Turbojet Engine 3D Model (CATIA V5)

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Project Overview

This project involves the creation of a 3D model of a turbojet engine using CATIA V5. The primary purpose is to showcase proficiency in computer-aided design (CAD) and mechanical modelling skills. All components were modelled in CATIA V5's Part Design workbench using standard solid modelling tools. The design is based on assumed dimensions (not a replica of any specific engine), focusing on visual realism and proper proportions rather than precise engineering specifications. By building this model from scratch, the project demonstrates the ability to conceptualize and assemble a complex mechanical system in a virtual environment.

Objectives

- **Showcase CAD Skills:** Demonstrate advanced 3D modelling capabilities in CATIA V5 by building a complex assembly from the ground up.
- **Practice Turbojet Geometry:** Gain experience modelling typical turbojet engine components (fan, compressor, turbine, etc.) and understanding their geometry.
- **Apply Mechanical Design Principles:** Apply sound mechanical design practices (symmetry, alignment, proper feature use) throughout the modelling process to create a plausible engine layout.

Turbojet Engine – Basic Working Principle

A turbojet engine is a type of gas turbine engine that produces thrust by expelling high-speed exhaust gases. Its operation can be summarized in several key steps:

- **Intake:** Air is drawn into the engine through the inlet (front fan). The fan and initial compressor stages guide and accelerate the airflow inward.
- **Compression:** The air passes through a series of compressor blades that progressively squeeze (compress) the air into a high-pressure, high-temperature state. Compressors in turbojets are often multistage axial designs, meaning the air flows along the engine's axis through several rows of rotating blades and stationary vanes that incrementally raise the pressure.
- **Combustion:** The highly pressurized air enters the combustion chamber, which is mixed with fuel and ignited. The burning fuel-air mixture rapidly expands, producing hot, high-velocity gases.
- **Turbine:** The hot exhaust gases flow through turbine blades immediately after the combustion chamber. The turbines extract energy from the flow; as the gases push past the turbine blades, they cause the turbine (which is connected by a shaft to the compressor) to spin. This powers the compressor stages up front, sustaining the cycle.
- **Exhaust:** After passing through the turbine, the remaining hot gases are expelled out of the nozzle at the rear. The acceleration of these gases from the engine produces thrust in the opposite direction, propelling an aircraft forward. In a turbojet, virtually all the air goes through this core path, and the exhaust velocity is very high, generating the thrust directly (unlike turbofans, which have a bypass air stream).

This basic principle underlies the design of the model – with clearly defined sections for intake, compression, combustion (implied within the casing), turbine, and exhaust.

Design Breakdown

The turbojet model comprises several main components, each modelled and assembled to mimic a real engine's layout. Key components and the CAD approach for each are described below:

- **Intake Fan:** The front fan (large rotor at the engine inlet) is modelled with a central hub and multiple blades. A blade profile was sketched and extruded (using the Pad feature), then duplicated in a circular pattern to form the full fan wheel. The fan blades are coloured bronze/tan in the model, and a black spinner cap is placed at the centre front. This fan stage draws air into the engine and is the first compression stage.
- **Axial Compressors:** Behind the fan, multiple axial compressor stages are included. Each compressor stage consists of a row of rotor blades (and possibly stator vanes, though simplified in this model) that progressively compress the airflow. In the CAD model, one blade was created per stage (using sketches and Pad/Shaft features) and patterned in a circle to create a complete stage. Several stages of compressors are stacked in decreasing size further into the engine. For visualization, these stages are colour-coded (e.g., different stages shown in green, blue, red, and silver in the images) to distinguish one from another.
- **Combustion Chamber:** Air leaving the last compressor stage enters a combustion chamber in a real engine. This model represents the combustion section within the engine's central casing. While the internal details of the combustor are not explicitly modelled (no individual fuel injectors or flame tube details), the space allocated for combustion is between the compressor and turbine sections. The outer casing around this area (coloured pink in the model) has a slightly larger diameter, indicating where combustion would occur and the hot gases would expand.
- **Turbine Stages:** Immediately after the combustion region is the turbine stages. The turbine blades (smaller than the compressor blades and designed to withstand high temperatures) were modelled similarly by sketching blade profiles and revolving/extruding them, then using circular patterns. The model includes one or more turbine stages (coloured in contrast with compressor stages if applicable) that drive the compressor via the central shaft. These turbine wheels extract energy from the hot gas to keep the front stages running.
- **Central Shaft:** A long central shaft runs through the engine's core, connecting the turbine at the back to the compressor (and fan) at the front. This shaft was modelled using the Shaft feature (revolving a sketched profile along the engine's axis) or extruding a circle along the length. It ensures all rotating parts turn together. CATIA's axis system tools facilitated the alignment of features along this common axis to keep everything concentric.
- **Casing and Exhaust Nozzle:** The engine casing is the outer shell that holds everything together and directs airflow. In the model, the casing is represented by a tubular structure around the compressor/turbine core and a flared exhaust nozzle at the rear (both shown in pink/purple hues). These were created using revolved sketches (Shaft feature) to form

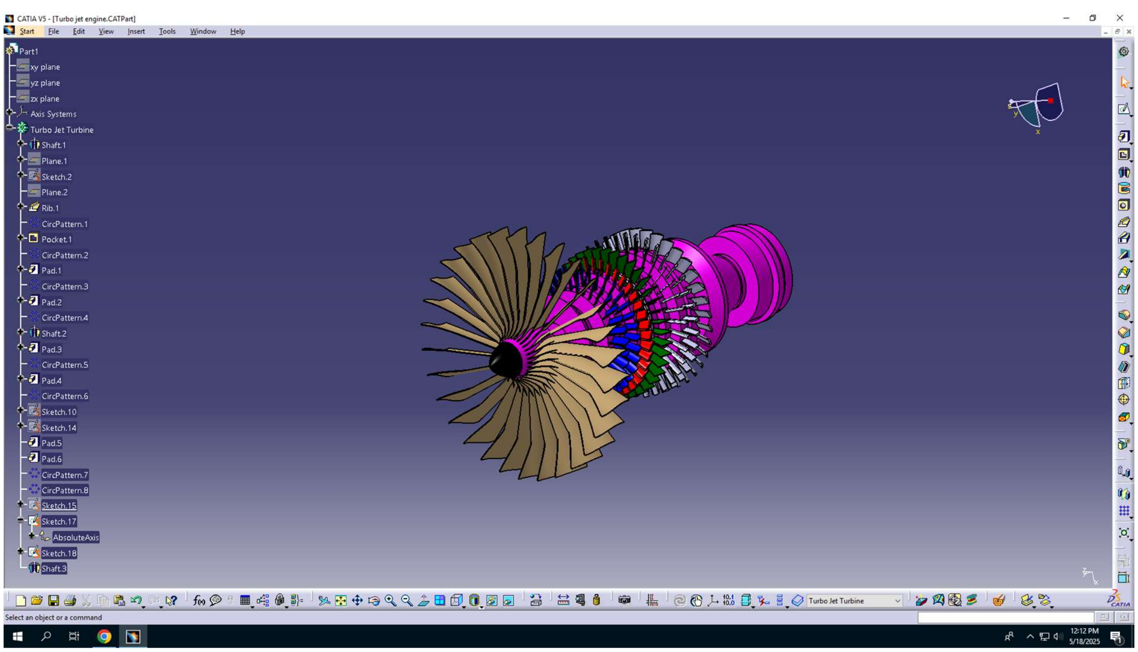
hollow shapes. The exhaust nozzle smoothly channels the exiting gases to produce thrust. Fillets and tapers might have been applied to mimic aerodynamic shaping. The casing not only gives the engine its shape but also illustrates how components are housed; in the model, the front of the casing around the fan is open to allow air intake, and the rear forms the nozzle for the exhaust jet.

- **Colour Coding & Visualization:** Different components are colour-coded throughout the design to enhance clarity. For instance, the fan blades are brown, the hub/spinner is black, compressor stages might alternate colours (green, blue, red, silver) to differentiate each stage, and the outer casing and exhaust are bright pink/purple. This colour coding makes it easy to separate the sections of the engine visually and is useful when presenting the model. An exploded or cross-sectional view was avoided since this is a single integrated model, but the chosen perspectives allow a clear look at internal parts. Additionally, the model leverages shading and lighting in CATIA for realistic visualization, and the screenshots were captured in isometric and orthographic views to best showcase the geometry.

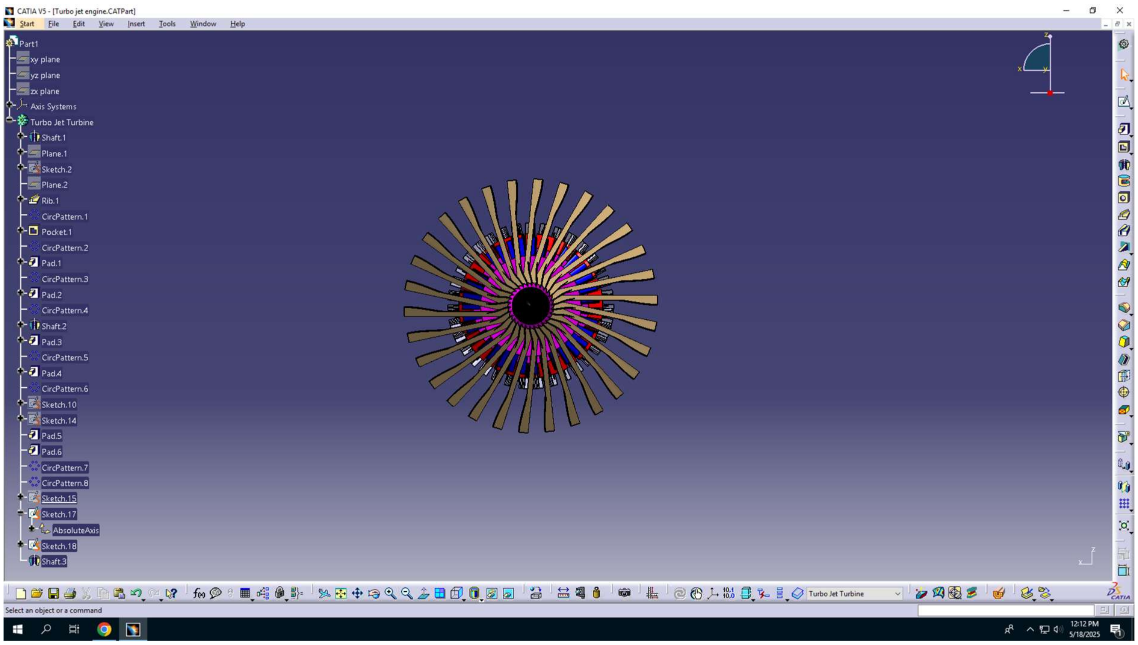
Visualization

Below are several views of the turbojet engine model captured from CATIA V5, demonstrating the overall design from different perspectives. A brief description accompanies each image:

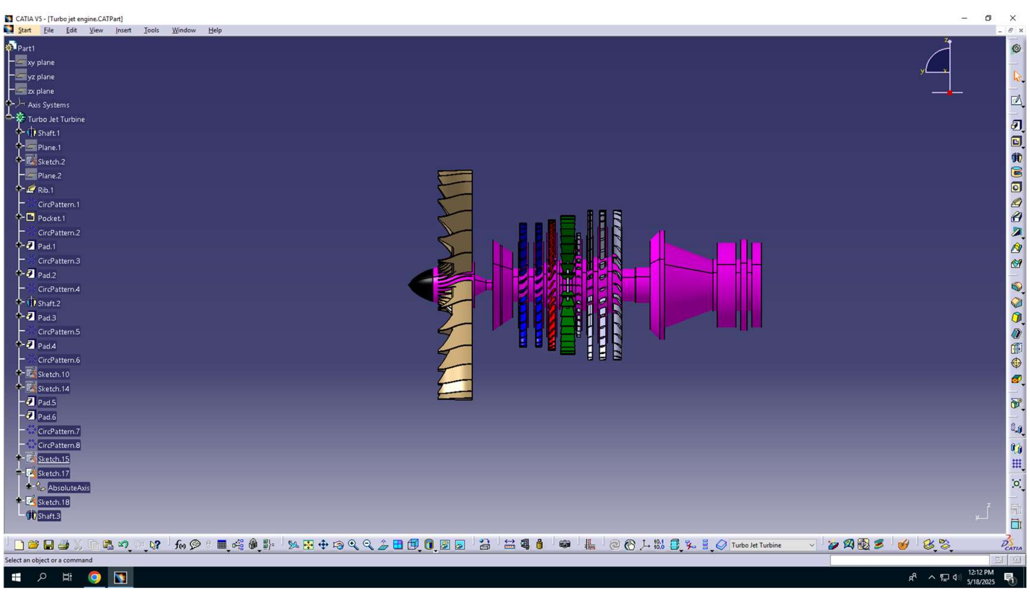
Isometric view *of the turbojet engine model, showing the complete assembly. In this view, the intake fan (foreground, with bronze blades and black hub) can be seen at one end, while the exhaust nozzle (pink structure) is at the opposite end. The multistage compressor and turbine core (multi-coloured discs and blades in the middle) are visible and aligned along the central shaft. This angled perspective highlights the components' spatial arrangement and the engine's general proportions.*



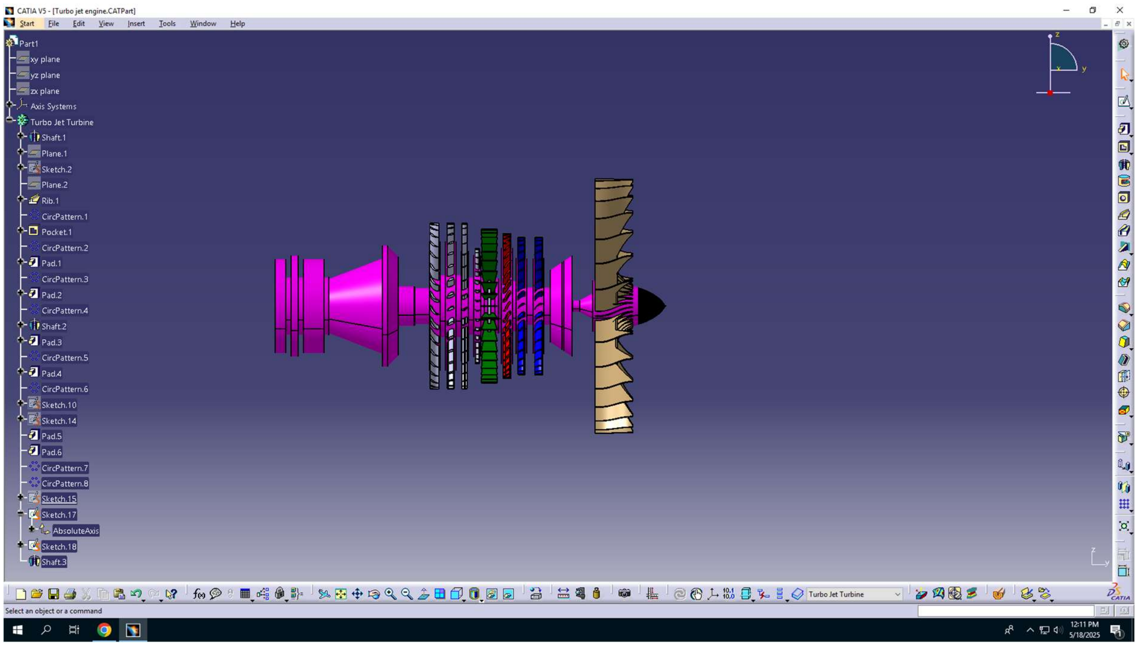
Front view *(intake end) of the engine model. The large fan blades are prominently visible in a circular array around the central spinner from this head-on perspective. The fan's 20+ blades (bronze-coloured) are evenly spaced, resulting from using a circular pattern in the CAD model. Behind the fan, you can glimpse the successive compressor stages (coloured rings) concentrically arranged and slightly obscured by the fan in front. This view demonstrates the symmetry of the design and how air would be drawn into the engine.*



Side profile view *of the turbojet model. Here, the internal arrangement of the engine is visible in a cutaway profile silhouette. On the left of this image (intake side) is the fan with its blades edge-on, followed to the right by the series of compressor stages (in various colours) and then the turbine and exhaust section (pink, at the far right/rear). All components are aligned co-axially, showing the straight-through flow path of the turbojet. This side view makes it easy to see the relative size of each section (the fan being large in diameter, compressors gradually tapering, and the exhaust nozzle narrowing down), illustrating a realistic engine proportion.*



Top view *of the turbojet engine model. The engine's layout can be seen above from this orthographic top-down perspective. The fan (to the right in this view) leads into the compressor core, and you can see the round profile of each stage's blades forming a symmetrical outline. The pink casing on the left (rear) end shows the exhaust outlet. The top view emphasizes the cylindrical form of the engine and confirms that all components are properly centred and aligned. It also highlights the uniform spacing achieved by the circular pattern feature for the blades, as their tips form neat concentric circles.*



(All screenshots were taken within the CATIA V5 environment, displaying the model tree on the left. This illustrates the feature-based modelling approach, where elements like pads, shafts, and patterns can be seen in the hierarchy.)

Tools and Skills Used

This project was a comprehensive exercise in 3D CAD modelling, utilizing various tools and techniques in CATIA V5:

- **CATIA V5 – Part Design:** Used as the primary CAD software and workbench for creating solid models of each engine component. All parts were built in a single CATIA file using parametric modelling features.
- **Sketching & Constraints:** 2D sketches were used to define the profiles of blades, discs, and casing cross-sections. Proper geometric constraints (tangencies, symmetries, dimensions) were applied to ensure sketches were accurate and could be easily adjusted if needed.
- **Feature Modeling (Pad, Shaft, Rib):** Standard Part Design features were employed extensively. The *Pad* feature (extrusion) helped create prismatic parts like blades and disk features. The *Shaft* feature (revolve) was used for all axisymmetric parts, such as the central shaft, hubs, and casing/nozzle shapes. A Rib (sweep) feature may have been used for any blades or fins that required a profile to be swept along a guide. These features allowed complex 3D geometries to be formed from simple sketches.

- **Circular Pattern (Radial Array):** The circular pattern tool was crucial for repeating blades around the hub. Instead of modelling each blade individually, one was created and then patterned around 360° to create a full wheel of blades for the fan, compressor, and turbine stages. This saved time and ensured perfect spacing and symmetry of blades.
- **Multi-Body Modeling:** The engine was organized into logical sections (fan, compressor, turbine, etc.), possibly using multiple bodies within the CATIA part. This approach makes it easier to manage different component groups and apply Boolean operations if needed. For example, one body could represent the rotor assembly, and another could represent the casing. Using a multi-body approach kept the design modular and flexible.
- **Axis Systems & Planes:** Custom axis systems and reference planes were defined to aid in positioning sketches and features. An engine has an axis-centric design, so establishing a central axis is vital for alignment. Planes were inserted at various locations (e.g., at each stage location) to sketch blade profiles or disk shapes. This ensured that features like compressors and turbines were aligned and correctly spaced along the length.
- **Mechanical Design Insight:** Beyond the CAD tools, fundamental mechanical design principles guided the model. This includes understanding how components fit together (e.g., the shaft running through and connecting rotating parts), the need for clearance between moving and static parts, and realistic proportions (the fan typically being the largest diameter, etc.). Although the model's dimensions are assumed, care was taken to make the design plausible from an engineering perspective. This attention to detail reflects an ability to think like an engineer while modelling.

Conclusion

Designing this turbojet engine model in CATIA V5 was a challenging and rewarding experience. It provided the opportunity to practice intricate 3D modelling techniques and reinforce knowledge of how a turbojet engine is structured. This project taught valuable lessons in planning a complex model (breaking the engine into manageable components), leveraging powerful CAD features like patterns and revolves to save time, and maintaining accuracy and symmetry throughout the design. The result is a visually detailed representation of a turbojet engine that can be showcased in a portfolio.

This project highlights personal growth in CAD proficiency – demonstrating the capability to take a concept from an idea to a detailed 3D model. By sharing this on platforms like GitHub and LinkedIn, the aim is to illustrate technical skills in CATIA and mechanical design and the enthusiasm for tackling complex engineering projects. It is an example of applying engineering principles in a virtual design, laying the groundwork for even more advanced modelling projects.