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3D PRINTING AND FABRICATION OF JET ENGINE

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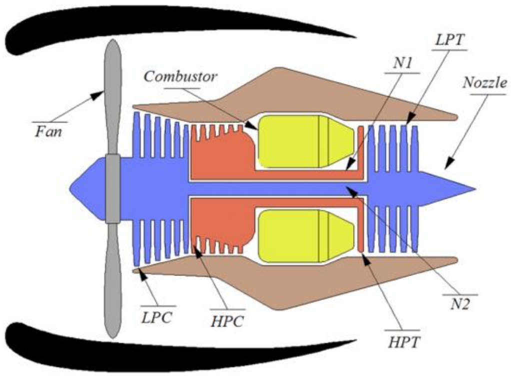
* **Abstract**: This comprehensive report delves into the intricate process of conceptualizing, designing, fabricating, and rigorously testing a groundbreaking 3D-printed jet engine. The innovative engine, a single-stage turbojet, encompasses a meticulously crafted array of vital components including a high-efficiency compressor, a precisely engineered combustor, a robust turbine, and an optimized exhaust nozzle. Noteworthy is the axial flow design of the compressor and turbine, enhancing the engine's performance, while the annular configuration of the combustion chamber ensures efficient combustion processes. The design phase was meticulously executed using design (CAD) software, enabling the creation of intricate and precise models of each component with meticulous attention to detail. These CAD models served as the blueprint for the additive manufacturing process, where state-of-the-art 3D printing technology was employed to transform virtual designs into tangible components. The utilization of PLA (Polylactic Acid) filament as the printing material further underscored the commitment to precision and quality in the fabrication process. The successful completion of this ambitious project not only represents a significant milestone in jet engine technology but also underscores the transformative potential of additive manufacturing techniques in revolutionizing the aerospace industry, paving the way for future advancements and innovations in propulsion systems.

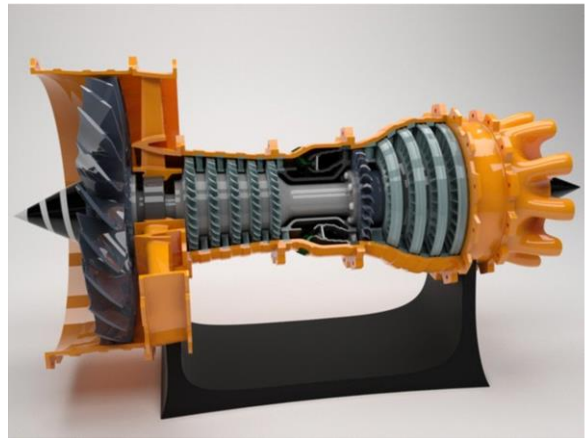
* ***Keywords***- CAD, Fusion360, Jet Engine, 3D Printing

* **Introduction**: Jet engines, intricate marvels of engineering, demand precision in their manufacturing processes. Conventional methods like machining and casting, while effective, often come with high costs and time constraints. In response to these challenges, the primary goal of our project is to develop, manufacture, and evaluate a 3D-printed miniature jet engine model. This educational tool serves as a tangible representation for students to grasp the inner workings of jet engines and how they generate thrust. [3]Educators can leverage this model to elucidate the sequential stages of a jet engine's operation, from the air intake by the fan to the compression by the compressor, ignition in the combustor, energy extraction by the turbine, and thrust generation through the nozzle. Beyond mere observation, students can actively engage with the model to construct their own simplified jet engines, fostering a hands-on understanding of the fundamental engineering principles underpinning jet engine design. By manipulating design parameters like fan size, compressor stages, compression ratio, and nozzle geometry, students can explore the cause-and-effect relationships that influence engine performance. This interactive learning approach not only empowers students to experiment and innovate but also cultivates a deeper appreciation for the complexities and nuances of jet engine technology, preparing them for future challenges in the domain of aerospace engineering.



Inner sections of Jet engine

* **Project identification and design:** The first step in the project was to identify the specific jet engine components that would be 3D printed. The components selected were the compressor, combustor, turbine, and exhaust nozzle. These components were selected because they are complex in shape and have fine features. The next step was to design the 3D printed components. The CAD models were created using a variety of software packages, including SolidWorks and Fusion 360. The CAD models were designed to meet the specific requirements of the jet engine, such as strength, weight, and durability.
* **Development of product:** The CAD model required for the project was sourced from [2]Chris Shakal, a CAD designer on Thingiverse, under the username Catiav5ftw. The model comprised various components such as the front fan, fan casing, fuel injector, HPC, LPC, LPT, HPT, Nozzle, Spinner, Stand, and Swirl Dome. These files were converted to STL format to be compatible with the 3D printer. The STL files were then imported into slicing software, UltiMaker Cura 5.4.0, and Lulzbot Taz 6 Cura, to generate G-code instructions for the printer to effectively print the parts layer by layer. Subsequently, all 29 parts were printed using a 3D printer.
* **Manufacturing of 3d printed part**.To assemble the 3D printed model, various tools and hardware were required. Tools such as angled tweezers, cutter, screwdriver, needle-nose pliers, and sandpaper were essential. The screwdriver was used to join parts together with screws, the sandpaper for smoothing surfaces and removing excess material, and the cutter for eliminating support material. Additionally, hardware like 77 screws, 146 washers, 77 nuts, and two sets of bearings were needed. The assembly process involved dry-fitting each major section to ensure proper fit before gluing. Starting with the compressor, the rotors were slid on in sequence, followed by stators and pressing the core into the case. The low-pressure turbine assembly involved dry-fitting rotors and adding stators before inserting the core into the case. The combustor assembly included fitting the HPC rotor, combustion liner, and fuel nozzles. Prior to gluing, the modules were disassembled, and bearings were dry-fitted. The assembly process commenced with the spinner cone.



Rendered image of assembled Jet engine model

* **Literature review:**

[1] The paper "A hybrid PCA-CART-MARS-based prognostic approach of the remaining useful life for aircraft engines" proposes a new data-driven approach for predicting the remaining useful life (RUL) of aircraft engines. This approach can combine the following machine learning techniques. Principal Component Analysis (PCA) :It is used to reduce the dimensionality of data and to identify the most important features for predicting RUL. Classification And Regression Trees (CART) : It is a decision tree algorithm that can be used to model both classification and regression problems. In this case, CART is used to predict the RUL of the engine based on the PCA-reduced features. Multivariate Adaptive Regression Splines (MARS) : It is a non-linear regression that can be used to model complex relationships between the input and output variables. In this case, MARS is used to refine the RULE prediction by card.

* **Conclusion**

, the development of a 3D-printed jet engine represent advancement in the aerospace technology, showcasing the potential of additive manufacturing in creating complex and efficient propulsion systems. The meticulous design process, utilization of cutting-edge CAD software, and innovative use of PLA filament underscore the commitment to precision and quality in fabrication. The educational value of the miniature jet engine model as a teaching tool for students to grasp the inner workings of jet engines and engage in hands-on learning is evident. By allowing students to manipulate design parameters and explore cause-and-effect relationships, the project fosters a deeper understanding of jet engine principles and encourages experimentation and innovation. This project not only serves as a milestone in jet engine technology but also paves the way for future advancements and innovations in the aerospace industry. The transformative potential of additive manufacturing techniques in revolutionizing propulsion systems is highlighted, promising a future of continued progress and excellence in aerospace engineering. predictions made by CART.

References

[1] Sánchez-Lasheras, Fernando & Garcia Nieto, Paulino Jose & de Cos Juez, Francisco & Bayón, Ricardo & González, Víctor. (2015). "A hybrid PCA-CART-MARS-based prognostic approach of the remaining useful life for aircraft engines." Sensors (Basel, Switzerland). 15. 7062-83. 10.3390/s150307062.

[2] CAD model - https://www.thingiverse.com/thing:1327093

[3] He, Sibo & Li, Yimeng & Pu, Zidong & Rao, Wenbo. (2023). "Aerodynamic Calculation and Computer Numerical Simulation Methods Applied in Jet Engine Research." Highlights in Science, Engineering and Technology. 62. 217-227. 10.54097/hset.v62i.10446.