DETAILED DESIGN

This chapter describes about the architectural design of the project which includes the Mail operation ecosystem and the working flow between the modules of the entire project architecture also it explains about the container orchestration Mesos framework along with the master and slave architecture.

5.1 Architectural design

This is a High-Level architecture diagram of custom application for product lifecycle management.

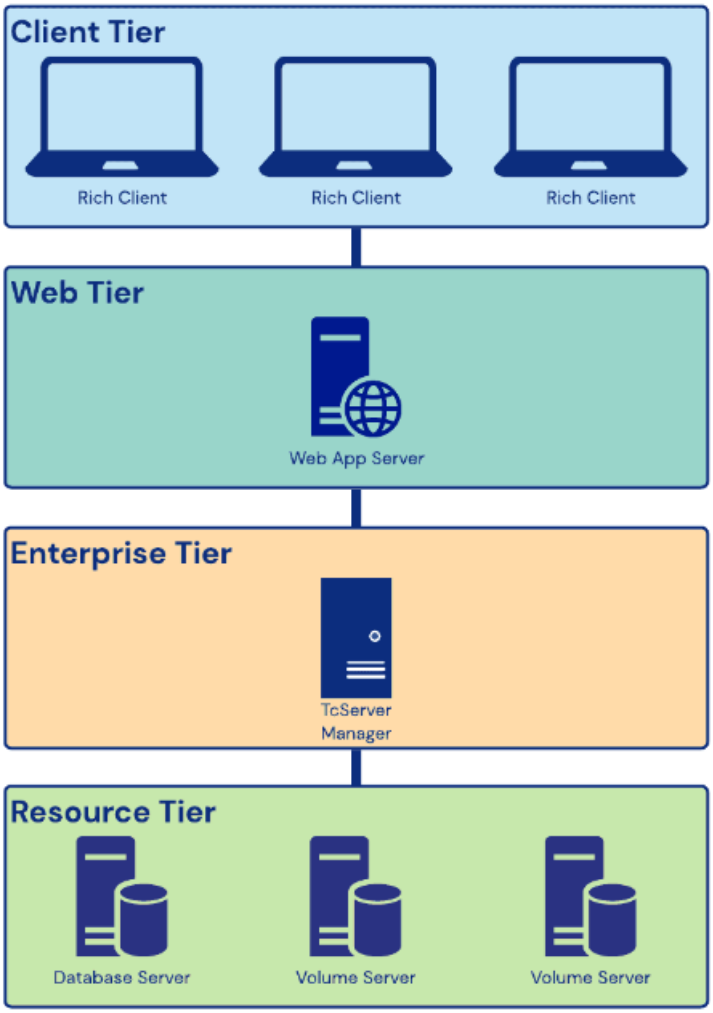

Figure 5.1: Architecture Diagram

Client Tier:

The user-facing portion of the PLM programme is called the client tier. It covers a variety of clients, including desktop programmes, web browsers, and visualisation tools (together referred to as "thin clients" and "rich clients"). Users engage with the PLM system, access product data, and carry out a variety of tasks pertaining to product design, documentation, and collaboration on this layer. A user-friendly and straightforward interface that is suited to the customers' individual needs is provided by the client tier, making it simpler for users to properly handle product data.

Web Tier:

Between the client tier and the enterprise layer, the web tier serves as a middleman. It oversees managing web-related services and functionalities. Web servers, application servers, and other web-related components that handle user requests, server-side application logic, and data display for web-based clients are included in this tier. To limit user access to PLM features and data, the web tier frequently implements security techniques like authentication and permission.

Enterprise Tier:

The PLM application's enterprise tier serves as its primary processing layer. It includes the functionality and business logic needed for lifecycle and product data management tasks.
For document management, CAD integration, quality control, reporting, analytics, and other PLM features, this tier contains a variety of modules and services. The enterprise tier manages data processing, storage, retrieval, and manipulation, assuring data correctness and consistency throughout the product lifecycle. This layer facilitates integration with other corporate systems, such as ERP or CRM, to share data and expedite cross-functional activities.

Resource Tier:

The resource tier represents the underlying infrastructure and resources, including as databases, file systems, and computer resources, required for the functioning of the PLM application. To help the enterprise tier in storing product data, documents, and other pertinent information, it offers data storage and management capabilities. The resource tier is tailored to fit the PLM application's unique performance and scalability needs, guaranteeing effective data handling and access.

5.1.1: Functional Modelling

Data Flow Diagram DFD a data-flow map is a way of serving a sail of statistics of a process or a system. The DFD additionally supplies databases about the outputs and inputs of each entity and the process itself. A data-flow map has no control flow, there're a lot of no decision rules and no loop.

a) DFD Level – 0

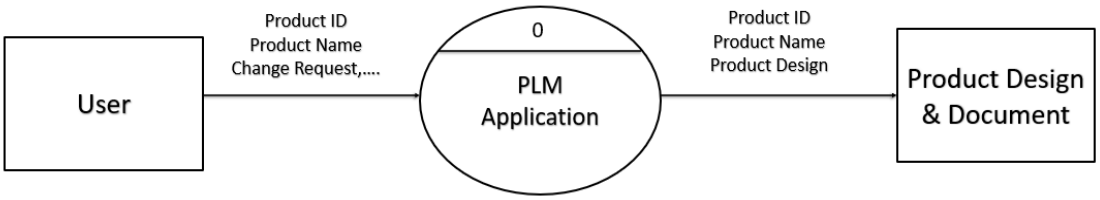

Figure 5.2: DFD Level – 0

The above diagrams show the different levels of the Data Flow Diagram. The figure. 5.2 shows the highest level of the DFD. The internal process that takes place when a user requests for application. The users here are the product designers, they access the application and design the whole product design and documentation.

b) DFD Level – 1

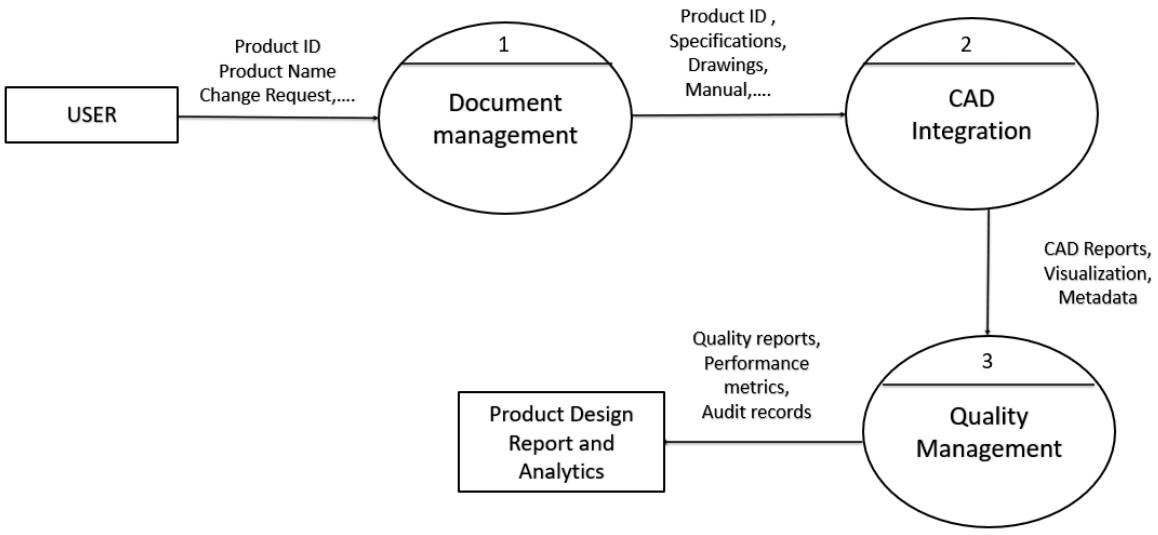

Figure 5.3: DFD Level – 1

At DFD Level 1, the Document Management, CAD Integration, Quality Assurance, and Report and Analytics modules of the Custom PLM application play crucial roles in providing a thorough overview of the programme's functions. A centralised platform that streamlines product lifecycle management procedures across sectors is advantageous to users.

By enabling users to generate, change, and manage a variety of product-related documents, the Document Management module streamlines the processing of documents. Version control and accessibility are ensured via the Document Repository's safe storage of these papers. Easy document searching based on author, type, and keywords is made possible by a user-friendly interface, guaranteeing rapid access to the information you need. Sensitive data is protected by access control measures, which make sure that only authorised individuals may interact with certain documents.

The PLM application and CAD software, such as AutoCAD, are in constant contact thanks to the CAD Integration module. Users may import, translate, and visualise CAD data with this connection, which encourages effective teamwork and design synchronisation. The module improves design processes by offering a seamless interface with CAD tools, encouraging innovation and minimising mistakes.

The goal of the Quality Assurance module is to maintain product quality through non-conformance control, audits, and inspections. Users can log test results, assuring compliance with predetermined quality requirements. The functionality of the module enables quality control checklists, making systematic assessments and tracking compliance easier. The Quality Assurance module improves overall product quality and customer happiness by quickly identifying and resolving quality concerns.

Users obtain knowledge by creating detailed reports and visualisations in the Report and Analytics module. Customizable report templates meet particular requirements, and tools for data aggregation and visualisation help in conducting efficient analyses of product data. These reports offer useful data for strategic planning, process optimisation, and decision-making, which helps to improve product development.

Module Specification

Module 1: Document Management

Inputs: Product-related documents such as specifications, drawings, user manuals, etc.
Outputs: Categorized and version-controlled documents, accessible to stakeholders
Purpose: The purpose of this module is to effectively manage and organize product-related documents throughout the product lifecycle. It serves as a centralized repository for storing various types of documents and provides functionalities to upload, categorize, and version-control them. The module ensures that stakeholders can access the most up-to-date information, facilitating collaboration and better decision-making.

Module 2: CAD Integration

Inputs: CAD designs and models
Outputs: Synchronized and up-to-date CAD data accessible from the PLM application
Purpose: This module is designed to integrate with CAD systems and manage CAD data effectively. It allows users to access and work with the latest CAD designs directly from the PLM application. The module streamlines the design process, improves collaboration among engineers and designers, and helps maintain design consistency throughout the product lifecycle.

Module 3: Quality Assurance

Inputs: Quality standards, specifications, and test plans
Outputs: Inspections, test results, and corrective actions
Purpose: The Quality Assurance module focuses on maintaining and ensuring product quality throughout the product lifecycle. It allows organizations to define and manage quality standards, conduct inspections, tests, and validations, and track non-conformances and corrective actions. The module helps achieve higher product quality, compliance with industry standards, and customer satisfaction.

Module 4: Reporting and Analytics

Inputs: Data from various modules

Outputs: Custom reports, dashboards, and metrics

Purpose: The Reporting and Analytics module empowers organizations to gain valuable insights into their product development processes and performance. It offers a wide range of reporting and data visualization tools to analyze data and generate actionable reports. The module supports data-driven decision-making, helping optimize product development processes, track project progress, and identify areas for improvement.

5.2: Detailed Design

The detailed design phase involves creating comprehensive specifications and blueprints for each component of the system, providing a more detailed view of how the system will be built and how the different modules will interact with each other.

PDL: Process definition language processes definition, both the graphics and the semantics of a workflow business process. It helps to gain knowledge on how the modules are implemented through algorithms and formulas in a system.

Module 1: Document Management

Description: The document management module is responsible for efficiently managing product-related documents throughout their lifecycle. It ensures proper storage, organization, version control, and security of documents to facilitate collaboration and maintain a reliable document history.

Process:

Start

Step 1: Read file

Step 2: While not end-of-file

Step 3: If record is valid

Step 4: Process the record

Step 5: Else

Step 6: Handle invalid record
Step 7: End if
Step 8: Read file
End while
End Process

Module 2: CAD Integration

Description: The CAD integration module facilitates seamless communication between the PLM application and Computer-Aided Design (CAD) software, such as AutoCAD. It ensures that design data remains consistent between the PLM system and CAD tools.

Process:

Step 1: Read CAD file
Step 2: While not end-of-file
Step 3: If CAD data is valid
Step 4: Import CAD file
Step 5: Synchronize Design Changes
Step 6: Else
Step 7: Print error
Step 8: End if
Step 9: Read CAD file
Step 10: End while
End Process

Module 3: Quality Assurance

Description: The quality assurance module is responsible for managing product quality control processes, inspections, and test results to ensure products meet specified quality standards.

Process:

Step 1: Read quality test results
Step 2: While not end-of-file
Step 3: If test results are valid
Step 4: Record Test Results
Step 5: Else

Step 6: Print error

Step 7: End if

Step 8: Read quality test results

Step 9: End while

End Process

Module 4: Reporting and Analysis

Description: The reporting and analysis module provide tools for generating various reports and analysing product data to make informed decisions and gain insights into the product lifecycle.

Process:

Step 1: Read data sets

Step 2: While not end-of-file

Step 3: If data is valid

Step 4: Design Customizable Report Templates

Step 5: Generate Reports

Step 6: Data Aggregation and Visualization

Step 7: Else

Step 8: Print error

Step 9: End if

Step 10: Read data sets

Step 11: End while

End Process

CHAPTER 6
IMPLEMENTATION

6.1: Implementation Screenshots

Document management

An organization's internal document organisation, storage, retrieval, and control process is known as document management. Document creation and categorization, version control implementation, document security assurance, and streamlined retrieval are all part of it.

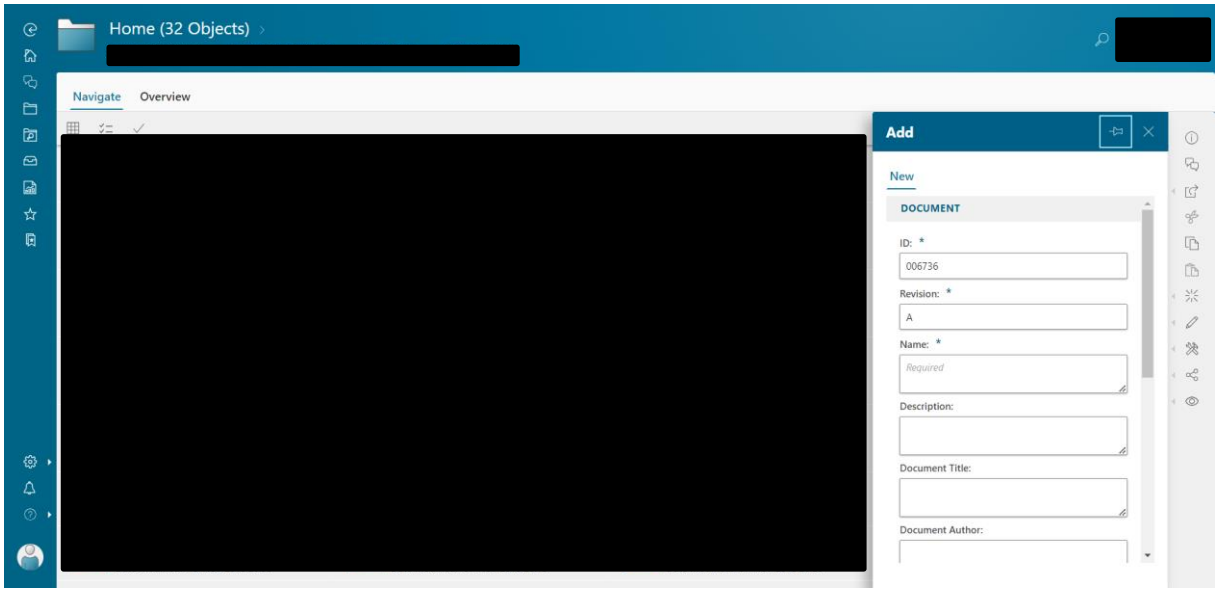

Figure 6.1: Document Management

In this module, users are given the capability to create and add new design documents, each containing essential details such as a unique Design ID, a descriptive Name, a comprehensive Description, and an informative Title. These design documents act as records for various designs associated with a product or project, facilitating organized storage and easy referencing. By inputting these specific pieces of information, users can effectively capture and document their designs, streamlining the design management process within the system.

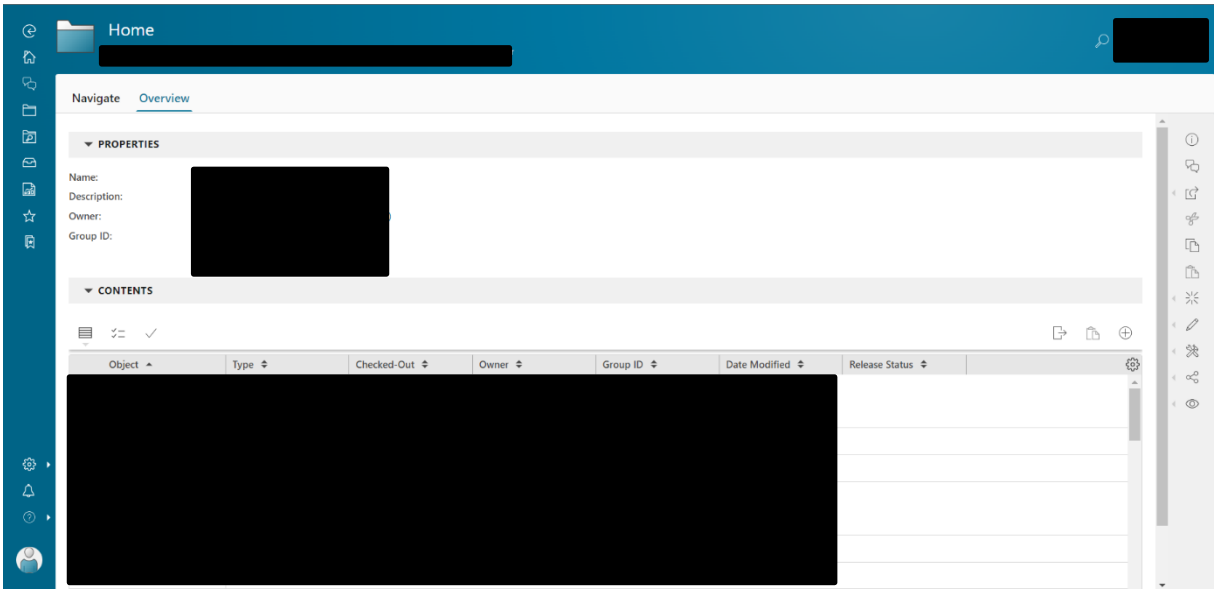

Figure 6.2: Document Overview

In this module, users have the capability to review the properties of a design, encompassing essential details like the Design ID, Name, Description, and Title. Additionally, they can access and examine all the contents associated with the design, including design files, documents, images, and other pertinent data. This comprehensive functionality enables users to efficiently manage and analyse their designs, fostering effective collaboration and informed decision-making throughout the design process.

CAD Integration

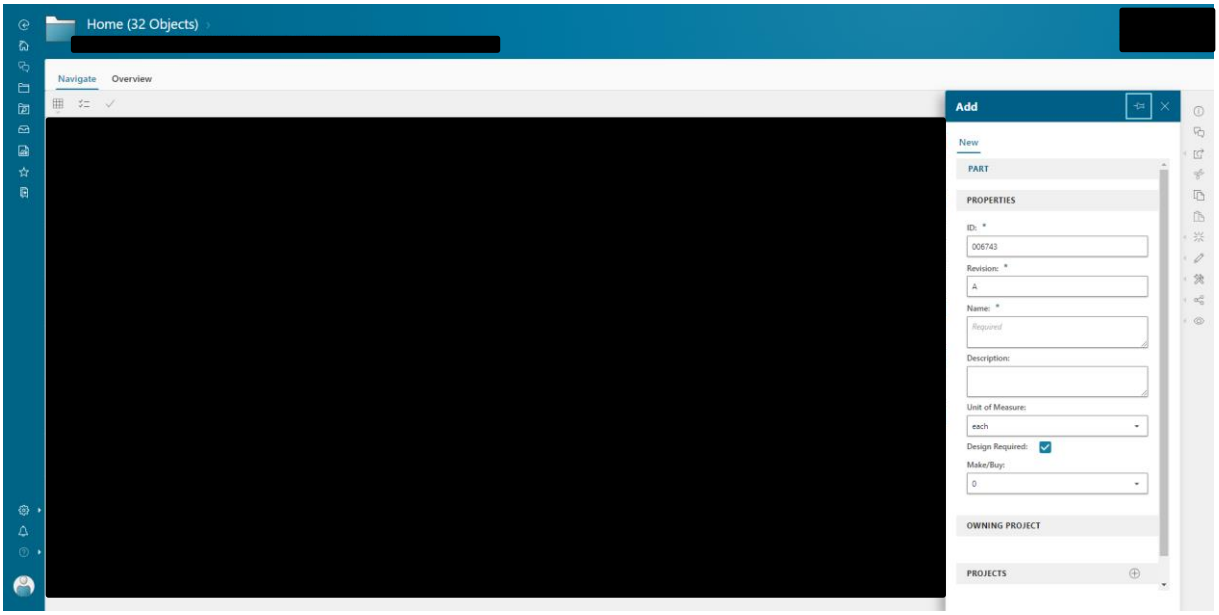

Figure 6.3: Creating new CAD file

In this module, users can create new design documents and include essential information such as the Design ID, Name, Description, and Title for each design. By providing these details during the creation process, users can effectively organize and categorize their designs, making it easier to track, reference, and manage the designs within the system. This feature streamlines the design documentation process, ensuring that all crucial information is captured and stored appropriately for future use and review.

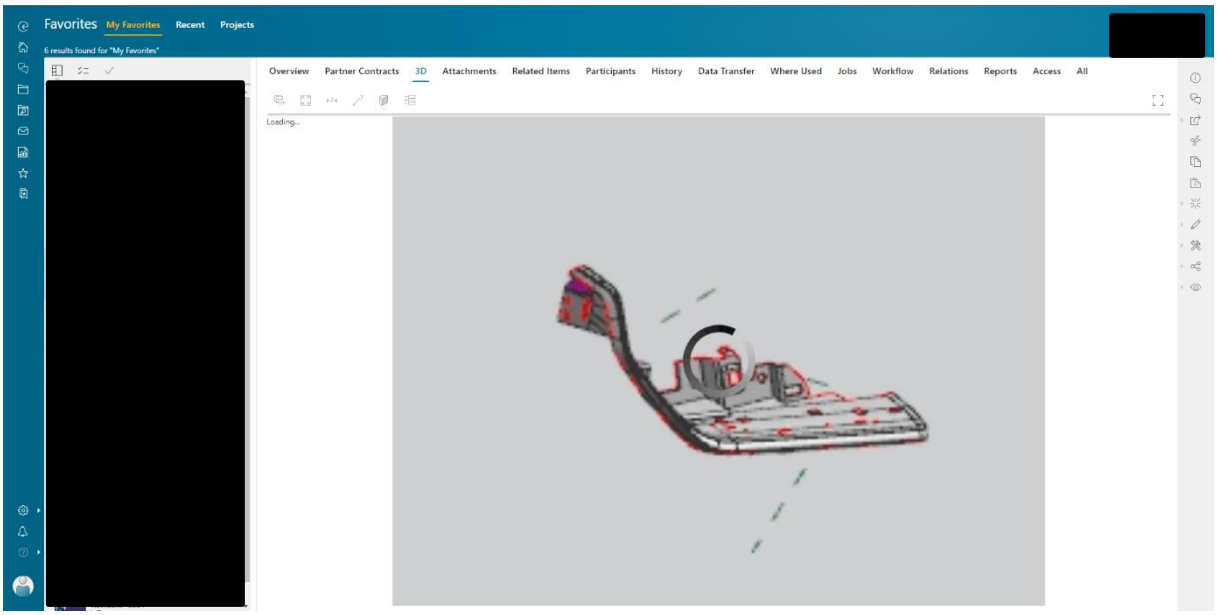

Figure 6.4: Creating New Design

In this module, the designer has the advantage of using AutoCAD, which is seamlessly integrated with the application. AutoCAD is a powerful computer-aided design (CAD) software that enables the designer to create detailed and precise product designs based on specific requirements. With the integration, the designer can directly access AutoCAD's robust features and tools within the application, making the design process more efficient and seamless. This integration allows for real-time collaboration and data exchange between the application and AutoCAD, ensuring that the final product design meets the desired specifications and standards. The use of AutoCAD enhances the designer's capabilities and contributes to the overall effectiveness and accuracy of the design process.

Quality Assurance

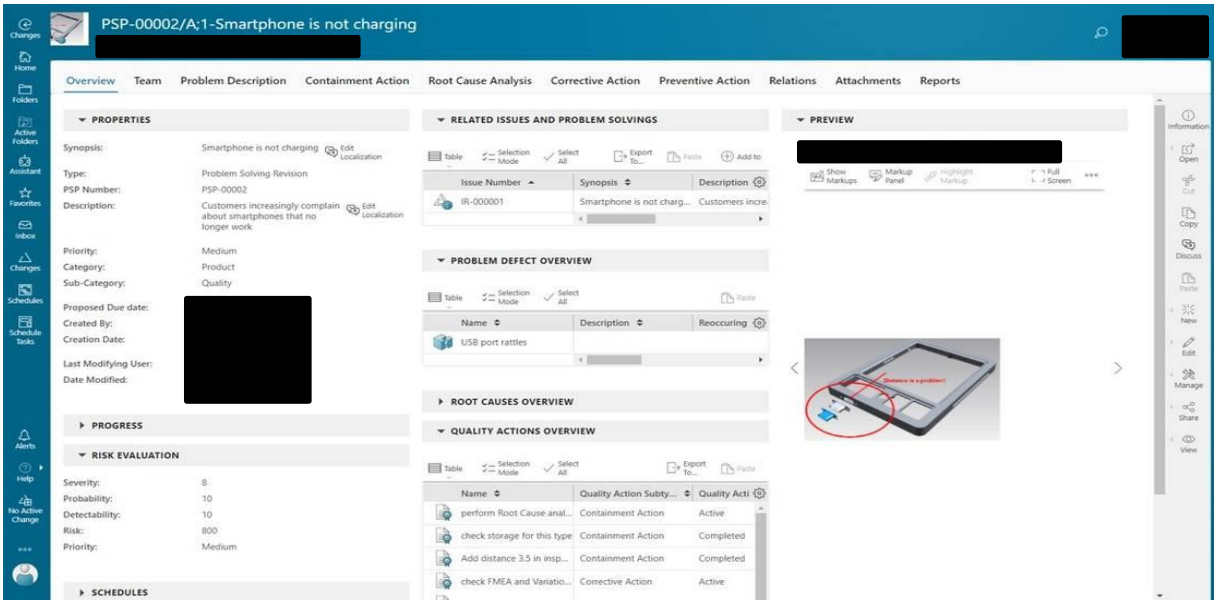

Figure 6.5: Quality Assurance

In this module, users have access to a comprehensive overview of the design process. They can view the properties of the design, track its progress, evaluate associated risks, review the schedule and related issues, examine problem-solving approaches and defect overview, analyse root causes, monitor quality actions, and preview the design itself.

Reporting and Analytics

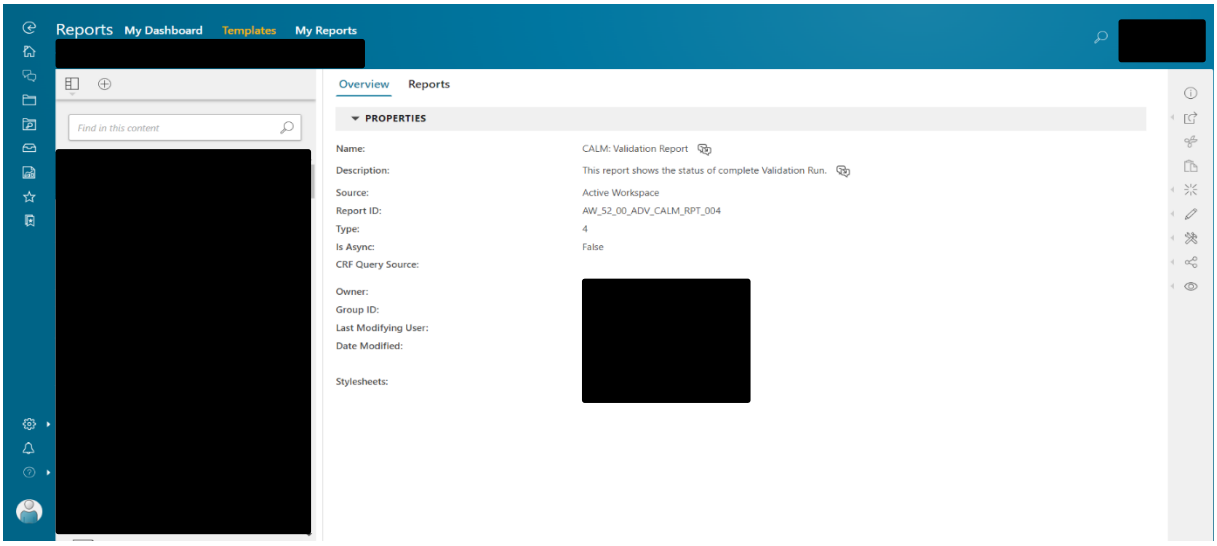

Figure 6.6: Report Overview

In this module, users are provided with the functionality to view a report overview, giving them a concise summary of the available reports. Additionally, users can access and review all the reports in detail. The report overview offers a quick glance at the contents and key insights of each report, allowing users to decide which specific report they want to explore further. By providing access to all the reports, this module facilitates comprehensive data analysis and informed decision-making, empowering users to gain valuable insights from the collected information.

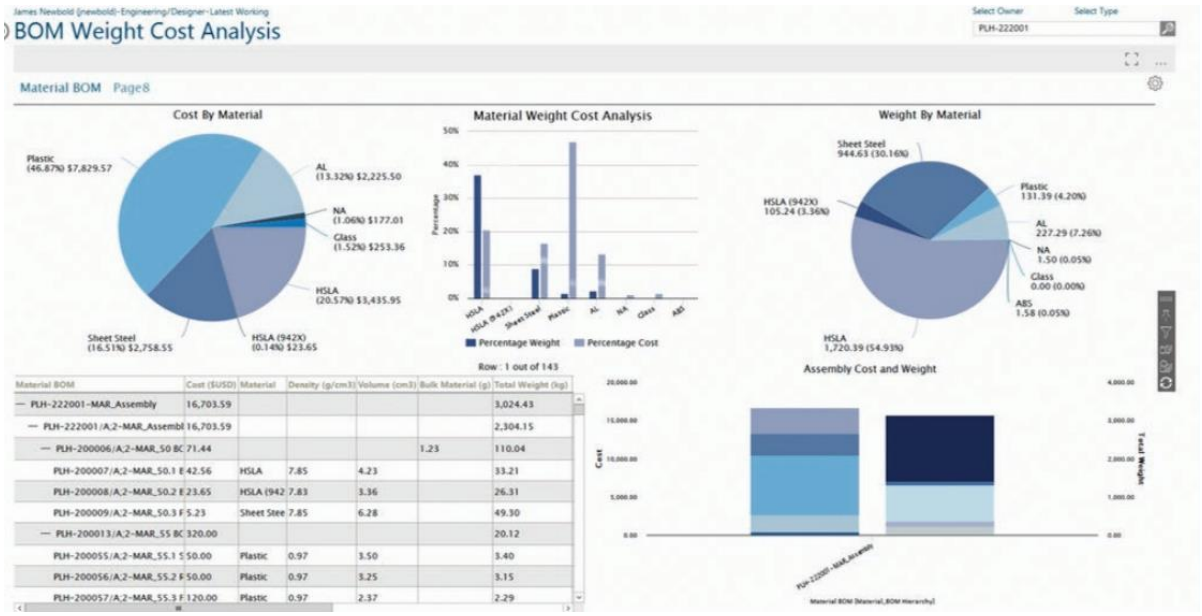

Figure 6.7: Analytics example

In this module, users have access to a detailed analysis of the cost of materials, which includes a comprehensive breakdown of the individual costs of each material used in the design. Additionally, the module provides a material weight cost analysis, enabling users to compare the cost implications of different materials based on their weights. Moreover, users can view the weight distribution of each material in the design through the "Weight by Material" feature, facilitating insights into the overall composition. This comprehensive information empowers users to make cost-effective and optimized material decisions during the design process, ultimately leading to more efficient and economically viable outcomes.

CHAPTER 7
SOFTWARE TESTING

Software testing is done to see if the system's actual result matches the expected result and to make sure the system is free of flaws. This activity is critical in ensuring that the client receives defect-free software. To accomplish this, the developed software is run, and the system's functionality is tested. This aids in the detection of code errors and bugs, as well as filling in the gaps between missing functionalities.

Test Cases

Test cases define the set of conditions that a tester will use to determine whether a system under test meets the requirements and functions correctly. The Test Case Template contains the following information: Test Case ID, Test Case Summary, Sample Input, Expected Output, and System Performance Remarks. Unit testing is the process of testing each module of a system to ensure that it functions properly. Each core unit of the system is validated by testing individual units or components of the modules. Unit testing is done during the development phase, and it isolates the code section and verifies its correctness. After each unit of the system has been combined and tested as a group, integration testing is performed. This is done to expose any defects in the interfaces and to determine whether the system's components are properly integrated.

7.1 Unit Testing

Unit testing examines a single aspect of the application's logic. A unit test does not test how the code interacts with dependencies or infrastructure, nor does it test the framework in which the code is written; it should be assumed that it works, or if it does not, a bug should be filed, and a workaround coded. The entire unit test is run in the process and memory. It has no network, file system, or database communication. Individual developers write code, and unit tests are used to test it.

Individual software development processes, such as functions, methods, or classes, are tested separately as part of the core practise known as unit testing. Unit testing's main objective is to evaluate a particular piece of code's functionality and accuracy, without reference to infrastructure or other dependencies.

Module 1: Document Management

Table 7.1: Testing the module Document Management

Test Case ID	Description	Input	Expected Output	Actual Output	Remarks
DM-TC-001	Document Creation - Valid details	Document details (title, author, version)	New document is created with provided details	New document created successfully	Pass
DM-TC-002	Document Creation - Missing information	Incomplete document details	Appropriate error message is displayed	Error message displayed as expected	Pass
DM-TC-003	Document Creation - Unique ID	N/A	Document ID is unique for each created document	Document ID is unique as expected	Pass
DM-TC-004	Document Creation - Storage	N/A	Document is stored in the Document Repository	Document stored in the Repository as expected	Pass
DM-TC-005	Document Editing - Valid details	Existing document ID, updated details	Document details are updated and saved	Document details updated successfully	Pass
DM-TC-006	Document Editing - Non-existent document	Non-existent document ID	Appropriate error message is displayed	Error message displayed as expected	Pass
DM-TC-007	Document Editing - Individual attributes	Existing document ID, updated attribute	Specific document attribute is updated	Attribute updated successfully	Pass

An overview of the test cases performed for the "Document Management" module in the unique PLM application is provided in Table 7.1. Test case IDs, descriptions, inputs, actual outputs, expected outputs, and notes are all listed in the table. The tests cover a range of situations, including the creation of new documents with valid and missing information, the maintenance of distinctive document IDs, the verification of successful document storage in the Document Repository, and the editing of documents with valid and non-existent IDs. All test cases succeeded, demonstrating that the Document Management module performs as intended and successfully manages various circumstances.

Module 2: CAD Integration

Table 7.2: Testing the module CAD Integration

Test Case ID	Description	Input	Expected Output	Actual Output	Remarks
CAD-TC-001	CAD Import - Valid CAD file	CAD file in supported format	CAD file is successfully imported	CAD file imported successfully	Pass
CAD-TC-002	CAD Import - Invalid CAD file	CAD file in unsupported format	Appropriate error message is displayed	Error message displayed as expected	Fail
CAD-TC-002	CAD Import - Invalid CAD file	CAD file in unsupported format	Appropriate error message is displayed	Error message displayed as expected	Pass
CAD-TC-003	CAD Import - Metadata Update	Updated CAD file metadata	CAD file metadata is updated	Metadata updated successfully	Pass

The test cases run for the "CAD Integration" module in the custom PLM application are listed in Table 7.2. It contains test case IDs, summaries, details, inputs, anticipated results, actual results, and notes. To ensure that unsupported formats generate the correct error messages, the tests involve importing CAD files in both valid and unsupported formats. The table also addresses validating successful modifications and updating CAD file metadata. The fact that the other test cases (CAD-TC-001 and CAD-TC-003) passed while one (CAD-TC-002) failed owing to an unsupported CAD file format shows that the CAD Integration module is capable of handling CAD imports and metadata modifications.

Module 3: Quality Assurance

Table 7.3: Testing the module Quality Assurance

Test Case ID	Description	Input	Expected Output	Actual Output	Remarks
QA-TC-001	Inspection Creation	Inspection details	New inspection is created	Inspection created successfully	Pass
QA-TC-002	Audit Creation	Audit details	New audit is created	Audit created successfully	Fail
QA-TC-003	Inspection Results	Inspection findings and results	Inspection results are recorded	Results recorded successfully	Pass
QA-TC-004	Audit Creation	Audit details	New audit is created	Audit created successfully	Pass

The test cases for the "Quality Assurance" module of the custom PLM application are shown in Table 7.3. Test case IDs, descriptions, inputs, actual outputs, expected outputs, and notes are all listed in the table. The tests entail developing inspections and audits, documenting inspection outcomes, and confirming their effective execution. Test case QA-TC-002 first failed because of a problem with the formation of the audit, but it was later fixed (QA-TC-004) and passed. The remaining test cases (QA-TC-001, QA-TC-003) were productive, showing that the Quality Assurance module carries out inspection and result recording operations as intended.

Module 4: Report and Analytics

Table 7.4: Testing the module Report and Analytics

Test Case ID	Description	Input	Expected Output	Actual Output	Remarks
RA-TC-001	Report Generation	Report criteria and parameters	Report is generated and displayed	Report generated successfully	Fail

RA-TC-002	Report Generation	Report criteria and parameters	Report is generated and displayed	Report generated successfully	Pass
RA-TC-002	Data Extraction	Data extraction parameters	Relevant data is extracted and available	Data extracted successfully	Pass
RA-TC-003	Analysis and Visualization	Analysed data and visualization parameters	Analysis and visualization are generated	Analysis and visualization successful	Pass

The test scenarios for the "Report and Analytics" module of the custom PLM application are shown in Table 7.4. Test case IDs, descriptions, inputs, actual outputs, expected outputs, and notes are all listed in the table. Successful demonstrations of report production, data extraction, analysis, and visualisation features may be found in test cases RA-TC-002, RA-TC-003, and others. However, test case RA-TC-001 succeeded after being corrected (RA-TC-002) after first failing owing to a problem with report production. Overall, the module successfully completes its intended tasks by handling report production, data extraction, analysis, and visualisation.

7.2 Integration Testing:

Integration testing provides a different insight for testing the project because in this testing type here the individual component is not tested testing is between a combination of modules or products. The purpose of the integration testing provides the exposure about the faults in the system and interaction between integrated units Table. Integration testing is mostly used to find errors or problems that could occur when merging several units or modules. It seeks to find any flaws in the data transfer, interactions, or interfaces between integrated devices. You may learn more about how well the components work together and whether they combine to provide the desired results by doing integration testing.

Table 7.5: Integration Testing of Custom Application for PLM

Test Case ID	Description	Input	Expected Output	Actual Output	Remarks
TC-001	Login Validation	Valid username, password	Successful login	Successful login	Pass
TC-002	Login Validation	Invalid username	Error message	Error message displayed	Pass
TC-003	Login Validation	Invalid password	Error message	Error message displayed	Fail
TC-004	Login Validation	Invalid password	Error message	Error message displayed	Pass
TC-005	Form Submission	Complete form data	Form submitted successfully	Form submitted	Pass
TC-006	Form Submission	Incomplete form data	Error message	Error message displayed	Pass
TC-007	Data Retrieval	Valid search criteria	Relevant data retrieved	Relevant data retrieved	Fail
TC-008	Data Retrieval	Valid search criteria	Relevant data retrieved	Relevant data retrieved	Pass
TC-009	Data Retrieval	Invalid search criteria	Empty result set	Empty result set	Pass
TC-010	Payment Processing	Valid credit card details	Payment successful	Payment successful	Pass
TC-011	Payment Processing	Expired credit card	Error message	Error message displayed	Fail
TC-012	Payment Processing	Expired credit card	Error message	Error message displayed	Pass

The integration testing outcomes for the PLM-specific custom application are shown in Table 7.5. The features tested include login verification, form submission, data retrieval, and payment processing. The application is shown to be resilient in handling valid inputs, form submissions, data retrieval, and successful payment processing in test cases TC-001, TC-002, TC-004, TC-005, TC-006, TC-008, TC-009, and TC-010. However, test cases TC-003 and TC-011 originally failed because of problems with incorrect password and, separately, incorrect credit card inputs. Later, the problems were fixed (TC-012), and the tests were successful. The entire integration test verifies the app's efficiency and functionality in addressing different scenarios.

7.3 System Testing

System testing is a level of testing that validates a complete and fully integrated software product. The purpose of this kind of system testing is always to evaluate the end-to-end system specifications of the project and provide the results for the same. A crucial stage of testing that ensures a fully integrated software solution is legitimate is system testing. System testing analyses how well modules, components, and external dependencies are integrated. By replicating real-world circumstances, it tests end-to-end functioning. To maintain system stability, it is important to spot flaws, errors, and inconsistencies. System testing reduces hazards and raises the standard of the system. It is essential for providing end customers with a trustworthy software solution.

Table 7.6: System Testing of Custom Application for PLM

Test Case ID	Description	Input	Expected Output	Actual Output	Remarks
ST-TC-001	Login functionality	Valid username and password	Successful login	User is logged in successfully	Pass
ST-TC-002	User Registration	User registration details	New user is successfully registered	User registration is successful	Fail
ST-TC-003	User Registration	User registration details	New user is successfully registered	User registration is successful	Pass

ST-TC-004	Access Control	User roles and permissions	Users can access authorized functionalities	Access control is properly enforced	Pass
ST-TC-005	User Interface Navigation	Clicking on menu items and links	Navigating to the respective pages and modules	User can navigate as expected	Fail
ST-TC-006	User Interface Navigation	Clicking on menu items and links	Navigating to the respective pages and modules	User can navigate as expected	Pass
ST-TC-007	Data Validation	Entering valid and invalid data	Valid data is accepted, invalid data is rejected	Data validation is functioning correctly	Pass
ST-TC-008	Error Handling	Triggering known and unknown errors	Appropriate error messages are displayed	Errors are handled gracefully as expected	Pass
ST-TC-009	System Integration	Integration with external systems or APIs	Successful communication and data exchange	System integration is successful	Fail
ST-TC-010	System Integration	Integration with external systems or APIs	Successful communication and data exchange	System integration is successful	Pass
ST-TC-011	Performance and Scalability	Load testing scenarios and stress testing	System performance meets defined criteria	System performs well under expected loads	Pass
ST-TC-012	User Acceptance Testing (UAT)	End-users testing the system	System meets user requirements and expectations	Feedback from users is positive	Fail

ST-TC-013	User Acceptance Testing (UAT)	End-users testing the system	System meets user requirements and expectations	Feedback from users is positive	Pass
ST-TC-014	Report Generation and Analytics	Generating reports and analysing data	Accurate reports and insightful analytics	Reports and analytics are as expected	Pass

The system testing findings for the PLM-specific custom application are shown in Table 7.6. The test cases include a wide range of features, such as user authentication, user registration, access control, user interface navigation, data validation, error handling, system integration, performance, scalability, user acceptability testing (UAT), and report creation. Successful completion of test cases ST-TC-001, ST-TC-003, ST-TC-004, ST-TC-006, ST-TC-007, ST-TC-008, ST-TC-010, ST-TC-011, ST-TC-013, and ST-TC-014 shows the application's ability to carry out tasks like login, user registration, access control enforcement, user interface navigation, data validation, error handling, system integration, performance, scalability, UAT, and report generation. However, due to problems with user registration and system integration, test cases ST-TC-002 and ST-TC-009 originally failed. The tests passed once these problems (ST-TC-003 and ST-TC-010) were fixed. Due to user interface navigational difficulties, test case ST-TC-005 initially failed, but was later fixed (ST-TC-006), leading to a successful test. User acceptance testing test case ST-TC-012 initially failed because it did not satisfy all user requirements, however it was later corrected (ST-TC-013) with favourable user input. The application's functionality and usability are confirmed by the overall system testing, with the majority of test cases passing satisfactorily after correcting the first problems.

CHAPTER 8
CONCLUSION

Creating a customised PLM application to manage the product lifecycle for a manufacturing company has a big impact and solve complicated problems with product development. The emphasis on the engineering, computer-aided design (CAD), and product lifecycle management (PLM) domains enables thorough administration of product data, procedures, and communication throughout the whole product lifetime.

The custom PLM application will efficiently simplify and automate numerous product-related activities by incorporating modules like, Document Management, CAD Integration, Quality Assurance and Report & Analytics. This may result in more cooperation between various teams and stakeholders as well as increased productivity and better data management.

The results of the custom application will be adapted to the organization's particular aims and objectives. The Document Management module empowers users to efficiently manage product-related documents. From creation to modification and version control, the module ensures secure storage and easy accessibility. By implementing access control and robust search functionalities, collaboration among teams is enhanced, resulting in increased productivity and better data management. The CAD Integration module seamlessly integrates the PLM application with CAD software, enabling smooth import, conversion, and visualization of CAD data. This synchronization fosters collaboration between design teams and ensures accuracy in product design and development. By facilitating a cohesive interface with CAD applications, the module promotes innovation, reduces errors, and expedites design processes. The Quality Assurance module focuses on maintaining product quality through inspections, audits, and non-conformance control. The module records test results, facilitates compliance tracking, and identifies quality issues promptly. By prioritizing product quality, the module enhances customer satisfaction and fosters a culture of continuous improvement within the organization. Lastly, the Report & Analytics module empowers users to gain insights through the generation of comprehensive reports and visualizations. Customizable report templates cater to specific needs, while data aggregation and visualization tools aid in analysing product data effectively. These reports support decision-making, process improvement, and strategic planning, contributing to enhanced product development and overall business success.

CHAPTER 9
FUTURE ENHANCEMENT

There are several potential future improvements that the unique PLM application may receive. These improvements strive to meet the changing requirements of organisations and users while enhancing the application's functionality, usability, and effectiveness.

The PLM application might benefit from the incorporation of cutting-edge technology like artificial intelligence (AI) and machine learning (ML). Intelligent document categorization and automated quality assurance checks are only two examples of procedures that may be optimised and automated using AI and ML. This would decrease human labour requirements, boost accuracy, and boost effectiveness all around.

Integration of Internet of Things (IoT) capabilities into the PLM application is yet another improvement that may be made. Organisations may discover important information about the functionality of products, consumer preferences, and use trends by connecting and gathering data from IoT devices embedded in products. Making data-driven decisions and driving product enhancements may both benefit from this knowledge.

Furthermore, improving the application's flexibility and scalability may prove to be a worthwhile future improvement. This involves making sure the programme can manage increasing volumes of data and the expanding expectations of users. Additionally, by allowing for customization choices and extensibility via a modular design, businesses may modify the programme to suit their own processes and needs.

In conclusion, future improvements to the unique PLM application may concentrate on scalability and flexibility while integrating cutting-edge technologies like AI, ML, and IoT. Organisations may promote innovation and success in their efforts to manage the product lifecycle by embracing these developments because they can unleash new capabilities, streamline procedures, acquire deeper insights, and more.

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9	54	A
SIMILARITY %	MATCHED SOURCES	GRADE

A-Satisfactory (0-10%)
B-Upgrade (11-40%)
C-Poor (41-60%)
D-Unacceptable (61-100%)

LOCATION	MATCHED DOMAIN	%	SOURCE TYPE
1	Submitted to Visvesvaraya Technological University, Belagavi	1	Student Paper
2	www.aras.com	<1	Internet Data
3	Animal welfare aspects of husbandry systems for farmed Atlantic salmon - Scienti by -2008	<1	Publication
4	qdoc.tips	<1	Internet Data
5	egyankosh.ac.in	<1	Publication
6	Submitted to Visvesvaraya Technological University, Belagavi	<1	Student Paper
7	qdoc.tips	<1	Internet Data
8	REPOSITORY - Submitted to P.E.S. College of Engineering Mandya on 2023-07-21 11-19	<1	Student Paper
9	Rheologicalthermal properties of poly(ethylene terephthalate) modified by chain by Dolatshah-2020	<1	Publication
10	Submitted to Visvesvaraya Technological University, Belagavi	<1	Student Paper
11	www.opm.gov	<1	Publication
12	Submitted to Visvesvaraya Technological University, Belagavi	<1	Student Paper
13	On the future of Internet management technologies by Schonwalder-2003	<1	Publication