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KNOWLEDGE-BASED PARAMETRIC MODELING FOR MECHANICAL COMPONENTS

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ABSTRACT

Knowledge-Based Parametric Modeling plays an important role in modern manufacturing industries by reducing design time, improving flexibility, and supporting mass customization. Traditional CAD modeling methods require repeated manual modifications whenever component dimensions or operating conditions change, which increases design complexity and development time. To overcome these limitations, this project presents the development of a Knowledge-Based System (KBS) for parametric modeling of mechanical components such as fasteners and bearings. The system integrates design knowledge, database management, and CAD automation to generate accurate three-dimensional component models automatically based on user requirements. The developed KBS uses Visual Basic as the graphical user interface, MS Access as the database management system, and SolidWorks as the CAD modeling software. Macros are created in SolidWorks to automate the generation of CAD models for bolts, nuts, and bearings. The user provides design parameters such as dimensions, loads, speed, and expected life through the GUI, and the system retrieves the required data from the database to generate the corresponding component model automatically. The project also includes bearing selection based on standard design equations and loading conditions. The developed system successfully supports multiple types of bolts, nuts, and bearings under different loading conditions. The proposed KBS reduces manual calculations, minimizes design modification time, improves modeling accuracy, and enhances productivity. The project demonstrates that integrating Knowledge-Based Systems with Parametric Modeling and CAD automation significantly improves intelligent mechanical component design and supports rapid product development in manufacturing industries.

KEYWORDS : Knowledge-Based System, Parametric Modeling, CAD Automation, SolidWorks, Mechanical Components, Fasteners, Bearings, Visual Basic, Database Management, Macro Programming.

I.INTRODUCTION

Knowledge-Based Parametric Modeling is an advanced design approach used in modern manufacturing industries to improve product development efficiency and reduce design time. Traditional CAD systems require repeated manual modifications whenever dimensions or operating conditions change, which increases complexity and reduces productivity. To overcome these limitations, this project presents the development of a Knowledge-Based System (KBS) for the parametric modeling of mechanical components such as fasteners and bearings [1][2]. The developed system integrates design knowledge, database management, and CAD automation techniques to automatically generate accurate three-dimensional component models based on user requirements [3]. The project uses Visual Basic for the graphical user interface, MS Access for database management, and SolidWorks for CAD modeling and macro programming [4]. By using parametric modeling techniques, dimensions and geometric constraints can be modified automatically without redesigning the complete component. The developed system reduces manual calculations, improves design accuracy, and supports rapid product customization in manufacturing industries [5][6].

A Knowledge-Based System consists of important components such as the user interface, inference engine, knowledge base, knowledge engineer, and domain expert [7]. In this project, the user enters design requirements such as dimensions, loading conditions, and operating parameters through the graphical user interface. The inference engine processes the information using rules and data stored in the knowledge base and automatically generates the required CAD model [8]. The project mainly focuses on automating the design and modeling of bolts, nuts, and bearings using SolidWorks macros and database integration [9]. Separate macros are developed for different mechanical components, and these macros retrieve the required dimensions from the database to generate the corresponding CAD model automatically [10]. The bearing selection module is designed based on standard engineering calculations involving radial load, axial load, speed, and expected life [11].

The developed KBS improves flexibility, reduces repetitive work, minimizes design modification time, and increases productivity in mechanical component design applications [12][13].

The methodology adopted in this project follows the Knowledge-Based System development lifecycle, which includes project initialization, system analysis and design, rapid prototyping, system development, and implementation [14]. The project uses iterative prototyping methods to continuously improve the system based on testing and user feedback [15]. The developed system successfully supports different types of bolts, nuts, and bearings under various loading conditions and industrial standards [16]. One of the major advantages of the project is its ability to support mass customization and rapid product development in modern manufacturing industries [17]. The generated CAD models are dimension specific and can be modified automatically by changing the design parameters in the database [18]. The project also demonstrates the effective integration of artificial intelligence concepts with CAD automation and database technologies [19]. Overall, the developed KBS provides an intelligent and efficient solution for mechanical component modeling, reduces design complexity, improves modeling accuracy, and enhances manufacturing productivity and flexibility [20].

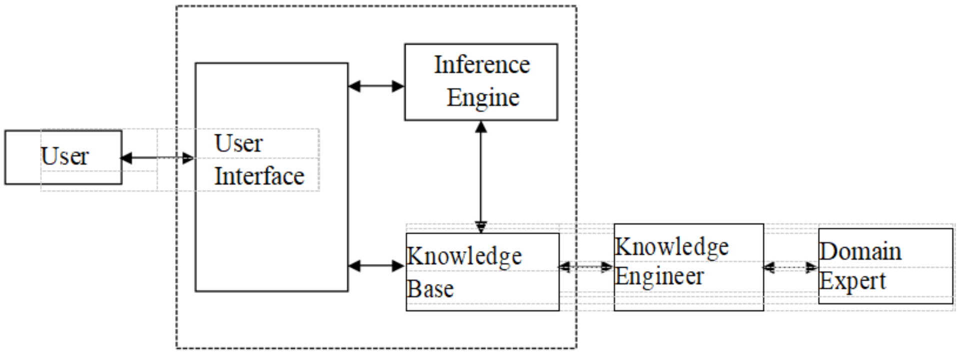

Fig1: Knowledge based system architecture

The above figure represents the architecture of a Knowledge-Based System (KBS) used for intelligent decision making and automated design processes. The system mainly consists of six important components: User, User Interface, Inference Engine, Knowledge Base, Knowledge Engineer, and Domain Expert. The user interacts with the system through the User Interface, which acts as a communication medium between the user and the Knowledge-Based System. The user enters the required design parameters, loading conditions, or problem details through this interface. The Inference Engine is the processing unit of the system, which analyzes the given inputs and applies logical rules to generate solutions or decisions. The Knowledge Base stores all engineering rules, formulas, design constraints, standards, and expert knowledge required for problem solving. The Knowledge Engineer is responsible for collecting and organizing knowledge into the system, while the Domain Expert provides technical expertise and industrial knowledge related to the application area. The arrows in the diagram indicate the flow of information between different components. This architecture enables the system to automate design calculations, support intelligent reasoning, reduce manual effort, and improve the efficiency of parametric modeling and CAD automation processes.

II SURVEY OF RESEARCH

1. Sehyun Myung and Soonhung Han proposed a knowledge-based parametric design system for mechanical products using configuration design methods. Their research mainly focused on integrating knowledge-based systems with CAD software to automate mechanical component design processes. The developed system was capable of generating different product models automatically based on user-defined parameters and design constraints. The authors used parametric modeling techniques to reduce repetitive manual design modifications and improve design flexibility. Their work demonstrated that knowledge-based parametric systems can significantly reduce design time and increase modeling accuracy in manufacturing industries. The study also emphasized the importance of feature-based modeling and intelligent rule integration for rapid product development. The proposed system proved effective in supporting product customization and automatic design updates whenever parameter values changed. Their research became an important foundation for developing intelligent CAD systems and automated modeling techniques for mechanical engineering applications [1][2].

2. P. H. Speel, A. Th. Schreiber, and G. Van Heijst conducted research on conceptual modeling for Knowledge-Based Systems and their applications in engineering design. The study explained the importance of knowledge acquisition, knowledge

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representation, and reasoning mechanisms in developing intelligent systems. The authors highlighted that proper organization of engineering knowledge is essential for building efficient Knowledge-Based Systems capable of solving complex industrial problems. Their research introduced systematic methods for storing expert knowledge in databases so that the system could perform intelligent reasoning automatically. The study also discussed the role of inference engines in analyzing user inputs and generating suitable solutions based on stored knowledge. The developed conceptual framework improved communication between users and intelligent systems and supported better decision making in engineering applications. Their research significantly contributed to the development of automated CAD systems and intelligent design support tools used in manufacturing industries [3][4].

3. Abdulrezak Mohamed and Tahir Celik developed an integrated knowledge-based system for alternative design, material selection, and cost estimation in manufacturing applications. The research focused on combining design automation techniques with engineering databases to improve industrial productivity and reduce development cost. The proposed system allowed users to select suitable materials and component designs automatically based on operating conditions and design requirements. The authors integrated database management systems with CAD tools to improve modeling efficiency and reduce manual calculations. Their research also emphasized the importance of intelligent systems in supporting rapid product development and design optimization. The developed system successfully minimized design errors and improved the overall decision-making process during product development. The study proved that integrating Knowledge-Based Systems with CAD and database technologies provides an effective solution for automated mechanical component design and manufacturing process planning in industrial environments [5][6].

4. Maarten J. G. M. Van Emmerik carried out research on the creation and modification of parametrized solid models using graphical interaction techniques. The study focused on parametric modeling methods used in CAD systems for automatic modification of engineering components. The author explained that parametric modeling enables designers to control dimensions and geometric relationships through parameters and constraints. Whenever dimensions are modified, the CAD model updates automatically without redesigning the component from the beginning. The research highlighted the importance of feature-based modeling approaches for improving flexibility and reducing design time. The proposed methodology also improved design consistency and reduced repetitive manual operations in CAD environments. The study concluded that parametric modeling techniques are highly suitable for mass customization and rapid product development in manufacturing industries. Their work contributed significantly to modern CAD automation systems and intelligent modeling techniques used for mechanical component design applications [7][8].

5. Darin S. Motz and Kamyar Haghighi developed a knowledge-based design model for mechanical components using artificial intelligence and CAD integration techniques. Their research mainly focused on automating engineering calculations and CAD model generation using intelligent systems. The authors integrated Visual Basic, database systems, and CAD software to automate component design processes and improve productivity. The developed system performed design calculations automatically and generated CAD models according to user-defined specifications and operating conditions. Their work reduced manual intervention and minimized errors during component modeling and design modification. The research also highlighted the advantages of integrating engineering databases with CAD software for efficient product development. The proposed knowledge-based model successfully improved design flexibility, reduced design cycle time, and supported intelligent decision making in manufacturing applications. Their study became an important reference for automated CAD modeling and knowledge-based mechanical component design systems [9][10].

6. Dixon and Simmons introduced a Knowledge-Based System for engineering design using a design-evaluate-redesign methodology. Their research explained how intelligent systems can continuously evaluate design parameters and automatically improve component designs through iterative processes. The developed system was implemented for standard V-belt drive design and demonstrated the effectiveness of automated design optimization techniques. The authors emphasized that engineering design is a continuous process requiring repeated analysis and modifications to achieve optimal performance. The system automatically evaluated design constraints, calculated engineering parameters, and suggested suitable modifications whenever design requirements changed. Their work significantly reduced manual calculations and improved the accuracy of engineering designs. The study also demonstrated the importance of inference engines and knowledge bases in supporting intelligent reasoning and automated problem solving. Their research contributed to the development of modern Knowledge-Based CAD systems and automated engineering design methodologies [11][12].

III. WORKING METHODOLOGY

The working methodology of the project "Knowledge-Based Parametric Modeling for Mechanical Components" begins with identifying the requirements for developing an intelligent Knowledge-Based System (KBS) capable of automatically generating CAD models for mechanical components such as bolts, nuts, and bearings. The system is developed to reduce manual calculations, improve modeling efficiency, and support rapid product customization in manufacturing industries. Initially, detailed knowledge regarding component dimensions, empirical proportions, design formulas, and industrial standards is collected from engineering data books, literature reviews, and domain experts [1][2]. The collected knowledge is organized systematically in the knowledge base for supporting intelligent reasoning and automated component generation. The project follows the Knowledge-Based System development lifecycle, which includes project initialization, system analysis and design, rapid prototyping, system development, and implementation. This methodology helps in improving system performance continuously through testing, refinement, and validation processes under different operating conditions and user requirements [3][4].

The second stage of the methodology involves developing the software tools required for implementing the Knowledge-Based System. Visual Basic is used for developing the Graphical User Interface (GUI), MS Access is used for database management, and SolidWorks is used for CAD modeling and macro generation [5]. The GUI acts as an interface between the user and the system, where the user enters design parameters such as bolt dimensions, thread pitch, bearing loads, speed, and expected bearing life. The database stores all standard dimensions, empirical proportions, engineering formulas, and design constraints related to mechanical components [6]. SolidWorks macros are developed for each type of bolt, nut, and bearing to automate CAD model generation. The macros retrieve the required dimensions from the database and generate corresponding three-dimensional CAD models automatically. This integration of GUI, database, and CAD software improves modeling speed, reduces repetitive work, and enhances design flexibility for mechanical component development [7][8].

The final stage of the methodology focuses on design calculations, automated component generation, testing, and validation of the developed Knowledge-Based System. The system performs engineering calculations automatically based on standard formulas and loading conditions. For example, the equivalent load acting on a bearing is calculated using the relation:

$$P = (VxF_r + yF_a)S$$

where P is the equivalent load, V is race rotation factor, Fr is radial load, Fa is axial load, and S is service factor. The bearing life is calculated using the formula:

$$L = \left(\frac{C}{P}\right)^k$$

where L is bearing life, C is dynamic load capacity, and k is bearing constant [9][10]. Based on these calculations, the system selects suitable bearings and generates corresponding CAD models automatically. The developed KBS is tested under different loading conditions and dimensional variations to verify its accuracy, reliability, and performance. The methodology proves that integrating Knowledge-Based Systems with Parametric Modeling and CAD automation significantly improves intelligent mechanical component design and reduces product development time [11][12].

IV RESULTS EXPLANATIONS

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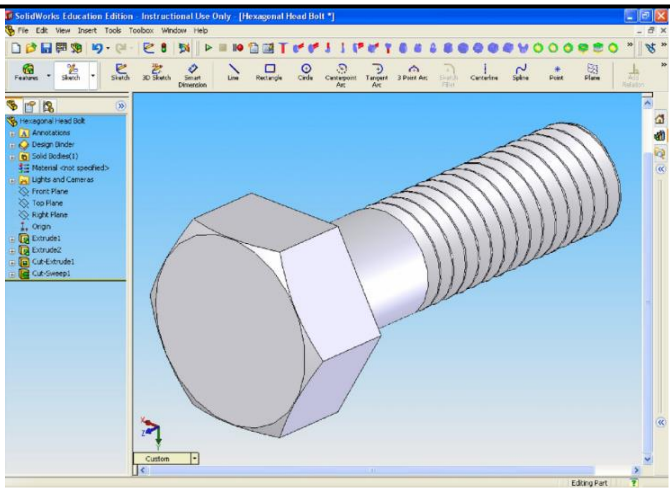

Fig. 2: Modeled Hexagonal Bolt Component

Fig. 2 shows the three-dimensional CAD model of a hexagonal bolt generated using the developed Knowledge-Based System and SolidWorks macro programming. The bolt model is created automatically after the user enters the required dimensions such as bolt diameter, shank length, and thread pitch through the graphical user interface. The generated bolt follows standard engineering proportions and dimensional constraints stored in the knowledge base. The model clearly shows important bolt features such as the hexagonal head, threaded shank, chamfer, and bolt length. The developed system supports both standard and customized bolt dimensions, which helps in reducing manual design effort and repetitive calculations. Parametric modeling enables automatic modification of the bolt geometry whenever the dimensions are changed. This figure demonstrates that the developed KBS successfully automates bolt design and CAD model generation, improving design flexibility, modeling accuracy, and productivity in mechanical component development applications.

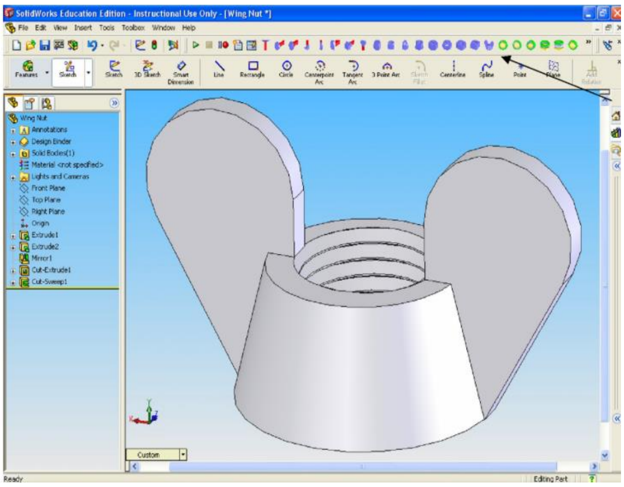

Fig. 3: Modeled Wing Nut Component

Fig. 3 illustrates the automatically generated CAD model of a wing nut developed using SolidWorks and the Knowledge-Based System. The wing nut is modeled based on standard dimensions and empirical proportions stored in the database. The graphical user interface allows the user to select the required nut type and standard size before generating the model automatically. The generated model clearly represents the threaded hole, wing extensions, and overall nut geometry required for easy manual tightening applications. The developed system reduces manual CAD modeling operations and provides quick generation of customized or standard wing nut models. Parametric modeling techniques enable automatic updates in geometry whenever design parameters are modified. The figure proves that integrating database management with SolidWorks macros improves modeling speed and design flexibility. Overall, the developed KBS successfully supports intelligent nut design automation and rapid CAD model generation for manufacturing and assembly applications.

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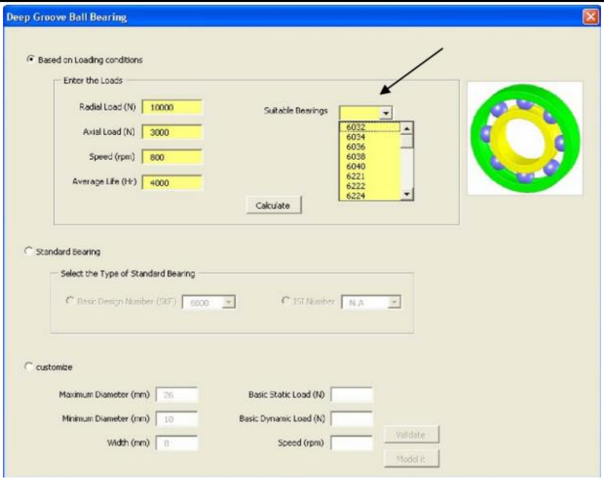

Fig. 4: Suitable Bearings for Loading Conditions

Fig. 4 shows the bearing selection results generated by the Knowledge-Based System based on the entered loading conditions. The system calculates the equivalent load and expected life of the bearing using standard design equations and compares them with standard bearing specifications stored in the database. The user enters parameters such as radial load, axial load, rotational speed, and expected bearing life through the graphical user interface. Based on these inputs, the system identifies suitable bearings capable of supporting the required operating conditions. The figure displays the list of recommended bearings along with corresponding dimensions, load capacities, and bearing specifications. This automated bearing selection process minimizes manual calculations and reduces the possibility of selecting incorrect bearings. The figure demonstrates that the developed KBS effectively supports intelligent decision making, improves design accuracy, and simplifies bearing selection processes in mechanical engineering applications.

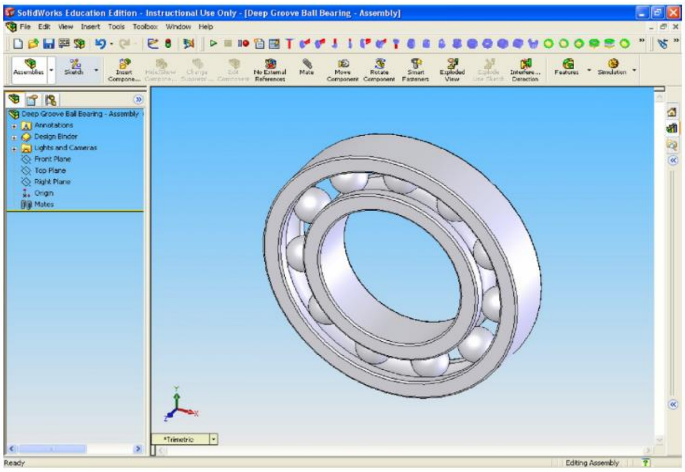

Fig. 5: Modeled Bearing Component

Fig. 5 presents the three-dimensional CAD model of the deep groove ball bearing generated automatically using the developed Knowledge-Based System and SolidWorks macro programming. The model includes important bearing components such as the inner race, outer race, rolling balls, and bearing cage arrangement. The generated bearing geometry is based on standard dimensions and design calculations obtained from the database. The CAD model is automatically created after selecting the suitable bearing according to the loading conditions and expected bearing life. The figure clearly demonstrates the assembly structure and internal arrangement of the rolling elements inside the bearing. Parametric modeling techniques allow automatic generation and modification of the bearing model whenever the design parameters are changed. The developed system significantly reduces modeling time, improves dimensional accuracy, and supports rapid product customization. This figure confirms that the proposed KBS successfully integrates engineering calculations, database systems, and CAD automation for intelligent bearing modeling applications.

V.CONCLUSION

The development of an intelligent Knowledge-Based System for automating the design and modeling of mechanical components such as bolts, nuts, and bearings. The developed system integrates Visual Basic, MS Access, and SolidWorks to perform automatic design calculations, database management, and CAD model generation based on user-defined parameters and loading conditions. The implementation of parametric modeling techniques enabled automatic modification of component geometry whenever design dimensions were changed, thereby reducing repetitive manual operations and improving design flexibility. The developed Knowledge-Based System successfully generated accurate three-dimensional CAD models for different types of fasteners and bearings under various operating conditions. The bearing selection module effectively calculated equivalent loads and bearing life using standard engineering equations and automatically selected suitable bearings from the database. The project also demonstrated the importance of integrating Knowledge-Based Systems with CAD automation and database technologies for supporting intelligent decision making and rapid product customization in manufacturing industries. Overall, the developed system reduced design time, minimized manual calculations, improved modeling accuracy, and enhanced productivity. The project proved that Knowledge-Based Parametric Modeling is an effective approach for intelligent mechanical component design and automated CAD modeling applications.

REFERENCES

[1] S. Myung and S. Han, “Knowledge based parametric design of mechanical products based on configuration design method,” *Expert Systems with Applications*, vol. 21, no. 2, pp. 99–107, 2001.

[2] P. H. Speel, A. T. Schreiber, W. Van Joolingen, and G. Van Heijst, *Conceptual Modeling for Knowledge-Based Systems*. Amsterdam, Netherlands: University of Amsterdam, 2001.

[3] A. Mohamed and T. Celik, “An integrated knowledge-based system for alternative design and material selection and cost estimating,” *Expert Systems with Applications*, vol. 14, no. 3, pp. 329–339, 1998.

[4] M. J. G. M. Van Emmerik, *Creation and Modification of Parametrized Solid Models by Graphical Interaction*. Delft, Netherlands: Delft University of Technology, 2003.

[5] R. T. Plant and P. Tsoumpas, “An integrated methodology for knowledge based system development,” *Expert Systems with Applications*, vol. 7, no. 2, pp. 259–271, 1994.

[6] J. R. Weitzel and L. Kerschberg, “A system development methodology for knowledge based systems,” *IEEE Transactions on Systems*, vol. 19, no. 3, pp. 598–605, 1989.

[7] M. Duribreux-Cocquebert and B. Houriez, “A user-centered methodology for knowledge based systems development,” University of Valenciennes, France, 1995.

[8] D. S. Motz and K. Haghighi, “A knowledge based design model for mechanical components,” *Engineering Applications of Artificial Intelligence*, vol. 4, no. 5, pp. 351–358, 1991.

[9] J. R. Dixon and M. K. Simmons, “Expert systems for engineering design: Standard V-belt drive design,” in *Proc. Computers in Engineering Conf.*, Las Vegas, NV, USA, 1984, pp. 332–337.

[10] Y. E. Kalay, L. M. Swerdloff, and A. C. Harfmann, “A knowledge-based computable model of design,” *Expert Systems in Computer-Aided Design*, vol. 5, no. 2, pp. 203–223, 1987.

[11] A. J. Dentsoras and P. Maurommatis, “Knowledge-based mechanical spring selection during preliminary design,” University of Patras, Greece, 1993.

[12] R. M. O'Keefe and A. D. Preece, "The development, validation and implementation of knowledge-based systems," *European Journal of Operational Research*, vol. 92, no. 3, pp. 458–473, 1996.

[13] E. Turban and J. E. Aronson, *Decision Support Systems and Intelligent Systems*, 4th ed. New Delhi, India: Pearson Education, 2004.

[14] J. O'Keefe, "Experiences with an expert system prototyping methodology," *Expert Systems: The International Journal of Knowledge Engineering*, vol. 11, no. 1, pp. 13–22, 1994.

[15] R. S. Khurmi and J. K. Gupta, *Machine Design*. New Delhi, India: S. Chand Publications, 2005.

[16] V. B. Bhandari, *Design of Machine Elements*. New Delhi, India: Tata McGraw Hill, 2010.

[17] J. E. Shigley, *Mechanical Engineering Design*, 8th ed. New York, USA: McGraw Hill, 2008.

[18] S. S. Rao, *Engineering Optimization: Theory and Practice*, 4th ed. New Delhi, India: Wiley India, 2009.

[19] T. R. Chandrupatla and A. D. Belegundu, *Introduction to Finite Elements in Engineering*. New Delhi, India: Pearson Education, 2008.

[20] J. N. Reddy, *An Introduction to the Finite Element Method*. New York, USA: McGraw Hill, 2005.

[21] S. Kalpakjian and S. Schmid, *Manufacturing Engineering and Technology*. New Delhi, India: Pearson Education, 2010.

[22] G. E. Dieter, *Engineering Design: A Materials and Processing Approach*. New York, USA: McGraw Hill, 2009.

[23] Dassault Systemes, *SolidWorks User Guide*. Paris, France: Dassault Systemes Publications, 2018.

[24] Microsoft Corporation, *Visual Basic Programming Guide*. Redmond, WA, USA: Microsoft Press, 2010.

[25] Microsoft Corporation, *Microsoft Access Database System User Manual*. Redmond, WA, USA: Microsoft Press, 2009.