



## Design and Analysis of Turbo Jet Engine

Sridhar Bathina<sup>1</sup>, Veeramani Aketi<sup>2</sup>, Mahesh Dangeti<sup>3</sup>

<sup>1</sup>M.Tech Scholar, Dept of Mechanical Engineering,  
KAKINADA INSTITUTE OF ENGINEERING & TECHNOLOGY

<sup>2</sup>Assistant Professor, Dept of Mechanical Engineering,  
KAKINADA INSTITUTE OF ENGINEERING & TECHNOLOGY

<sup>3</sup>Research Scholar, Dept of Mechanical Engineering,  
Acharya Nagarjuna University, Guntur

### Abstract:

This project endeavors to create a turbojet engine using Catia software. The design draws upon extensive research from industry experts and historical advancements in jet engine technology. Carefully chosen design methodologies were employed to streamline the engine design process, with the primary goal being the development of a fully functional turbojet engine.

The landscape of air travel has evolved significantly, enabling swift global travel. However, the aviation industry faced limitations in the past, relying on Rotary Piston IC engines characterized by constrained travel speeds and distances, high fuel consumption, and elevated transportation expenses. The advent of turbojet engines, classified as Rotary-Reaction Turbine Engines, marked a pivotal advancement in aviation. In contrast to Rotary piston engines, turbojet engines demonstrate superior efficiency, catalyzing the subsequent evolution of engines like turbofan, turboprop, and turbo shaft engines as enhancements over the original turbojet design.

Keywords: Rotary Piston, Turbojet Engine, Tolerance, Combustion Engine.

### I. Introduction

Jet engines find extensive use across various applications, notably in aviation and energy production. Their design and assembly necessitate expertise spanning diverse disciplines, including Thermodynamics, Fluid Mechanics, and Mechanical Engineering. Building a contemporary jet engine demands the collective skillset of seasoned professionals from these fields. A modern jet engine stands as an engineering marvel, boasting precise spatial tolerances, resilience to extreme temperatures, and stress endurance.

Throughout its evolution, the jet engine has undergone substantial enhancements in performance,

efficiency, and reliability. Among the most prevalent types are turbo engines, turboprop engines, turbofan engines, turboshaft engines, and ramjet engines. While these engines vary in their specifics, they fundamentally operate on principles akin to internal combustion engines: involving stages of intake, compression, combustion, and exhaust.

### II. Types of Jet Engines

#### A. Turbojet Engines

The turbojet aircraft engine operates by drawing air in from the rear of the engine and compressing it within the compressor. Furthermore, fuel is introduced into the combustion chamber where it undergoes combustion, raising the temperature of the fluid mixture to approximately 1000 degrees.

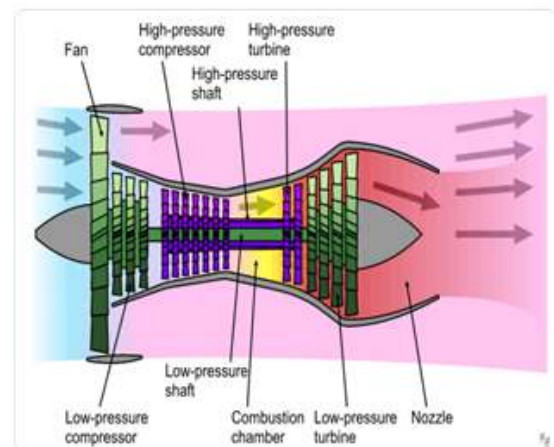


Fig 1.1 Turbo jet engine

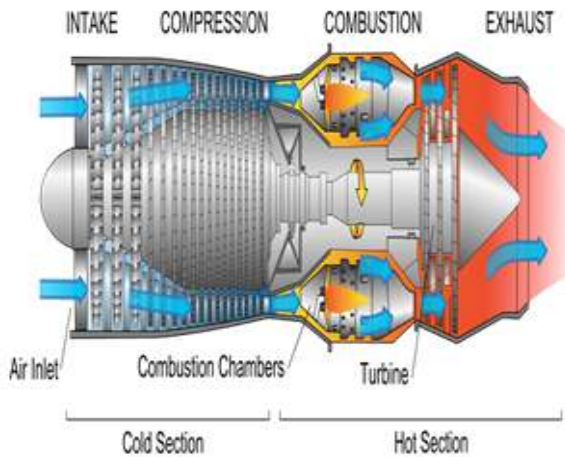


Fig 2.1 Turbofan jet engine

The process begins with the generation of hot air, which subsequently propels a turbine responsible for rotating the compressor. The pressure at the turbine's discharge typically exceeds atmospheric pressure, although this can vary based on the efficiency of the aircraft engine. This heightened pressure then moves toward the nozzle, generating gas streams that create thrust.

Moving on to turbofan engines, they feature a large fan at the front that draws in air. This design allows most of the airflow to circulate around the exterior of the engine, enhancing the aircraft's thrust even at lower speeds.

Today, turbofan engines power the majority of airliners. All incoming air passes through a generator within the engine, producing the necessary hot air. This generator comprises a turbine, combustion chamber, and compressor. However, only a small portion of the air that traverses the turbofan engine reaches the combustion chamber.

In contrast, a turboprop engine functions as a gas generator driving a propeller. The hot gases generated by the gas generator spin a turbine at the engine's rear, which, in turn, rotates a shaft connected to the propeller. Turboprop engines excel in low-speed flights and short-field takeoffs. However, as flight speed nears the speed of sound, these engines experience decreased efficiency due to a loss of aerodynamic effectiveness in the propeller

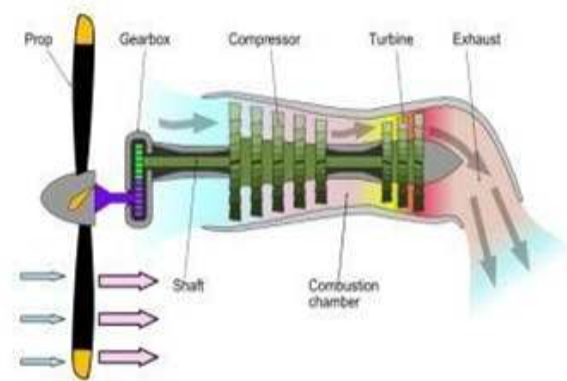


Fig 2.3 Turbo prop engine

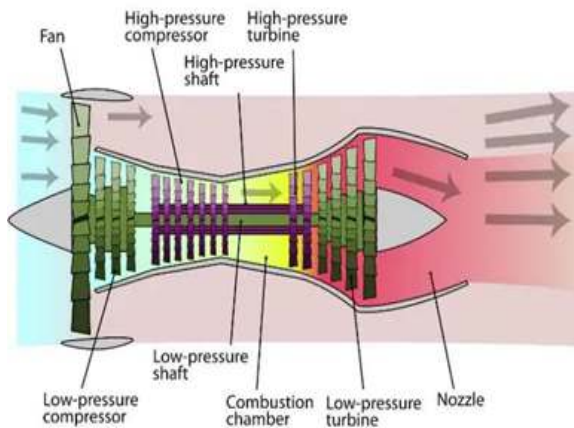
#### D. Turboshaft Engines

The final type among jet engines is the turboshaft, closely resembling turboprop engines. The key disparity lies in how power is transmitted: while turboprops channel power to the propeller, turboshafts direct it to a shaft. Typically, this shaft provides power to a helicopter. Similar to other jet engine variations, the gas generator process engages with the air, generating high-energy gases. Yet, in a turboshaft engine, a significant portion of this energy is harnessed to operate the turbine rather than generating forward thrust.

### III.WORKING OF TURBOJET ENGINE

A turbojet engine powers aircraft. These engines, known as air-breathing engines, draw in air from the atmosphere to facilitate combustion. They consist of several components including an inlet, compressor, combustion chamber, turbines, and nozzle. The process involves pulling air into the turbojet engine, compressing it, mixing it with fuel, and sustaining continuous combustion.

The exhaust resulting from this combustion drives the turbine, powering the compressor and generating thrust that propels the aircraft. Turbojets are utilized in larger aircraft due to their inefficiency at low speeds, whereas turboprops are preferred for smaller, slower planes. Additionally, turbofan engines boast better specific fuel consumption compared to turbojets. These engines are typically installed beneath the wings or positioned in close proximity to the fuselage.



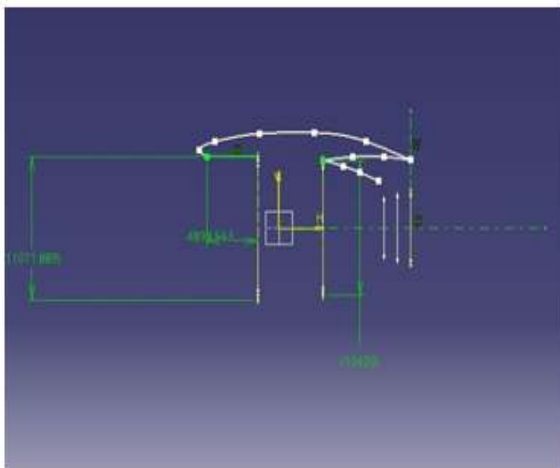
**Fig3.1: Turbojet engine and its components**

#### IV. DESIGN AND CALCULATIONS

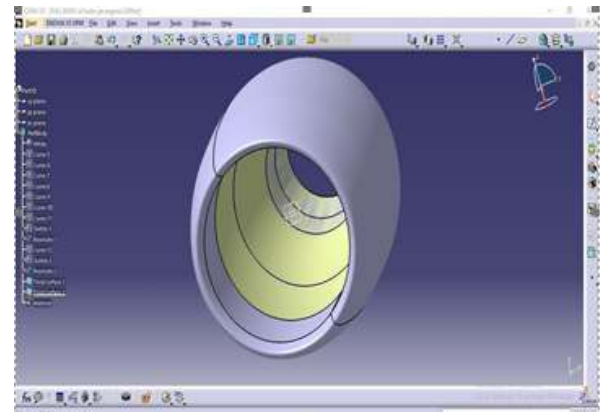
##### Stator or rotor casing

When you launch Catia V5, an interface will appear. Click on 'Start' to create a new part, then choose a plane (XY, YZ, ZX). An Etcher interface will pop up for 2D sketching. Use the line and spline commands to draw the profile of the turbojet engine stator.

Next, generate XY planes for sketching the curve profiles in the Sketcher Workbench. Exit the Sketcher Workbench and access the Sketch-Based Features. Select 'Pocket' to remove the necessary material and position it within the 3D model



**Fig4.1 Turbo jet engine stator or rotor sketch**



**Fig4.2 Turbojet engine casing**

Begin by selecting the sketch and using the line, profile, and spline commands to outline the desired shape. Once done, exit the sketcher workbench. Next, choose the drawn profile, opt for the shaft command, select the stator axis, and execute a 360-degree revolution around it. This action will create the profile shape around the stator axis.

Moving on to the rotor with blades:

When you launch Catia V5, an interface appears. Start by selecting 'start,' create a new part, and then choose any plane (xy, yz, zx). This action will prompt the 2D sketching interface. Utilize the line, spline, and profile commands to draw the profile for the turbojet engine rotor.

Calculations:

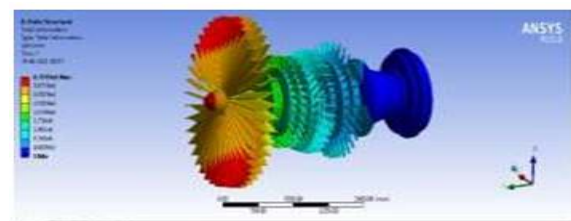
The assumptions made for the calculations include: I sentropic and adiabatic nature of compression and expansion processes. The working fluid being an ideal gas with a constant specific heat ratio.

Heat for combustion originates from an external source, with neglect of fuel mass.

Specifications: The compression ratio was established before the design phase. Additionally, ambient air temperature and pressure are known, along with an inlet Mach number.

Analysis: NSYS Workbench, a cutting-edge solution by ANSYS, offers robust methods to interact with the ANSYS solver functionality. This environment seamlessly integrates with CAD systems and the design process, delivering optimal CAE results.

ANSYS Workbench is comprised of five modules:



**Fig 4.3 Simuyltion result**

his process involves various tools within the ANSYS suite for structural and thermal analyses, including the ANSYS solver, CFX-Mesh, Design Modeler, Design Explorer, Design Explorer VT, and FE Modeler. To conduct the analysis, the following steps should be followed:

Launch ANSYS Workbench and open the Steady-State Thermal module.

Select Aluminum Alloy in the Engineering Data section. Import the geometry from CATIA software and perform model updates.

Carry out meshing with standard considerations.

Insert temperature loads and heat flux in the setup.

Specify parameters for results, such as temperature, total heat flux, and directional heat flux.

Initiate the solving process for results.

Integrate Static-Structural (SAMCEF) with Steady State Thermal to create a standalone Static Structural model connected to Steady State Thermal.

Apply loads—axial, radial, and tangential—and secure the base.

Include parameters for total deformation, Von-Mises Stress, normal stress, and shear stress for result analysis.

Solve for the desired results.

The figure presented demonstrates the Total Deformation of the Blade (Fig 5.1).

## Conclusion:

The structural and thermal analysis of the jet turbine engine under specified conditions yielded the following conclusions:

Comparison of total heat flux distribution among different materials revealed superior heat distribution characteristics in the heat-treated alloy compared to aluminum and titanium alloys.

Analysis of total deformations across various materials indicated the heat-treated alloy's ability to withstand heavy loads with reduced deflections.

Comparison of Equivalent Von-Mises Stresses displayed lower stresses in heat-treated alloys, showcasing their suitability for implementation.

Future Scope:

Detailed feasibility studies for each configuration considering practical aspects.

Attempting optimization of individual elements within different configurations.

Development of more refined mathematical models for realistic situations.

Enhancing cooling models.

Investigating alternative blade cooling techniques.

Exploring sophisticated cycle configurations for increased plant efficiency.

Studying the effects of inlet air-cooling through fogging and refrigeration systems.

## REFERENCES

- [1] Spittle, Peter. *Gasturbinetechnology*. Rolls-Royce plc, Coventry, 2003.
- [2] RollsRoyce. *The Jet Engine*, Renault Printing Co Ltd, Birmingham 1986.
- [3] Boyce, Meherwan P. *Gas Turbine Engineering*. Butterworth-Heinemann, Waltham, fourth edition, 2012.
- [4] Weston, Kenneth C. *Energy Conversion*. PWS Publishers, 1992.
- [5] Glenn Research Center (US). *General Thrust Equation* [Internet].
- [6] Sforza, Pasquale M. *Theory of Aerospace Propulsion*. Butterworth-Heinemann, Waltham, 2012.
- [7] Cengel, Yunus A. and Boles, Michael A. *Thermodynamics: An Engineering Approach*. McGraw-Hill, New York, eighth edition in SI units, 2015.
- [8] Kiameh, Philip. *Power Generation Handbook*. McGraw-Hill, New York, 2002.
- [9] International Journal of Engineering Research and General Science Volume 2, Issue 4, June - July, 2014
- [10] Ronald D. Flack. 2013. "Fundamentals of Jet Propulsions and Application" University of Virginia: <http://www.scribd.com>.
- [10] Changduk Kong, Jongha Park. "Transient Performance Simulation of Propulsion System for CRW Type UAV Using SIMULINK", Dept. of Aerospace Engineering, Chosun University,
- [11] George Kopasakis, Joseph W. Connolly, Daniel E. Paxson and Peter Ma. "Volume Dynamics Propulsion System Modeling for Supersonics Vehicle", Glenn Research Center, Cleveland, Ohio, 2008.
- [12] Jaya Chandran Kamaraj, "Modeling and Simulation of Single Spool Jet Engine", Master Thesis, University of Cincinnati, 2004.
- [13] Kirk J. Gomes, Konstanty C. Masiulaniec and Abdollah A. Afjeh, "Performance, Usage and Transient Simulation Comparisons Between Modelica (Dymola),

MATLAB/Simulink, 2008.

[14] <http://exploration.grc.nasa.gov>. "RocketExploration", 2013.

[15] Anderson, J.D., Aircraft Performance and Design, McGraw-Hill, Boston, 1999.

[16] Mattingly, J.D. Aircraft Gas Turbine Engine. In Elements of Gas Turbine Propulsion; McGraw-Hill: Singapore, 1996.

[17] Bammert, K., and Deuster, Status of closed cycle Turbine plant, ASME paper, 1974.

[18] Arthur H. Lefebvre, 'Gas Turbine Combustion', Hemisphere Publishing, USA 1983.

[19] Nikola Davidović, 'Mathematical Model of Turbojet Engine Combustion Chamber Primary Zone', May 2007.

[20] P.P. Walsh & P. Fletcher, 'Gas Turbine Performance', Blackwell Science, England 1998



Sridhar Bathina<sup>1</sup>, M.Tech Scholar from Department of Mechanical Engineering in Kakinada Institute of Engineering & Technology, Koringa.



Veeramani Aketi<sup>2</sup>, working as Assistant Professor in Department of Mechanical Engineering in Kakinada Institute of Engineering & Technology, Koringa. She is having an experience of 5 years.



Mahesh Dangeti<sup>3</sup>, Research Scholar in Department of Mechanical Engineering, from Acharya Nagarjuna University, Guntur