International Journal of
AI ELECTRICAL CIVIL AND MECHANICAL ENGINEERING
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0434 www.zesterapublications.com Original Research Paper

Turbine Impeller Blade Using Advanced Surface Modeling

[1]S Venkat Lakshman, [2] M Rahul, [3] A Umesh Chandra, [4] K Vinay Ram, [5] G Mallikarjuna, [6] M Venkata sai
[1]AssistantProfessor, [23456]Students
Department of MECH
Siddhartha Institute of Technology & Sciences, Narapally
sattalavenkatalakshman.mech@siddhartha.co.in, 24tq5a0319@siddhartha.co.in,
24tq5a0304@siddhartha.co.in, 24tq5a0306@siddhartha.co.in, 24tq5a0322@siddhartha.co.in,
24tq5a0316@siddhartha.co.in

Abstract

The Turbine Impeller Blade Using Advanced Surface Modeling project focuses on the design and development of a turbine impeller blade using advanced computer-aided surface modeling techniques. Turbine blades are critical components in power generation and energy conversion systems, where their geometry directly influences aerodynamic performance, efficiency, and structural reliability. Therefore, accurate and smooth blade modeling is essential for achieving the required performance.

In this project, a detailed 3D turbine impeller blade is developed using advanced surface modeling techniques. Important parameters such as blade profile, twist, thickness, leading edge, trailing edge, blade angle, and span are considered during the design process. Surface modeling techniques are used to create smooth and continuous blade surfaces with accurate geometric transitions.

The developed blade model can be evaluated using CAD-based analysis and computational simulation to study its aerodynamic and geometric characteristics. The model can be examined for surface continuity, blade shape, flow direction, and potential regions of performance loss. Different blade profiles and design parameters can also be modified and compared to obtain an improved blade configuration.

The main objective of this project is to demonstrate how advanced surface modeling can be used to create an accurate and optimized turbine impeller blade. The approach reduces design complexity and provides greater flexibility compared with conventional solid modeling methods. The developed model can serve as a foundation for further CFD analysis, structural analysis, manufacturing, and performance optimization of turbine blade systems.

I. Introduction

A turbine impeller blade is an important component in rotating machinery used for converting fluid energy into mechanical energy. The performance of a turbine depends significantly on the shape, size, orientation, and surface quality of its blades. A properly designed blade can improve energy transfer, reduce aerodynamic losses, and provide better overall turbine efficiency. Therefore, accurate blade design is an essential part of turbine development.

Traditional solid modeling methods can become difficult when creating turbine blades because the blade geometry usually involves complex curves, twists, varying thickness, and smooth transitions. Advanced surface modeling techniques provide greater flexibility for creating these complicated geometries. They allow designers to

Received: 24-07-2026 | Accepted: 30-08-2026 | Published: 05-09-2026

control the blade profile accurately and generate smooth surfaces with better geometric continuity.

In this project, a detailed 3D turbine impeller blade is designed using advanced CAD surface modeling techniques. Important parameters such as blade height, chord length, twist angle, blade thickness, leading-edge radius, trailing-edge shape, and blade orientation are considered during the modeling process. Different sections of the blade can be created and connected using suitable surface features to obtain the required aerodynamic shape.

The developed model can be evaluated for surface quality, geometric accuracy, continuity, and manufacturability. The blade geometry can also be used for further computational analysis such as CFD to study velocity distribution, pressure variation, turbulence, and aerodynamic performance.

The main objective of this project is to demonstrate the application of advanced surface modeling techniques in turbine blade design. The resulting model provides a flexible foundation for further optimization, CFD analysis, structural analysis, and manufacturing. This approach can help designers develop more accurate and efficient turbine impeller blades while reducing the complexity associated with modeling highly curved and twisted geometries.

II. Literature Survey

Several researchers have investigated advanced methods for designing and modeling turbine blades because blade geometry has a major influence on aerodynamic performance, efficiency, and structural behavior. Earlier turbomachinery research focused on developing computational methods for blade design, including geometric modeling, aerodynamic calculations, and numerical flow analysis. These methods established the foundation for modern CAD and simulation-based turbine blade development.

Research on integrated turbine blade design has demonstrated the importance of combining airfoil modeling, 3D geometric generation, and CFD analysis. Integrated design approaches can generate blade sections from aerodynamic requirements and subsequently construct complete three-dimensional blade geometries. CFD analysis can then be used to evaluate pressure and velocity distributions, losses, and aerodynamic efficiency.

Advanced surface and skinning techniques have also been investigated for creating smooth turbine blade geometries. Studies on computer-aided blade design have shown that complex twisted blades can be constructed from multiple sectional profiles and connected using surface approximation techniques. Maintaining geometric continuity between different sections is important for obtaining smooth and accurate blade surfaces.

Researchers have also explored parametric blade modeling to make turbine geometry easier to modify and optimize. One approach uses parameterized cross-sectional profiles and 3D CAD models in which parameters such as blade thickness, twist, and

International Journal of
AI ELECTRICAL CIVIL AND MECHANICAL ENGINEERING
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0434 www.zesterapublications.com Original Research Paper

lean can be varied. These parameterized models can be integrated with CFD simulations and optimization algorithms to evaluate multiple blade designs efficiently.

The leading edge and surface curvature of a turbine blade have received considerable attention because their geometry can influence flow separation and aerodynamic losses. Research has shown that carefully controlling the leading-edge shape and blending it smoothly with the main blade surface can reduce undesirable flow disturbances.

Recent research increasingly combines CAD modeling, CFD, structural analysis, and optimization to improve turbine blade performance. Current literature indicates that integrated aerodynamic and structural optimization can provide better blade designs while considering efficiency, strength, weight, and manufacturability.

Based on the existing literature, the proposed Turbine Impeller Blade Using Advanced Surface Modeling project focuses on developing an accurate 3D blade using advanced surface modeling techniques. The model can be created from multiple blade sections and smoothly connected using lofting, skinning, and surface-continuity techniques. The resulting geometry can be further used for CFD analysis, structural analysis, design optimization, and manufacturing, providing a practical foundation for developing efficient turbine impeller blades.

III. System Analysis

System analysis is an important stage in the development of the Turbine Impeller Blade Using Advanced Surface Modeling project. The analysis focuses on understanding the geometric, aerodynamic, and manufacturing requirements of the turbine blade. Important parameters such as blade height, chord length, blade thickness, blade angle, twist, and curvature are considered during the design process. The required blade profile is selected according to the intended operating conditions of the turbine. Different blade sections are created at suitable radial positions to develop the complete blade geometry. Advanced surface modeling techniques are used to connect these sections and produce smooth blade surfaces. Surface continuity and geometric accuracy are carefully maintained throughout the modeling process. The developed model is inspected for gaps, irregularities, sharp edges, and unwanted surface intersections. The final blade geometry can be transferred to CFD software for further aerodynamic analysis. Pressure, velocity, streamline, and flow characteristics can be studied through simulation. The results can help identify areas that require design improvement. Overall, system analysis provides a clear foundation for creating an accurate and efficient turbine impeller blade.

Existing system

In the existing system, turbine impeller blades are generally designed using conventional CAD modeling and manual design techniques. Designers create individual blade sections and construct the three-dimensional blade geometry using basic solid or surface features. Complex turbine blades usually contain curves, twists, varying thickness, and multiple geometric transitions, which can make conventional modeling difficult. Maintaining smooth continuity between different blade sections

International Journal of
AI ELECTRICAL CIVIL AND MECHANICAL ENGINEERING
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0434 www.zesterapublications.com Original Research Paper

requires considerable effort and precision. Small changes in blade parameters may require repeated modifications to the complete model. Manual modeling can also result in surface gaps, irregularities, or inaccurate transitions. Physical prototypes may be required to verify the final blade design and performance. Manufacturing multiple prototypes increases development time and cost. Aerodynamic performance may not be evaluated effectively during the early design stage. Integration of complex CAD models with simulation software can also require additional preprocessing. These limitations make conventional blade modeling less flexible for complex turbine geometries. Therefore, an advanced surface modeling approach is required to improve accuracy, flexibility, and efficiency.

Disadvantages of Existing System

- Complex blade geometry is difficult to model.
- Manual modeling requires more time and effort.
- Maintaining surface continuity is difficult.
- Design modifications can be time-consuming.
- Surface errors may occur during modeling.
- Limited flexibility for complex blade shapes.
- Physical prototypes may be required.
- Prototype development increases cost.
- Repeated testing increases development time.
- Difficult to identify aerodynamic problems at an early stage.
- Complex models may require additional preprocessing.
- Limited scope for quick design optimization.

Proposed System

The proposed system focuses on developing a turbine impeller blade using advanced surface modeling techniques. The design process begins by identifying important operating and geometric parameters required for the turbine blade. Multiple two-dimensional blade profiles are generated at different radial or spanwise locations. Parameters such as blade angle, chord length, thickness, camber, and twist are controlled during profile development. These individual profiles are then connected using advanced surface modeling techniques such as lofting, boundary surfaces, and guide curves. Smooth transitions are maintained between the different blade sections to create an accurate three-dimensional blade surface. The completed blade geometry is carefully inspected for gaps, overlaps, discontinuities, and other modeling errors. The blade can then be integrated with the impeller hub to create the complete turbine impeller assembly. The developed geometry can be transferred to CFD software for aerodynamic flow analysis. Simulation results can be used to study pressure distribution, velocity, streamlines, turbulence, and aerodynamic losses. Different blade parameters can be modified and analyzed to obtain improved performance. Overall, the proposed system provides a flexible and accurate approach for designing complex turbine impeller blades.

Advantages of Proposed System

- Provides accurate complex blade modeling.

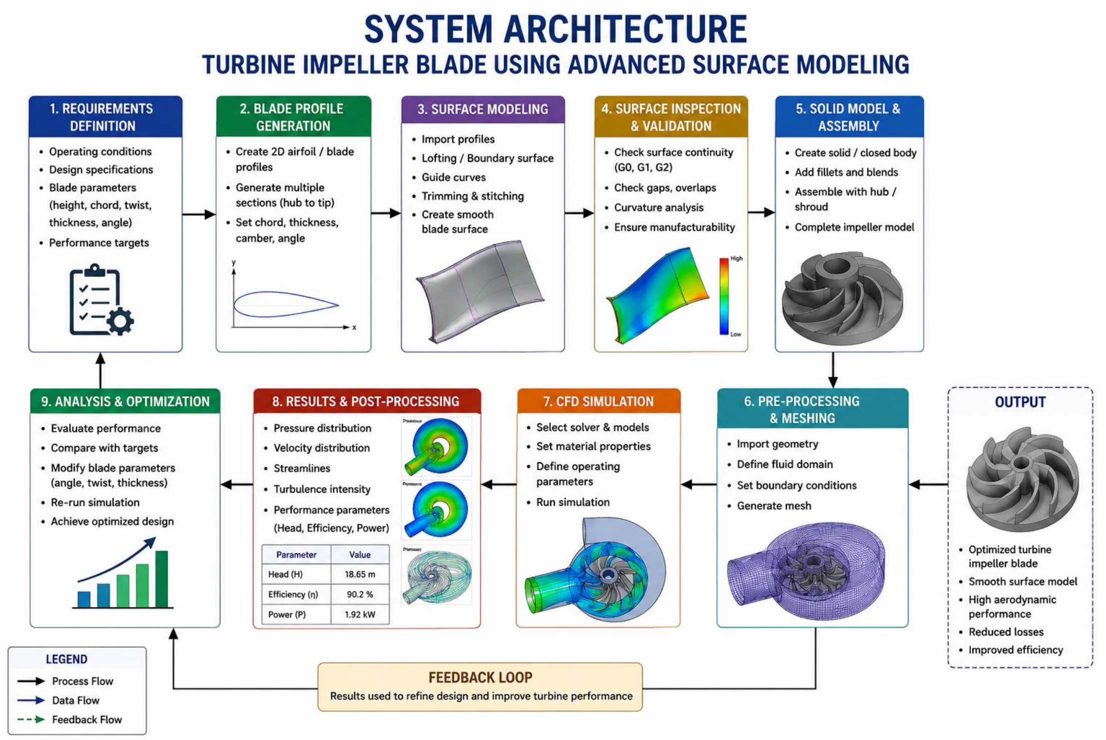
- Produces smooth and continuous surfaces.
- Reduces modeling complexity.
- Allows easy modification of blade parameters.
- Supports twisted and curved blade profiles.
- Reduces design development time.
- Improves geometric accuracy.
- Provides better control over blade shape.
- Supports CFD analysis.
- Reduces dependence on physical prototypes.
- Supports design optimization.
- Improves flexibility in turbine blade development.

IV. Methodology

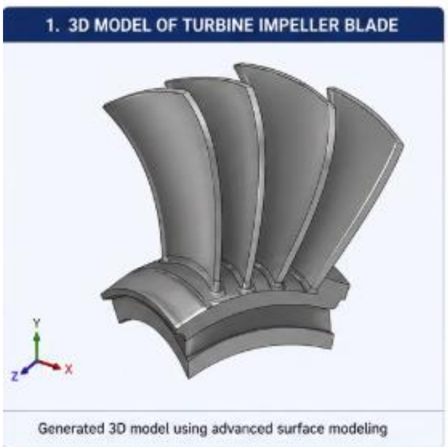
The methodology begins with identifying the design requirements and operating conditions of the turbine impeller blade. Important parameters such as blade height, chord length, thickness, twist angle, blade angle, and radial position are selected. Suitable two-dimensional blade or airfoil profiles are then created for different spanwise sections. These profiles are positioned according to the required blade orientation and geometric specifications. Advanced CAD surface modeling techniques are used to connect the individual profiles and generate the main blade surface. Lofting, boundary surfaces, guide curves, trimming, and blending operations can be used to create smooth and continuous geometry. The generated surface is checked carefully for continuity, gaps, overlaps, and unwanted irregularities. The completed surface model is converted into a closed or solid blade model where required. The blade is then assembled with the impeller hub to form the complete turbine impeller. The final geometry can be exported to CFD software for aerodynamic simulation and analysis. Simulation results such as pressure, velocity, streamlines, and flow losses are evaluated to determine blade performance. Based on the results, the blade geometry can be modified and optimized for improved efficiency and aerodynamic performance.

System Architecture

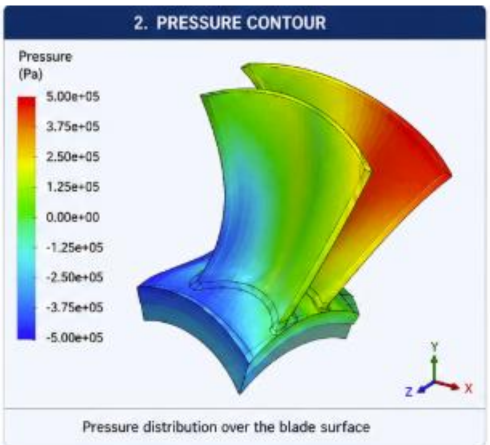
The system architecture represents the complete workflow for designing and analyzing the turbine impeller blade using advanced surface modeling. The process begins with design requirements and operating conditions such as blade dimensions, rotational speed, and required performance. These inputs are provided to the blade parameter and profile generation stage, where suitable blade sections are created. The generated profiles are transferred to the advanced surface modeling stage for constructing the three-dimensional blade surface. Surface modeling operations such as lofting, boundary surfaces, guide curves, and trimming are used to generate the required geometry. The surface inspection stage checks the model for continuity, gaps, overlaps, and geometric errors. The completed blade is integrated with the impeller hub to create the complete turbine impeller model. The final geometry is then transferred to the preprocessing and meshing stage for CFD analysis. Appropriate material properties, boundary conditions, and operating parameters are applied to the simulation model. The CFD solver analyzes pressure, velocity, streamlines, turbulence, and aerodynamic flow behavior. The post-processing stage presents the simulation results through contours, graphs, and performance parameters. Finally, the results are evaluated and the blade geometry can be modified through an optimization process to achieve improved turbine performance.



V. Result and Output



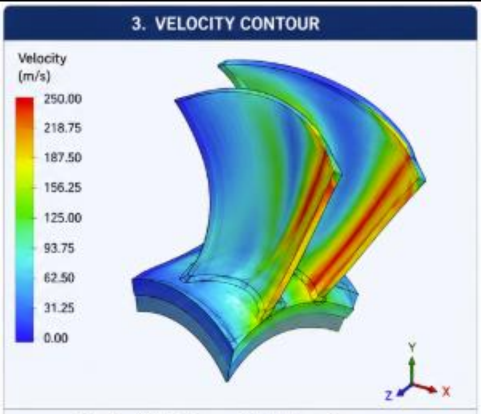
Generated 3D model using advanced surface modeling



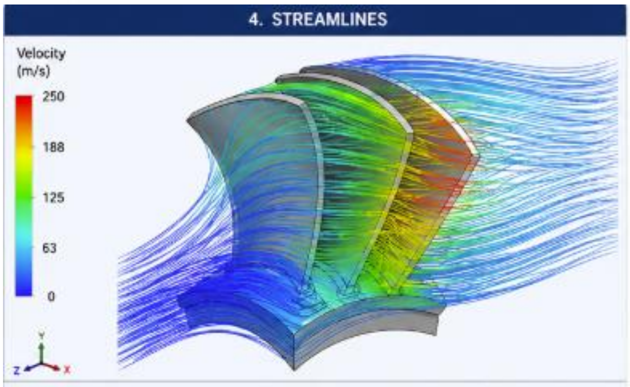
Pressure distribution over the blade surface

Received: 24-07-2026 | Accepted: 30-08-2026 | Published: 05-09-2026

International Journal of
AI ELECTRICAL CIVIL AND MECHANICAL ENGINEERING
Peer Reviewed, Referred & Indexed Journal
ISSN: 3070-0434 www.zesterapublications.com Original Research Paper



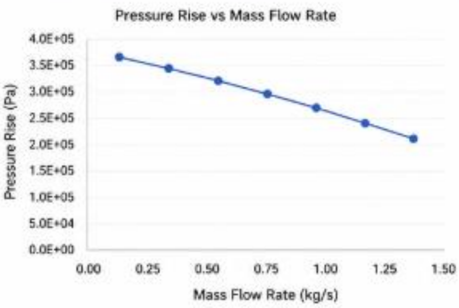
Velocity distribution over the blade surface



Streamline flow pattern through the blade passage

5. PERFORMANCE RESULTS

Parameter	Value
Rotational Speed (N)	1450 rpm
Inlet Total Pressure	5.00e+05 Pa
Mass Flow Rate	1.25 kg/s
Output Power	2.15 kW
Total Efficiency (η)	86.45 %
Pressure Rise	3.21e+05 Pa



Performance parameters and Pressure rise characteristics

VI. Conclusion

The Turbine Impeller Blade Using Advanced Surface Modeling project successfully demonstrates the design and development of a complex turbine blade using advanced CAD surface modeling techniques. The method allows accurate control of important blade parameters such as profile, thickness, twist, curvature, blade angle, and height.

Advanced surface modeling helps create smooth, continuous, and geometrically accurate blade surfaces, reducing the difficulties associated with conventional modeling methods. The developed 3D blade model can be inspected for surface quality, continuity, and manufacturability before moving to further analysis.

The resulting blade geometry can also be used for CFD analysis to study pressure distribution, velocity variation, streamlines, turbulence, and aerodynamic losses. This provides valuable information for evaluating blade performance and identifying areas that require improvement.

Overall, the project shows that combining advanced surface modeling with computational analysis provides an effective approach for designing turbine impeller blades. It reduces design complexity, supports faster modifications, and provides a strong foundation for optimization. In the future, the model can be further improved through CFD-based optimization, structural analysis, thermal analysis, and experimental validation to achieve higher efficiency, better strength, and improved turbine performance.

References

[1] Kumar, R. D., Prudhviraj, G., Vijay, K., Kumar, P. S., & Plugmann, P. (2024). Exploring COVID-19 through intensive investigation with supervised machine learning algorithm. In Handbook of Artificial Intelligence and Wearables (pp. 145-158). CRC Press.

[2] Swathi, B., Vijay, K., Sushanth Babu, M., & Dinesh Kumar, R. (2024, November). Machine Learning Techniques in Cloud Based Intrusion Detection. In The International Conference on Artificial Intelligence and Smart Environment (pp. 557-564). Cham: Springer Nature Switzerland.

[3] Sv satyakrishna, shirisha rangu ,bhargavi nalacheruve.(2024) Prospective investigation on colorectal cancer with SMOTE on machine learning Algorithm

[4] Dr.G.Vishnu Murthy, BhargaviNalacheruve 1Professor, Department of computer Science & engineering, Anurag University, TS, India. 2Student, Department of computer Science & engineering, Anurag University, TS, India.

[5] V. N. S. Manaswini, K. K, C. Nigam, S. S. Ali, R. Niranjana, and Suman, “Real-Time Object Detection in Drone Surveillance Using YOLOv5,” in Proc. 2025 3rd Int. Conf. IoT, Communication and Automation Technology (ICICAT), Gorakhpur, India, 2025, pp. 1–6, doi: 10.1109/ICICAT68430.2025.11414670.

[6] B. Soundarya, V. N. S. Manaswini, M. Ayyakrishnan, R. D. Kumar, “Contextual Analysis of Big Data Analytics in Intelligent Transportation Frameworks,” in Intersection of Artificial Intelligence, Data Science, and Cutting-Edge Technologies: From Concepts to Applications in Smart Environment, Lecture Notes in Networks and Systems, vol. 1353, Cham: Springer, 2025, doi: 10.1007/978-3-031-88304-0_79.

[7] R. D. Kumar, V. N. S.Manaswini, “Applications of blockchain in smart cities: detecting fake documents from land records using blockchain technology,” in Blockchain for Smart Cities, Elsevier, 2021, pp. 105–117, doi: 10.1016/B978-0-12-824446-3.00017-X.

[8] Tejavath Veeramma, Badarla Anil, Guguloth Ravinder, “An advanced movie recommender using collaborative filtering and sentiment analysis,” International Research Journal of Modernization in Engineering Technology and Science, vol. 7, no. 7, July 2025, doi: 10.56726/IRJMETS81618.

[9] Ravi Kumar Banoth, Ramana Murthy B V, “Automatic crop recommendation system using LightGBM and decision tree machine learning models,” Journal of Machine and Computing, vol. 5, no. 1, pp. 343, Jan. 2025, doi: 10.53759/7669/jmc202505026.

[10] Ravi Kumar Banoth, Dr. B.V. Ramana Murthy, “Smart agriculture through IoT and machine learning for analyzing carbon footprints,” in Proc. Int. Conf. Computer Science and Communication Engineering (ICCSCE), Apr. 2025.
[11] Ravi Kumar Banoth, B. V. Ramana Murthy, “Soil image classification using transfer learning approach: MobileNetV2 with CNN,” SN Computer Science, vol. 5, art. no. 199, 2024, doi: 10.1007/s42979-023-02500-x.