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REVIEW ON DESIGN AUTOMATION FOR 2-STAGE GEARBOX USING VB ENVIROMENT IN CATIA

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Abstract

This report explores the application of automation technologies in the design and modeling of mechanical products, focusing on gearboxes, to reduce design time and improve efficiency in the competitive market. The report emphasizes the importance of minimizing the time-to-market for products by leveraging parametric modeling and knowledge-based approaches. It highlights the role of CATIA software in automating the design process, particularly in gearbox assembly, and integrates it with Visual Basic (VB) for user interface development. A comprehensive review of existing literature reveals several advancements in automation and optimization techniques, including the use of VBA, parametric CAD-based evolutionary algorithms, and knowledge-based engineering (KBE) to enhance productivity, reduce errors, and optimize performance. Case studies such as the design and topology optimization of a two-stage gearbox for BAJA SAE INDIA and the development of automated gear modeling systems using CATIA V5 further illustrate the effectiveness of these methods in streamlining the design process. The findings demonstrate significant reductions in design time, enhanced accuracy, and cost-effective solutions, offering valuable insights into improving engineering workflows for industrial applications.

Keywords - Gearbox Design, VBA Automation, CAD, Catia GUI Macros, Design Parametric modeling, Two stage spur gearbox

Introduction

Automation technologies are great fit for design tasks that involve exacting requirements and manufacturing. Current scenario of the market is competitive. To sustain in the market for company product time to the market have to be minimum. Companies existing product demands from the customer are to be provided quickly as soon as possible. Existing product requirement has same parametric features of components for different specification. Design and modeling time of the product is generally 60-70% of overall time of the product development. Design phase has lot of potential where time can be saved. Parametric modeling can be used for saving the modeling time. Knowledge based approach can be useful for saving the design time. Lot of repetitive calculations can be saving for avoiding tedious work. CATIA software is selected having strong parameterization. Mechanical product selected is gearbox. Gearbox manufactured by many companies across the world. System has to define for the automatic design, modeling and assembly of gearbox. Process is implemented for assembly of gearbox. User interface is developed with VB environment.

Literature Review

Aamani and Valaramathi (2018) [1] investigated an automated gear modeling system developed using CATIA V5 and VBA, leveraging Knowledge-Based Engineering (KBE) to optimize the design process. It focuses on reducing manual effort and errors by automating the creation of 3D CAD models for various gear types, including spur, bevel, and worm gears. The system integrates analytical and simulation capabilities, performing static and thermal analyses in ANSYS, with results validated against theoretical calculations. This approach significantly reduces design time by 90%, enhances accuracy, and provides an efficient solution to bridge the gap between design engineers and computational experts.

Balzerkiewitz and Stechert (2023) [2] developed a methodology to automate the conversion of VR-generated surface models into CAD-usable solid models. Their approach utilizes VBA and CATIA V5 to classify geometries from OBJ files and create parameterized models through automated routines. Tested on use cases like cable and tube routing, the approach significantly reduces manual effort and enhances data integration between VR and CAD systems. Challenges with complex geometries and data sorting suggest potential for improvements using AI-based classification and advanced programming tools. This innovation offers notable time and cost savings in product design workflows.

Jadeja et al. (2014) [3] focused on enhancing the design process of mechanical components through automation. They explored the development of a GUI-based design software using Visual Basic, integrated with CREO for modeling and analysis. Using an unprotected flange coupling as a case study, the research highlights the systematic methodology for input and output parameter integration via Excel, enabling efficient 3D parametric modeling. This tailored approach addresses industrial challenges, enhancing productivity, and knowledge retention.

König et al. (2004) [4] investigated evolutionary design optimization using CATIA V5. They introduced two approaches: parametric CAD-based evolutionary algorithms (EAs) for parameter optimization and CAD-feature-based EAs for structural optimization. These methods are demonstrated through applications like optimizing a race car rim and a fuel cell end plate, achieving notable improvements in weight reduction and stiffness. The CAD-feature-driven EA outperforms traditional methods, such as simulated annealing, showcasing its potential for tackling complex, constrained engineering optimization problems.

Menavlikar et al. (2019) [5] focused on the design and topology optimization of a two-stage gearbox for all-terrain vehicles used in BAJA SAE INDIA competitions. The gearbox is designed for compactness, lightweight construction, and durability. Using SAE 8620 for gears and 6061-T6 aluminum for the casing, finite element analysis (FEA) validated its performance under harsh conditions. Topology optimization with Hypermesh reduced the gearbox weight by 16.3%, enhancing acceleration by 15%. The design replaces conventional differential units with locked axles, optimizing maneuverability in rugged terrains while ensuring cost efficiency and competitive performance.

Ramamurti et al. (1997) [6] presented a comprehensive design methodology for two-stage gearboxes. It integrates classical design principles with finite-element analysis (FEM) to calculate key parameters like gear specifications, shaft dimensions, and housing stresses. The study emphasizes the comparison of stresses and deflections obtained through classical and FEM methods, highlighting their alignment. It also incorporates dynamic and vibration analysis to refine the design. Overall, the work offers a user-friendly, knowledge-based expert system to simplify and optimize gearbox design.

Torres et al. (2013) [7] proposed a method to integrate product conceptual design information into commercial CAD systems, addressing the lack of interoperability between early design-stage tools and CAD systems. It combines techniques like Quality Function Deployment (QFD), Axiomatic Design (AD), and Failure Mode and Effects Analysis (FMEA) to create a continuous information flow. Using MOKA forms, it captures and integrates customer needs, functional requirements, and design parameters. A prototype application developed for CATIA V5 demonstrates improved traceability and automation, facilitating seamless transitions from conceptual to detailed design phases.

Research Gap

Although recent advancements have streamlined CAD modeling and optimization, significant gaps persist in fully automating and integrating the design process. Current systems often rely on rule-based programming, lacking advanced AI for robust classification of complex geometries, and suffer from limited interoperability between conceptual, parametric, and detailed design stages. Additionally, there is a need for unified frameworks that seamlessly incorporate real-time simulation feedback across various platforms, along with enhanced user interfaces that facilitate knowledge capture and adaptability.

Conclusion

The reviewed studies highlight advancements in CAD automation, optimization, and integration, emphasizing improved productivity, reduced costs, and enhanced design efficiency. They demonstrate the use of tools like VBA, CATIA V5, and MOKA to automate workflows, optimize performance through parametric and topology methods, and bridge gaps between design stages. These innovations cater to industrial needs by reducing errors, improving accuracy, and streamlining data integration, offering tailored solutions for diverse engineering challenges. Together, they showcase the growing role of computational tools in transforming design processes.

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