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Design Project Of 200-Seater Passenger Aircraft (Boeing 757)

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Abstract - The development of a 200-seater passenger aircraft represents a significant advancement in modern aviation, addressing the need for efficient, cost-effective, and environmentally sustainable air travel. This aircraft design balances passenger capacity with fuel efficiency, ensuring optimal performance for medium to long-haul flights. Incorporating cutting-edge materials, advanced aerodynamics, and fuel-efficient propulsion systems, the aircraft is designed to meet the increasing demand for air travel while minimizing environmental impact. The cabin layout focuses on passenger comfort, with enhanced seating arrangements, modern entertainment systems, and improved air quality. Additionally, the aircraft complies with the latest safety regulations and noise reduction standards, ensuring both passenger and crew well-being. This 200- seater aircraft aims to set a new benchmark in the airline industry by providing a sustainable and passenger-centric solution to the evolving demands of global aviation.

I. INTRODUCTION TO AIRCRAFT DESIGN

Aircraft design is a complex and multidisciplinary field that involves the development of safe, efficient, and functional aircraft capable of meeting specific operational requirements. It combines principles of aerodynamics, materials science, propulsion, structural engineering, and avionics to create a system that can safely transport passengers and cargo over varying distances and under diverse conditions.

The process begins with defining the mission requirements, including payload, range, speed, and operational environment. These parameters guide the selection of key design features such as the size and shape of the aircraft, its propulsion system, and its structural components. The design process involves iterative testing and optimization to balance performance, cost, and safety.

Aerodynamics plays a crucial role in determining how the aircraft moves through the air. Designers focus on minimizing drag and maximizing lift, ensuring efficient fuel usage and stable flight characteristics. The materials chosen for the aircraft must be lightweight yet strong enough to withstand the stresses of flight, and innovations in composites and alloys have significantly enhanced the strength-to-weight ratio of modern aircraft.

Another essential aspect of aircraft design is the integration of advanced technologies for flight control, navigation, and communication. Modern aircraft are equipped with sophisticated avionics systems that ensure precise operation, safety, and efficiency.

Ultimately, aircraft design is a collaborative effort that combines cutting-edge technology with strict regulatory standards to create vehicles capable of fulfilling the demands of commercial, military and private aviation. As the aviation industry continues to evolve, new trends in sustainability, automation and digitalization are reshaping the future of aircraft design.

2.INTRODUCTION TO 200-SEATER PASSENGER AIRCRAFT

A 200-seater passenger aircraft refers to an airplane designed to transport approximately 200 passengers. These aircraft are typically medium to large-sized commercial airliners used by airlines for short to medium-haul flights, although some can also be used for longer distances depending on their range and configuration. They are designed to balance fuel efficiency, passenger comfort, and operational costs while adhering to aviation regulations.

A 200-seater passenger aircraft, a common size for medium-range flights, typically features a narrow-body design with a single aisle, offering a balance of passenger capacity and fuel efficiency. These aircraft are often used for routes within a region or for some longer-distance flights.

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arrangements of 2-3 abreast, and can be powered by twin or triple engine configurations, depending on the model.

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Passenger Capacity:
These aircraft are designed to seat around 200 passengers, typically in a two-class (economy and business) or all-economy configuration.
The seating arrangement usually involves a 3-3 or 2-4-2 configuration in the economy class and a 2-2 configuration in business class.

Range:
Depending on the model and airline configuration a 200-seater aircraft can typically fly between 2,500 to 6,000 nautical miles.
It can be used for regional routes (e.g., domestic flights within countries) or for international flights to nearby regions (e.g., within the same continent).

Wingspan and Aerodynamics:
A wingspan typically ranges between 30 to 40 meters depending on the design.
The aircraft must be aerodynamically efficient to reduce drag and improve fuel economy while maintaining stable flight characteristics.

Engines:
These aircraft are usually equipped with 2 turbofan engines that provide the necessary thrust for take-off, cruise, and landing.
Modern engines are designed to be more fuel-efficient and environmentally friendly, reducing carbon emissions and operating costs.

Airframe:
The airframe is typically made from lightweight, high-strength materials such as aluminum alloys or composites, designed to withstand the forces of flight while reducing overall weight.
The aircraft will feature a fuselage designed for optimal aerodynamics, comfortable passenger seating, and easy loading/unloading of passengers and cargo.

Flight Systems:
Advanced avionics systems are included to ensure safe navigation, weather monitoring, and communication with air traffic control.
Fly-by-wire systems are commonly used in modern aircraft for smoother control and greater precision.

Examples of 200-Seater Aircraft:
Airbus A320: The A320 family, including the A320neo, typically seats around 150 to 240 passengers, making it a popular choice for airlines. It is used for both domestic and international routes.

Boeing 737: The Boeing 737, especially the 737 MAX 8 variant, can accommodate between 160 to 230 passengers, depending on the seating arrangement. It's one of the most common aircraft for short-to-medium- haul flights.

III.COMPARITIVE STUDY

A comparative study of 200-seater passenger aircraft involves examining several key factors such as seating configuration, fuel efficiency, performance, range, and operational costs. These factors influence the choice of aircraft for airlines depending on their routes (short, medium, or long-haul) and the specific requirements of passengers and fleet operations.

SPECIFICATION	BOEING 757-200	AIRBUS A320-200	AIRBUS A321- 200
Geometrical			
Length (m)	47.32	37.57	44.51
Height (m)	13.56	11.76	11.76
Aspect ratio	8.2	9.44	9.5
Wing span (m)	38.05	34.10	34.1
Wing area (m^2)	176.5	112.4	122.4
Total Seating Capacity	200	140	185
Crew	4	2	3
Wing Configuration			
Type of Wing	Low wing, tapered wing design with raked wingtips.	Low wing, tapered wing design with winglets.	Low wing, tapered wing design with winglets.
Specification of Weight			
Empty Weight	87000 kg (191800 lbs)	42000 kg (92594 lbs)	48500 kg (107800 lbs)
Fuel Weight	41150 kg (90700 lbs)	20300 kg (44800 lbs)	27200 kg (60000 lbs)
Take Off Weight	115680 kg (255000 lbs)	78000 kg (172000 lbs)	93500 kg (206000 lbs)
Performance			
Maximum Speed	850 km/h	828 km/h	840 km/h

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Mach Number	0.82	0.82	0.82
Range	7240 km (4500 miles)	6300 km (3900 miles)	5950 km (3700 miles)
Endurance	9-10 hours	7-8 hours	7-8 hours
Service Ceiling	42000 ft (12800 m)	39000 ft (12000 m)	39000 ft (12000m)
Take Off	2500 m (8200 ft)	2000 m (6600 ft)	2100 m (6890 ft)
Engine Configuration			
Engine Type	Rolls-Royce RB 211-535, Pratt & Whitney PW 2000	CFM56-5B, IAE V2500	CFM56-5B, IAE V2500
Payload (kg)	39800	19000	23800
Number of Engine	2	2	2

IV.SELECTION OF AEROFOIL WING

A wing is a type of fin that produces both lift and drag while moving through air. Wings are defined by two shape characteristics, an airfoil section and a planform. Wing efficiency is expressed as lift-to-drag ratio, which compares the benefit of lift with the air resistance of a given wing shape, as it flies. Aerodynamics is the study of wing performance in air.

CONFIGURATION OF AN AEROFOIL

An airfoil configuration is defined by its shape, including the leading and trailing edges, chord line, and camber line, which are crucial for generating lift and managing drag

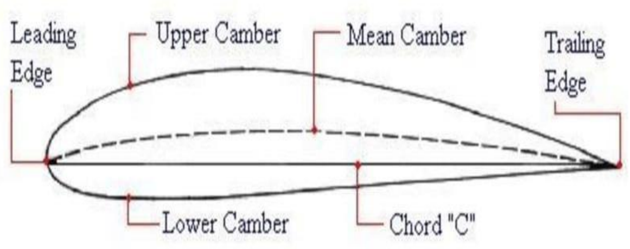

Fig 1: Configuration

during flight.

Leading Edge:
The front, rounded edge of the airfoil where the airflow first encounters the surface.

Trailing Edge:
The rear, often sharp or pointed, edge of the airfoil.

Chord Line:
A straight line connecting the leading and trailing edges, serving as a reference for airfoil geometry.

Camber Line:
The center line between the upper and lower surfaces of the airfoil, indicating its curvature.

Airfoil Shape:
The overall shape of the airfoil, which can be designed for different flight speeds and conditions.

Subsonic Flight: Airfoils for subsonic flight typically have a rounded leading edge.

Supersonic Flight: Airfoils for supersonic flight tend to be slimmer with a sharp leading edge.

Design Variables:
Airfoil configuration can be defined using B-spline curves with fixed points (leading and trailing edges) and flexible control points whose coordinates can be specified.

NACA Airfoils:
The National Advisory Committee for Aeronautics (NACA) developed a system for classifying airfoil shapes, with 4-digit airfoils defining the shape.
For example, the NACA 2408 has a 2% camber, the +maximum camber location is at 40% of the chord length and the airfoil is 8% thick.

NACA Airfoil Classification:
The NACA airfoils are typically represented by a 4-digit, 5-digit, or 6-digit code, with each digit or group of digits representing a specific feature:

4-Digit NACA Airfoils:
The 4-digit NACA airfoil is the simplest and most widely known. It is represented as NACA ABCD, where:
Maximum camber (as a percentage of the chord length).
The position of maximum camber (as a percentage of the chord length).
Maximum thickness (as a percentage of the chord length).
Not used for these airfoils (it’s always a zero).
For example, NACA 2412 means:
Maximum camber is 2% of the chord length.
Maximum camber is located 40% of the chord from the leading edge.
The maximum thickness is 12% of the chord length.

V.SELECTION OF AIRCRAFT

The fuselage is one of the main parts of a standard aircraft, along with the wings, landing gear, tail, and cockpit. A fuselage is essentially the “body” on an aircraft or, specifically, the large outer shell that encompasses the aircraft's main body.

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The fuselage is the main body or "core" of an aircraft, housing the crew, passengers, or cargo, and serving as the primary structure to which other parts like wings and tail are attached.

The fuselage is a core aspect of the aircraft and serves many purposes: Provides the shape and necessary aerodynamics for flight.

The aircraft fuselage is the main body of the aircraft, serving as the primary structure that supports and connects all other components, including the wings, landing gear, and engines. It provides space for the crew, passengers, cargo, and essential equipment. The fuselage shape and size are determined by the aircraft's intended mission and design requirements.

Structural Support:

The fuselage acts as the central backbone, holding all other parts of the aircraft together.

Payload Capacity:

It provides space for crew, passengers, cargo, fuel, and other necessary equipment.

Aerodynamic Shape:

The shape of the fuselage is crucial for minimizing drag and improving aerodynamic performance.

Weight Distribution:

The fuselage helps distribute the aircraft's weight and center of gravity.

Definition:

The fuselage is the central, tube-shaped body of an aircraft that houses the crew, passengers, or cargo, and protects them from the elements.

Function:

It provides the structural framework for the aircraft.

It accommodates the cockpit, passenger cabin, and cargo hold.

It serves as the point of attachment for wings, tail, engines, and landing gear.

It helps to maintain the stability and maneuverability of the aircraft by positioning the control and stabilization surfaces

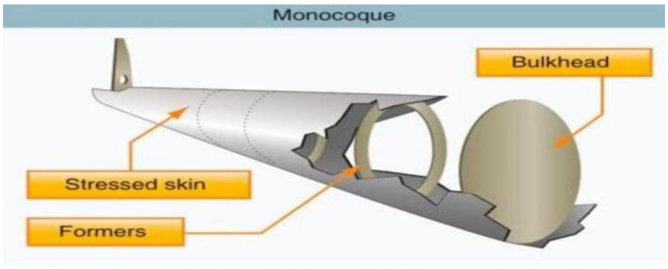

Fig 2: Monocoque

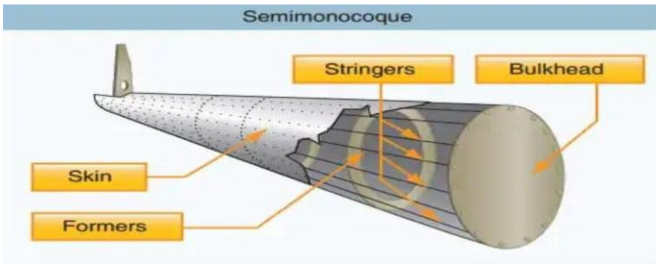

Fig 3: Semi Monocoque

VI.SELECTION OF POWER PLANT

For a 200-seater passenger aircraft, engine selection typically depends on several factors such as performance requirements, fuel efficiency, operating costs, and the aircraft's range. Some common engine options for this size class include:

CFM56 Series: Used on aircraft like the Airbus A320 and Boeing 737. Known for fuel efficiency and reliability.

LEAP-1A: A newer generation engine from CFM International, used on the Airbus A320neo series. It offers better fuel efficiency and lower emissions.

Pratt & Whitney PW1000G: Found on the Airbus A320neo series as well, this geared turbofan engine provides better fuel efficiency and lower noise.

Rolls-Royce Trent 7000: Used on the Airbus A330neo, offers high efficiency and performance for larger aircraft in this range

The power plant of an aircraft, also known as the engine, is the system responsible for producing thrust and power to propel the aircraft. It can be a variety of types, including reciprocating engines, turboprops, turbofans, turbojets, and even electric motors. The choice of powerplant depends on factors like aircraft size, speed, and intended use.

TURBO FAN ENGINE

Turbo fan engine, sometimes referred to as a fanjet or bypass engine, is a jet engine variant which produces thrust using a combination Of A turbofan jet core efflux and bypass air which has been accelerated by a ducted fan that is driven by the jet core.

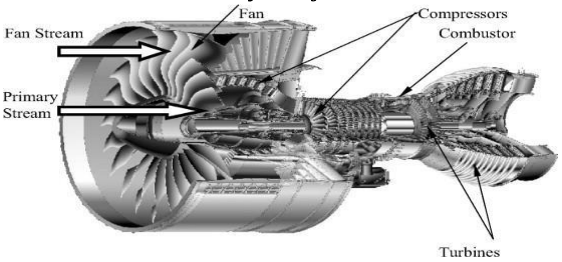

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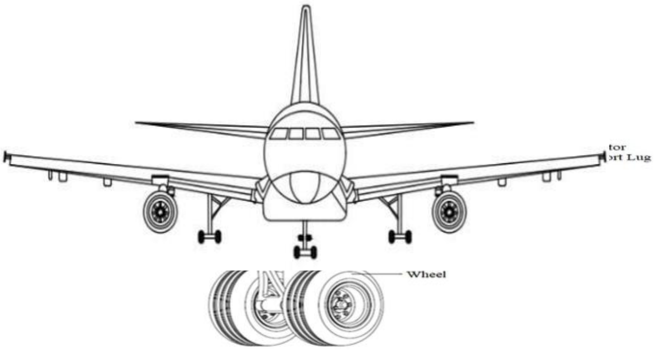
Fig 4: Turbo Fan Engine

Principle of turbofan engine

The turbine is a series of airfoil-shaped blades that are very similar to the blades in the compressor. As the hot,



high-speed air flows over the turbine blades, they extract energy from the air, spinning the turbine around in a circle, and turning the engine shaft that it's connected to.

VII.SELECTION OF LANDING GEAR

The wheeled landing gear on small aircraft consists of three wheels: two main wheels (one located on each side of the fuselage) and a third wheel positioned either at the front or rear of the airplane. Landing gear with a rear mounted wheel is called conventional landing gear.

Landing gear, also known as the undercarriage, is the system of wheels and struts that allows an aircraft to safely land, taxi, and take off. It includes the main gear and nose gear, which consist of various parts like struts, drag braces, and hydraulic actuators.

Components of landing gear

Shock Absorbers: Oleo-pneumatic struts or spring steel legs absorb the impact of landing.

Retraction Mechanisms: Hydraulic or electric systems move the gear up and down.

Steering: Allows the aircraft to steer on the ground.

Structural Members: Strong components that support the aircraft's weight.

Wheels and Tires: These provide the rolling contact with the runway.

Struts: These act as shock absorbers, absorbing the impact of landing and take- off.

Hydraulic Actuators: These control the extension and retraction of the landing gear.

Brakes: These are essential for stopping the aircraft on the ground

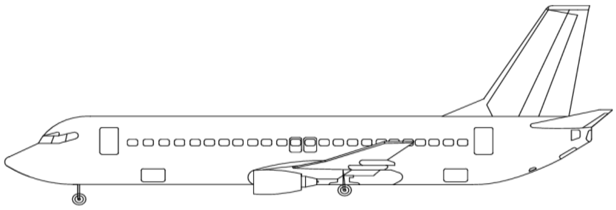
Drag Braces: These provide additional structural support and help to control the movement of the landing gear.

Fig 5: Landing Gear

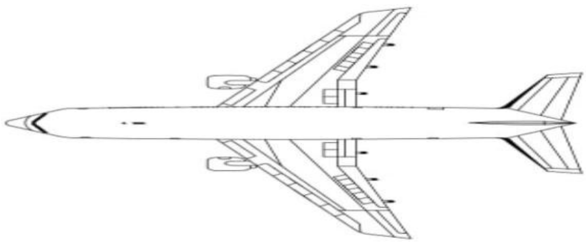
VIII.THREE VIEW DIAGRAM

FRONT VIEW

SIDE VIEW



TOP VIEW



IX.CONCLUSION

The Boeing 757 stands as one of the most successful narrow-body, mid-size airliners in aviation history. First introduced in the early 1980s, it combined efficiency, power, and range, making it a favorite among airlines for both domestic and transcontinental routes. With its advanced aerodynamics and reliable performance, the 757 played a crucial role in shaping medium-haul air travel. Though production ended in 2004, the aircraft remains in active service around the world due to its durability and versatility, proving its long-lasting impact on commercial aviation. The Boeing 757-200, a twin-engine narrow-body aircraft, is a versatile and reliable workhorse of the aviation industry, known for its fuel efficiency, long range, and ability to operate from shorter runways. It has proven successful in both passenger and cargo roles, with many passenger versions converted to freighters. Its popularity among pilots and its enduring presence in airline fleets highlight its continued value in the aviation market.

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