IJARETY

International Journal of Advanced Research in Education and TechnologY (IJARETY)

Volume 12, Issue 3, May-June 2025

Impact Factor: 8.152

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

INNO SPACE SJIF Scientific Journal Impact Factor

doi crossref

निस्केयर NISCAIR

International Journal of Advanced Research in Education and TechnologY(IJARETY)

| ISSN: 2394-2975 | www.ijarety.in| | Impact Factor: 8.152| A Bi-Monthly, Double-Blind Peer Reviewed & Refereed Journal |

|| Volume 12, Issue 3, May - June 2025 ||

DOI:10.15680/IJARETY.2025.1203103

Modelling and 3D Printing of Piston Crown

Vijay Kumar, S.Vinay, M. Vignesh, A.Venkata Swami

UG Scholars, Department of Mechanical Engineering, Guru Nanak Institutions Technical Campus, Hyderabad, Telangana, India

Associate Professor, Department of Mechanical Engineering, Guru Nanak Institutions Technical Campus, Hyderabad, Telangana, India

ABSTRACT: The piston crown is a crucial component in internal combustion engines, directly influencing combustion efficiency, thermal management, and overall engine performance. This study focuses on the design, material selection, and manufacturing process of a piston crown using 3D printing technology with PLA material. By utilizing advanced 3D modelling and rapid prototyping techniques, the aims to optimize the piston crown's geometry to enhance strength, durability, and thermal resistance. The study explores the feasibility of using PLA as a prototyping material for testing design modifications before final manufacturing. The integration of modern engineering tools in piston crown development helps reduce production time, improve design accuracy, and enhance overall engine efficiency. The findings demonstrate that 3D printing can serve as a valuable tool in engine component development, enabling innovative design solutions and cost-effective prototyping

KEYWORDS: Piston Crown | 3D Printing | PLA Material | Internal Combustion Engine | Rapid Prototyping | Design Optimization

I. INTRODUCTION

This project focuses on the **modelling and 3D printing of a piston crown**, which is a key component in internal combustion engines. The study explores the use of **3D printing technology with PLA material** as a prototyping method to test design modifications, improve efficiency, and support further development of engine components.
The **piston crown** is a crucial part of reciprocating engines, pumps, and gas compressors. Located inside the engine cylinder and sealed with piston rings, it transfers the force generated by expanding combustion gases to the crankshaft via the connecting rod. In reverse operation, such as in pumps, it transfers mechanical energy from the crankshaft to move or compress fluids. In some engine designs, the piston crown also functions as a valve by covering or uncovering ports in the cylinder wall.

Over the years, the **design and material selection of piston crowns have evolved** to enhance performance, reduce wear, and withstand high temperatures and pressures. As one of the most stressed parts of the engine, the piston crown is often referred to as the **"heart" of the engine**, and ongoing innovation is essential for improving engine efficiency and durability.

This project aims to contribute to this advancement by **using CAD modelling and 3D printing techniques** to prototype a piston crown. PLA, a widely used thermoplastic in additive manufacturing, is utilized to create a physical model for design validation and testing. This approach supports **cost-effective development**, **faster design iterations**, and **improved accuracy** before final production using high-performance materials.

II. METHODOLOGY

1. 3D Modeling Using SolidWorks

- The piston crown geometry was designed using **SolidWorks**, a parametric solid modeling software widely used in mechanical engineering. The design was developed based on typical dimensions for internal combustion engine pistons, with emphasis on key features such as:
- Crown profile and bowl shape suitable for enhanced combustion characteristics
- Precise dimensional tolerances to ensure manufacturability
- Uniform wall thickness and smooth geometry to minimize support structures during printing
- The model was developed with printing feasibility and structural simplicity in mind.

International Journal of Advanced Research in Education and TechnologY(IJARETY)

| ISSN: 2394-2975 | www.ijarety.in| | Impact Factor: 8.152| A Bi-Monthly, Double-Blind Peer Reviewed & Refereed Journal |

|| Volume 12, Issue 3, May - June 2025 ||

DOI:10.15680/IJARETY.2025.1203103

2. STL Conversion and Slicing

- Once the 3D model was finalized, it was exported in **STL (Standard Tessellation Language)** format, which is compatible with most 3D printing platforms. The STL file was imported into slicing software (e.g., **Ultimaker Cura**) to generate G-code instructions for the printer. The slicing parameters used included:
- **Layer height**: 0.2 mm
- **Infill density**: 20% (grid or hexagonal pattern)
- **Print speed**: 50 mm/s
- **Nozzle temperature**: 200–220°C (depending on filament material)
- **Bed temperature**: 60°C (for PLA)
- Support structures and brim settings were applied as needed to prevent warping and ensure model stability.

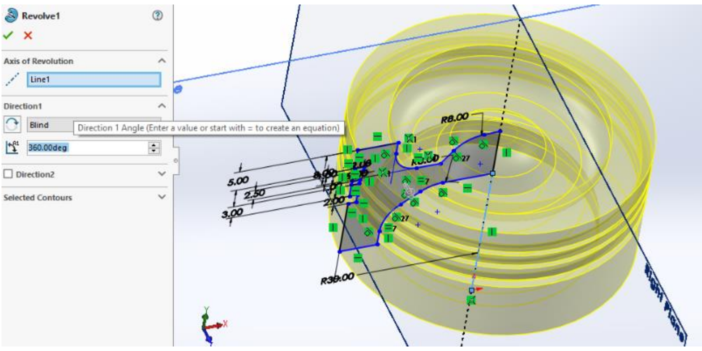
3. 3D Printing Process

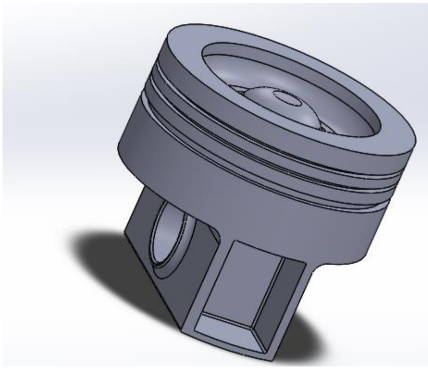
- The piston crown was fabricated using **Fused Deposition Modeling (FDM)** technology on a desktop 3D printer. The material used for printing was **PLA (Polylactic Acid)**, chosen for its dimensional stability and ease of use. Key printing specifications included:
- **Printer type**: FDM-based desktop 3D printer
- **Nozzle diameter**: 0.4 mm
- **Printing resolution**: 100–200 microns
- **Cooling fan enabled** for layer adhesion and reduced warping
- The print duration varied between 3–6 hours depending on model complexity and layer height.

4. Post-Processing and Dimensional Validation

- After printing, the component was subjected to the following post-processing steps:
- Manual removal of support structures
- Surface finishing (light sanding if required)
- Dimensional verification using vernier calipers and micrometers
- The printed model’s dimensions were compared with the original SolidWorks design to assess accuracy and reproducibility.

III. 3D MODELING USING SOLIDWORKS





The modeling of the piston crown was carried out using the Revolve Boss/Base feature in SolidWorks. A two-dimensional profile was sketched to represent the cross-sectional geometry of the piston bowl, incorporating precise dimensions such as radii (e.g., R8.00, R5.00) and linear distances to define the shape accurately. A central axis, labeled "Line1," was established within the sketch to serve as the axis of revolution. The revolve operation was applied with a 360-degree sweep, generating a complete, axisymmetric three-dimensional model of the piston crown. This approach allowed for the creation of a geometrically accurate and manufacturable design, which is critical for optimizing the combustion process in internal combustion engines. The revolved model was subsequently used for slicing and 3D printing..

.

International Journal of Advanced Research in Education and TechnologY(IJARETY)

| ISSN: 2394-2975 | www.ijarety.in| | Impact Factor: 8.152| A Bi-Monthly, Double-Blind Peer Reviewed & Refereed Journal |

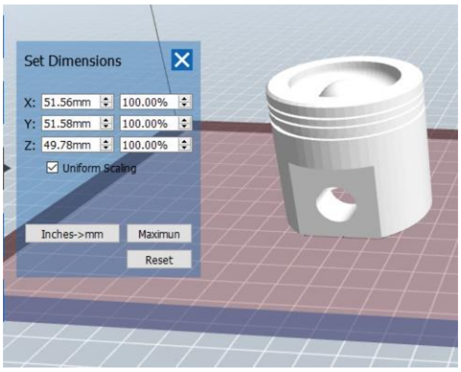
|| Volume 12, Issue 3, May - June 2025 ||

DOI:10.15680/IJARETY.2025.1203103

IV. STL CONVERSION AND SLICING

Following the completion of the 3D model in SolidWorks, the geometry was exported in **STL (Standard Tessellation Language)** format, which is widely used for additive manufacturing workflows. This format converts the solid model into a triangulated surface mesh that can be interpreted by slicing software. The STL file was imported into slicing software—such as Ultimaker Cura or PrusaSlicer—for toolpath generation and printer parameter configuration. Key slicing parameters were defined, including a layer height of 0.2 mm, infill density of 20%, and printing speed of 50 mm/s. The nozzle and bed temperatures were set according to the material properties, with typical values being 200–220°C for the nozzle and 60°C for the bed when using PLA filament. Support structures and brim settings were applied where necessary to ensure build stability and dimensional accuracy. The final slicing process generated G-code, which was then used to guide the 3D printer during fabrication.

V. 3D PRINTING PROCESS



The 3D printing of the piston crown was carried out using **Fused Deposition Modeling (FDM)** technology, a widely adopted additive manufacturing method known for its cost-effectiveness and ease of use. The prepared G-code was transferred to an FDM-based desktop 3D printer equipped with a 0.4 mm nozzle. **PLA (Polylactic Acid)** filament was selected as the printing material due to its favorable properties such as low warping, biodegradability, and good dimensional stability. Printing parameters were configured based on material and model requirements, with a layer height of 0.2 mm, print speed of 50 mm/s, nozzle temperature set to 210°C, and bed temperature maintained at 60°C. The print process was monitored to ensure continuous extrusion and layer adhesion. Upon completion, the printed piston crown was allowed to cool gradually to avoid thermal stress and warping. This stage resulted in a physical prototype suitable for dimensional validation and further analysis.

V. RESULT

The project on **modeling and 3D printing of a piston crown** was successfully completed using **SolidWorks** software. A precise 3D CAD model was designed with essential features such as the crown profile, valve cut-outs, and ring grooves. The model was exported as an STL file and printed using FDM technology with PLA material. The final prototype accurately represented the intended design, helping to visualize the component in physical form. Throughout the project, various challenges such as dimensional accuracy and print optimization were addressed, enhancing **problem-solving skills**. This project demonstrated the practical application of 3D printing in **rapid prototyping** and mechanical design

V. CONCLUSION

In conclusion, the modeling and 3D printing of the piston crown using **SolidWorks** successfully demonstrated the integration of CAD design and additive manufacturing. The project not only produced an accurate physical prototype but also enhanced understanding of component design and printability. By overcoming challenges related to modeling precision and printing limitations, the project significantly improved **problem-solving abilities** and showcased the effectiveness of 3D printing as a tool for **rapid prototyping** in mechanical engineering applications

| ISSN: 2394-2975 | www.ijarety.in| | Impact Factor: 8.152| A Bi-Monthly, Double-Blind Peer Reviewed & Refereed Journal |

|| Volume 12, Issue 3, May - June 2025 ||

DOI:10.15680/IJARETY.2025.1203103

REFERENCES

[1] Sunday Aribo, Joseph Ajibade Omotoyinbo, Davies Oladayo Folorunso, ―High temperature mechanical properties of silicon carbide particulate reinforced cast aluminum alloy composite, Metallurgical and Materials Engineerings,Vol 18, pp. 9-16, 2011.

[2] Gopinath C.V, ―Finite Element Analysis of Reverse Engineered Internal Combustion Engine Dowel Pston‖ , AIJSTPME, Vol 2, pp. 85-92, 2011

[3] Ekrem Buyukkaya, Muhammet Cerit, ―Mechanical characterization of Aluminium silicon carbide composite‖, International journal of applied engineering research, Volume 1, pp. 4-9, 2007

[4] Khurmi, Pandya and Shah, ―Design of machine Elements‖, S Chand, 14th edition, 2006.

IJARETY

INNO SPACE
SJIF Scientific Journal Impact Factor

doi crossref

निस्केयर NISCAIR

International Journal of Advanced Research in Education and Technology

ISSN: 2394-2975 Impact Factor: 8.152

www.ijarety.in editor.ijarety@gmail.com