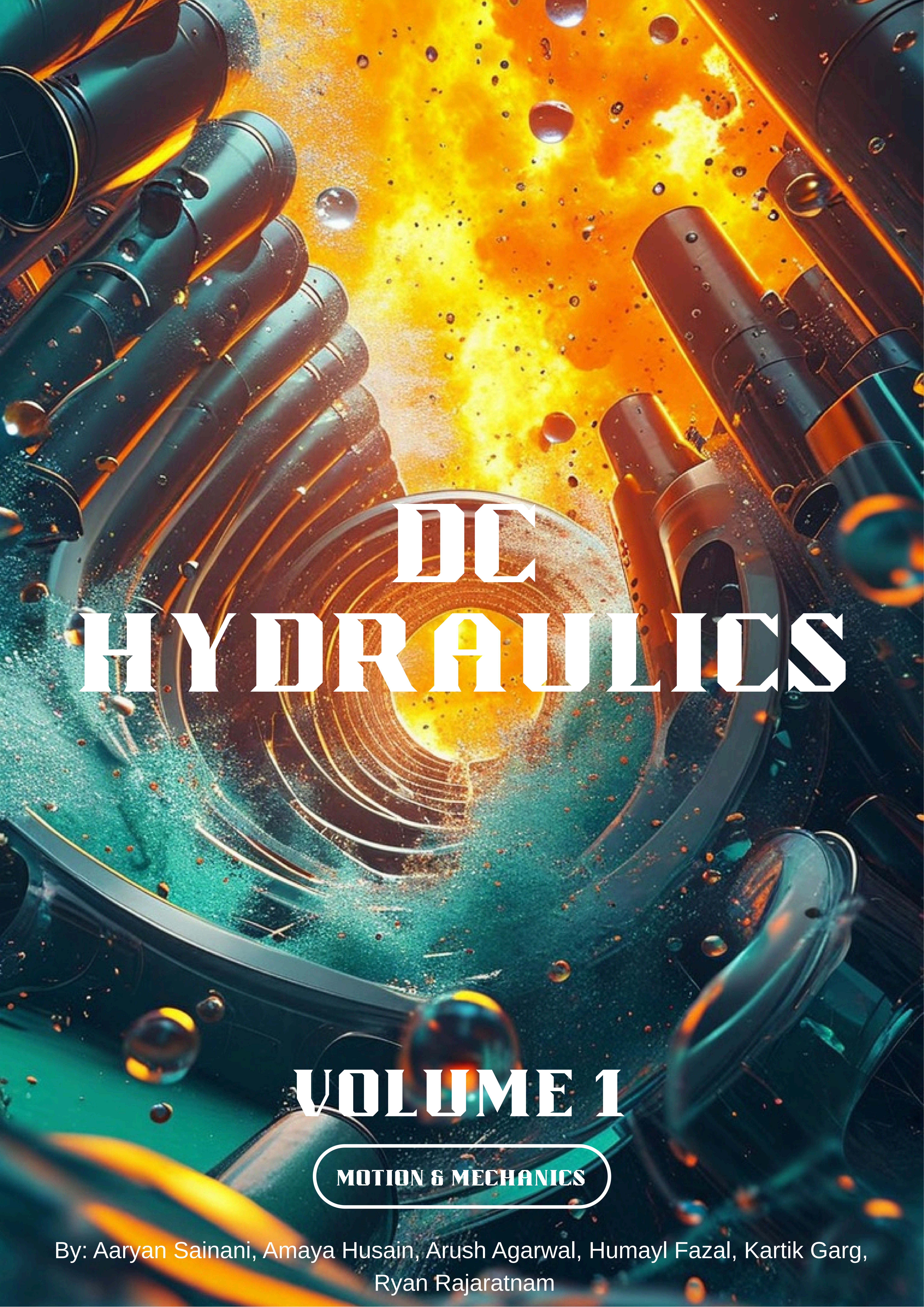


DC HYDRAULICS

VOLUME 1

MOTION & MECHANICS

By: Aaryan Sainani, Amaya Husain, Arush Agarwal, Humayl Fazal, Kartik Garg, Ryan Rajaratnam

CONTENTS

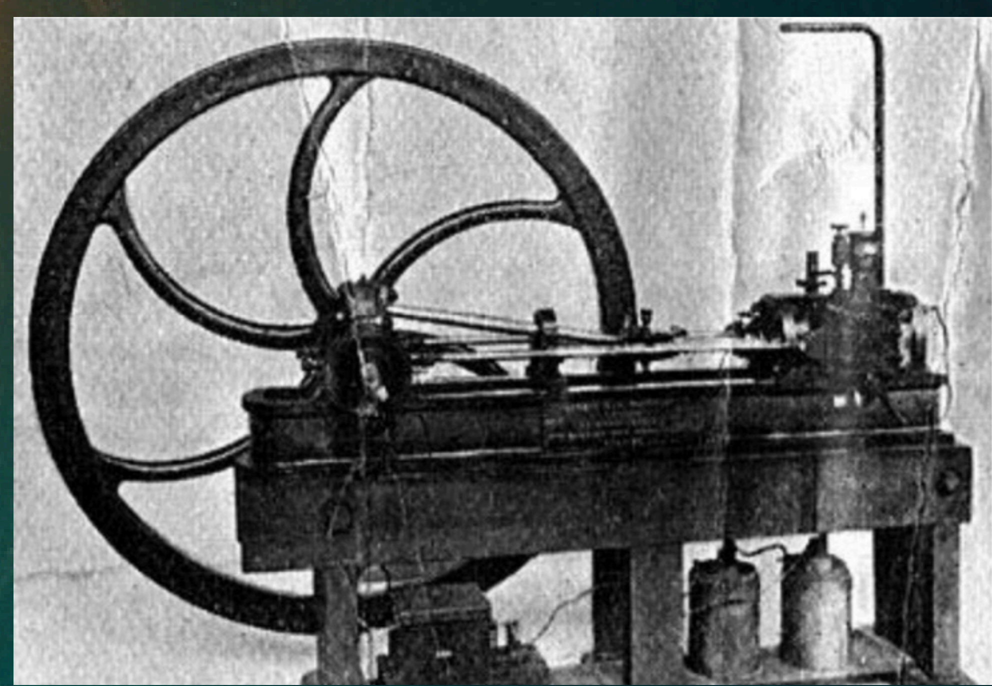
THE EVOLUTION OF MECHANICAL ENGINEERING

Mechanical engineering has shaped the world around us, from the industrial revolution to the cutting-edge technologies of today. It is the art and science of designing, building, and improving machines and systems that make our lives easier and more efficient. But how did we get here?

The Birth of Mechanical Engineering: The Steam Engine Era

The roots of mechanical engineering can be traced back to ancient civilizations where simple tools like levers and pulleys were developed. However, the field truly took off during the Industrial Revolution in the 18th century with the invention of the steam engine.

A steam engine operates by converting heat energy from steam into mechanical work. How it works:



Boiling Water to Create Steam: Water is heated in a boiler until it turns into steam.

Expansion of Steam: The steam enters a cylinder and pushes a piston.

Piston Movement: The piston moves back and forth, transferring energy to a connecting rod and a crankshaft.

Conversion to Rotational Motion: The crankshaft converts the linear motion of the piston into rotational motion, which can power machinery.

James Watt's improvements to the steam engine in the late 1700s allowed factories to run machinery and locomotives to transport goods. Watt's addition of a separate condenser to the steam engine greatly improved its efficiency by preventing the loss of steam during each cycle. This innovation reduced fuel consumption and allowed steam engines to be more practical for industrial use. His work laid the foundation for modern mechanical engineering practices, including thermodynamics and machine design. At this time, engineers focused on thermodynamics and materials science to create stronger and more durable machines. Factories and transportation systems expanded rapidly, laying the foundation for modern industry.

The Age of Industrialization: Gears and Machines

In the 19th and early 20th centuries, mechanical engineers began designing more complex machines, including internal combustion engines and automobiles. Henry Ford's assembly line revolutionized manufacturing, making cars affordable and

By enforcing the idea that each worker focuses on a particular part in the production of cars, he was able to increase the quality and efficiency of his work while simultaneously reducing costs. Engineers developed more accurate measurement tools and quality control systems to ensure parts fit seamlessly, reducing variability in production as they became specialised in their tasks.
The efficiency gains from Ford's assembly line not only transformed the automotive industry but also influenced manufacturing processes across various sectors. By standardising parts and implementing interchangeable components, Ford streamlined production, minimising waste and improving overall reliability.

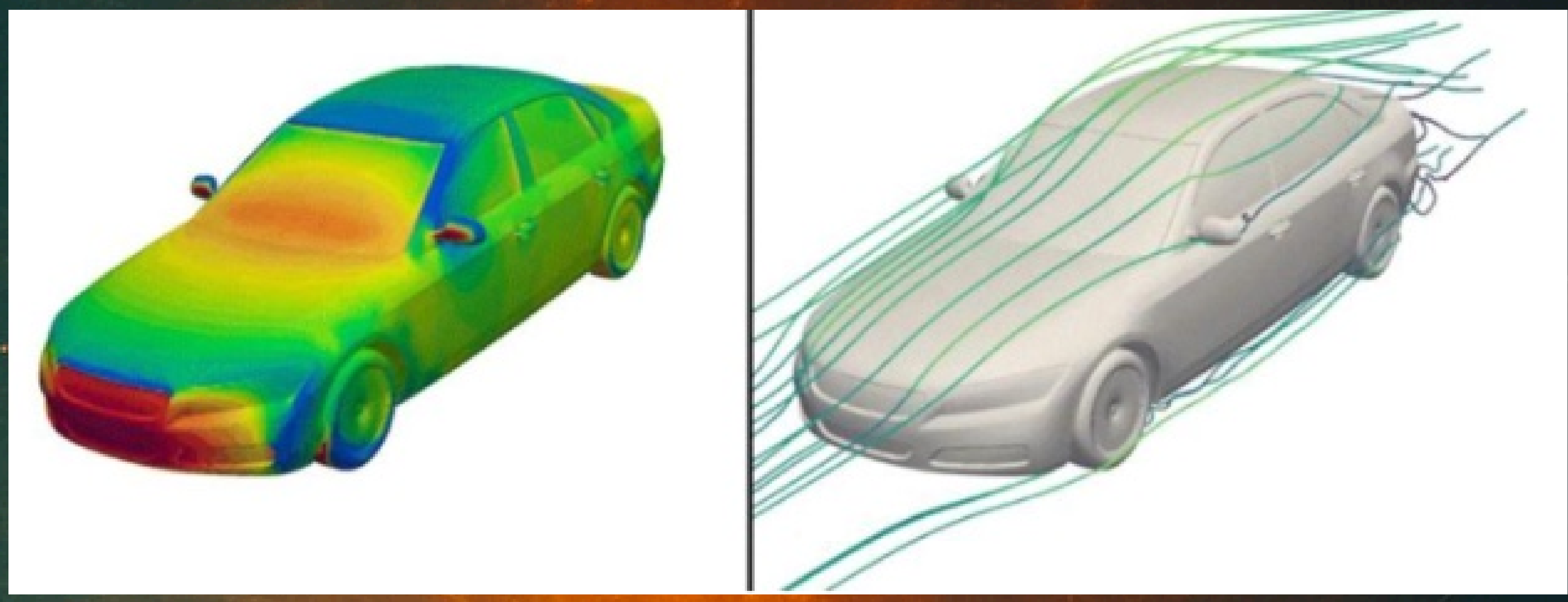
The Digital Revolution: Robotics and Automation

The latter half of the 20th century brought about the integration of mechatronics—a multidisciplinary field combining mechanical engineering, electronics, computer science, and control engineering. Engineers began designing robots for manufacturing, such as the robotic arms used in car assembly lines. The invention of Computer-Aided Design (CAD) and computer-aided manufacturing (CAM) software allowed engineers to create precise 3D models of their designs, allowing engineers to create and test models in virtual environments before physical production, thereby reducing errors and costs.
This integration led to the development of automated systems and robotics, transforming industries like automotive manufacturing, where robots began performing tasks with speed and precision beyond human capabilities. This led to parts increasing significantly in quality due to the reduction in human error.
Advancements in materials science led to the development of lightweight and durable materials like carbon fibre and titanium alloys, which improved the performance of aircraft, spacecraft, and high-performance cars.

The Modern Era: Autonomous Systems and Artificial Intelligence

Today, mechanical engineering is at the forefront of innovation. Engineers are designing autonomous systems, such as self-driving cars and drones, which use sensors, cameras, and AI algorithms to navigate the world without human intervention.
For instance, researchers at the Massachusetts Institute of Technology (MIT) have utilized AI to design more efficient and eco-friendly vehicles. By analysing extensive datasets of 3D car models, AI can quickly generate and evaluate new designs for improved aerodynamics, reducing development time and costs. [3]

These advancements not only enhance performance but also contribute to sustainability by optimizing fuel efficiency and reducing emissions.



The Future: What’s Next for Mechanical Engineering?

The journey of mechanical engineering from steam engines to autonomous systems reflects a continuous pursuit of innovation and improvement. Each era built upon the last, integrating new technologies and methodologies to address the evolving needs of society. As we move forward, mechanical engineers will undoubtedly continue to play a crucial role in developing technologies that shape our world. From the steam engine to autonomous robots, mechanical engineering has come a long way. With creativity and innovation, the next generation of engineers will tackle global challenges and build a more efficient and sustainable world.

HOW DOES AN INTERNAL COMBUSTION ENGINE WORK?

What is an internal combustion engine?

Internal Combustion Engines (ICEs) are a type of heat engine that is used extensively in transportation, and are the primary power source for airplanes, trains and automobiles [1] . The engine works by converting chemical energy from fuel into thermal energy, which in turn is converted into mechanical energy. This can then be transferred to the kinetic energy store of vehicles, which allows for them to move. Chemical energy in fuel is converted to thermal energy by combustion, which is the exothermic reaction between a Hydrocarbon and Oxygen. This produces Carbon Dioxide, water and thermal energy [2]. Figure 1 shows the complete combustion of Octane (fuel used in cars) with oxygen to produce Carbon Dioxide and water in an exothermic reaction. The Carbon Dioxide and water produced are side products of the reaction and have detrimental effects on the environment.

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$$

Figure 1

Operation of an internal combustion engine

Gas internal engines are extremely common and are used in most cars in the Middle East. A gas internal combustion engine has many key components to allow it to produce energy:

Cylinder – The cylinder is a sealed container in which the combustion of fuel occurs. It contains a mixture of air and fuel, which contains enough oxygen for the fuel to burn [3].

Piston – Each cylinder also has a piston, which moves up and down in a reciprocating motion. When the fuel is ignited and the air in the cylinder expands, the piston is pushed down. The piston then moves up to compress air in the cylinder so that it is ready to be ignited.

Crankshaft – The crankshaft is responsible for converting the linear motion of the piston into rotational motion, which can allow for wheels on a car to turn or the turbines on a jet engine to turn. The crankshaft is held in place by main bearings, which allow for it to rotate within the engine block.

Valves – The intake valve is responsible for regulating the flow of the air-fuel mixture that enters the cylinder. The exhaust valve is the used to expel exhaust gases like Carbon Dioxide from the cylinder.

Spark Plug – The spark plug is used to ignite the air-fuel mixture in the cylinder. It contains two electrodes separated by an air gap. Current then discharges across the electrodes through a spark, which ignites the fuel. The electrodes must be able to withstand the high temperatures of combusting fuel [4].

Fuel Injectors – The fuel injectors are responsible for adding fuel into the cylinder. They can control the proportions of air and fuel in the cylinder.

Four-Stroke Cycle

The four-stroke cycle is the engine cycle that most internal combustion engines use, although Porsche has recently developed a more efficient 6-stroke system. This system is not in use yet, so it won't be covered, but it has been patented.

Intake Stroke

During the intake cycle, the piston moves downwards to bottom dead centre (BDC), which creates an area of low pressure in the cylinder. The BDC is the lowest point of the piston's movement. At this time, the intake valve is also open, so atmospheric pressure forces the air-fuel mixture into the open valve and into the cylinder [5]. The cylinder continues to fill slightly past BDC, and the valve stays open a few degrees of crankshaft rotation after BDC. The intake valve then closes, and the cylinder is sealed.

Compression Stroke

The trapped air-fuel mixture is then compressed in the cylinder and sealed to form the charge. The charge is the volume of compressed air and fuel that is ready for ignition in the combustion chamber. Compressing this mixture allows for more energy to be released when the charge is ignited. The intake and exhaust valves must be closed to ensure that the cylinder is sealed to provide compression. The flywheel, which is attached to the crankshaft, provides the needed momentum for the piston to move towards top dead centre (TDC), which allows for air to be compressed. Top dead centre is when the piston is at the very top of its motion. Work is done by the piston to compress the air, which increases the temperature of the air-fuel mixture.

This causes the air-fuel mixture to increase in temperature and causes increased fuel vaporisation. This leads to faster combustion since the higher temperature increases the rate of reaction. Additionally, the increase in fuel vaporisation will increase the surface area of the droplets of fuel. This means that there will be a more complete burning of the fuel, which will increase the efficiency of the engine. The more the fuel molecules are compressed, the more energy is released from combustion since the energy needed to compress the charge is much less than the energy released from combustion.

The compression ratio of an engine is the ratio of the volume of the cylinder with the piston at BDC to the volume of the cylinder with the piston at TDC. The higher the compression ratio, the more efficient the engine, since this provides a higher combustion pressure on the piston. However, engines with a high compression ratio will often need more effort from the user to start up.

After the compression stroke, the charge is then ignited by the spark plug. This causes hot and rapidly expanding gas in the cylinder to force the piston to BDC. The spark plug initiates combustion at approximately 20 degrees of crankshaft rotation before TDC. The fuel vapour reacts with atmospheric oxygen to combust, and the oxygen is then burned by the flame front. The flame front is the boundary between the combustion by-products and the charge. The flame front progresses through the whole cylinder in a very small amount of time until all of the fuel is burned.

Power Stroke

The power stroke is when the motion of the piston is transferred through the connecting rod to apply torque to the crankshaft, which causes rotation. At this point, both valves are closed to prevent a loss of pressure on the piston.

Exhaust Stroke

The exhaust stroke is when the excess gases are forced out of the system and released into the atmosphere. This is the final stroke of the cycle and occurs when the exhaust valve is open and the intake valve is closed. As the piston moves, the exhaust gases are forced out of the cylinder. The piston moves up due to the inertia of the flywheel, which allows to piston to move to TDC.

There are three main types of combustion engines: gas engines, diesel engines and turbines. Gas engines are most used for cars and use the system described previously. Diesel engines are more rugged and durable than gas engines and offer better efficiency. These engines operate differently to gas engines since they don’t use a spark plug. Instead, these engines inject fuel directly into hot air in the cylinders.

Lastly, the turbine engine works by the engine sucking in air through its turbines. A compressor then increases the pressure of the air so that more force is produced when the fuel is burned. The compressor consists of blades attached to a shaft that spin at high speed to compress the air. Fuel is then sprayed into the compressed air, which then combusts when ignited with a spark. The burning gases then expand rapidly and are forced out of the back of the engine at high speed. This causes the aircraft to be thrust forward [6].

Conclusion

Overall, internal combustion engines are a revolutionary invention and are integral to the function of modern society. The invention of the four-stroke engine in 1876 paved the way for the first automobile to be created by Karl Benz in 1879. This led to the rise of vehicles and also led to the creation of diesel and turbine engines. Engines are now an invaluable feat of engineering, with them now being used extensively in transportation and are one of the greatest inventions in recent history.

THE HISTORY OF THE TELEPHONE: FROM TIN CUPS TO TOUCHSCREENS

Did you know there are 10 billion more phones in the world than people? (That's 18 billion phones!) Obviously, in the modern age we're in, this is mostly made up of smartphones. However, these complex communication devices weren't always less than a centimetre thick.

While you might think that Alexander Graham Bell created the first phone, Italian innovator Antonio Meucci created the original basic phone that could communicate. He designed the phone as a way of communicating with his wife, who was ill. It was an electromagnetic phone that originally worked with one person putting a copper wire in their mouth, and the receiver putting the end of the wire near their ear.

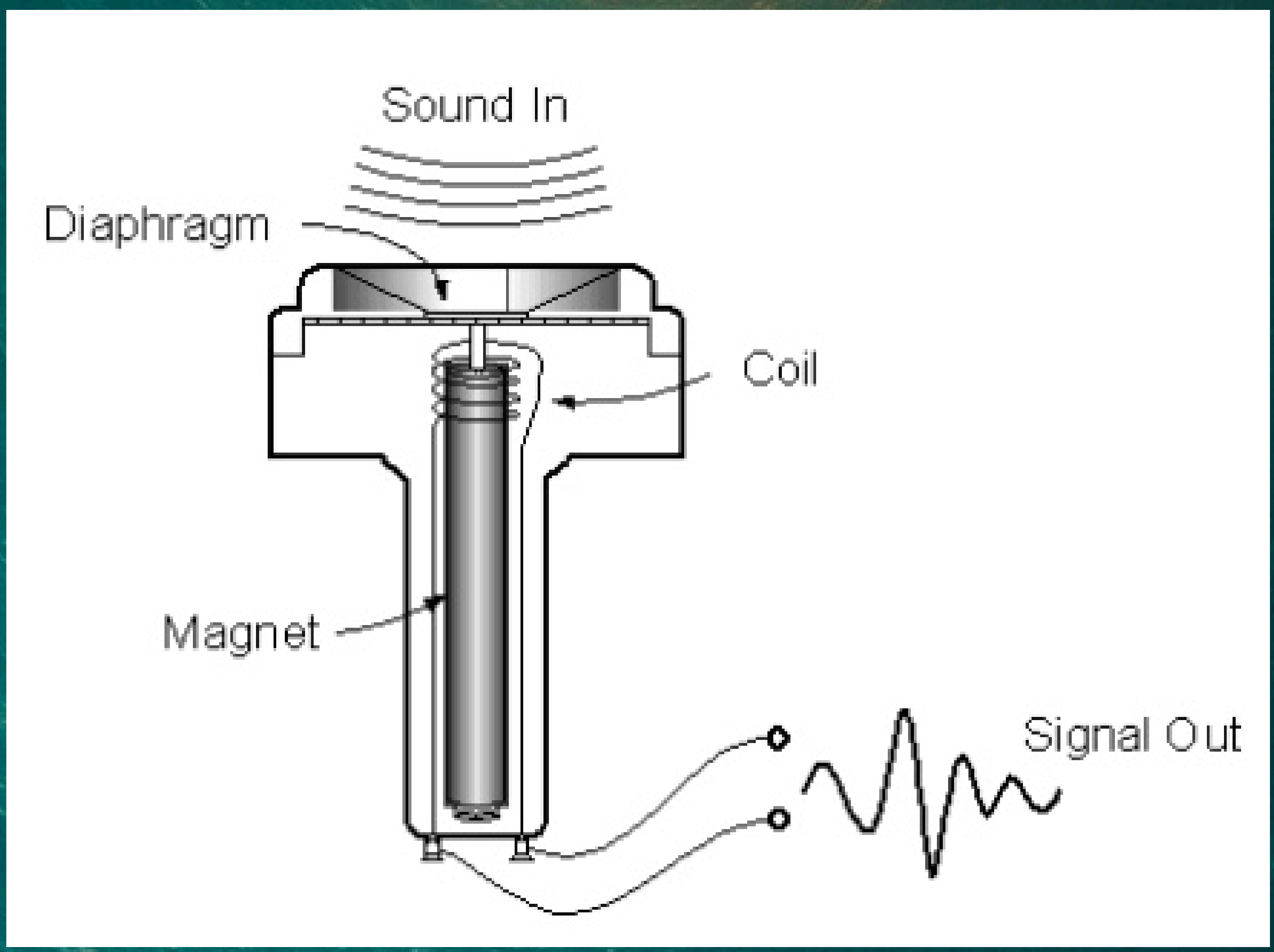
However, Meucci's first test of this harmed his patient, so he set out to find a way to communicate over wires, without an electric shock. There was a vibrating diaphragm (a thin disc used in telephones that magnifies sound) and a magnet that was electrified by a spiral coil around it. The vibrations changed the current of the magnet, which would recreate the sound from the beginning of the wire and carry it to the end.

You may have done something similar when you were younger: making a phone with 2 strings and a cup. The way this toy works is through vibrations and sound waves. The sound waves travel through the air, which turn into vibrations at the cup. The string carries these vibrations as longitudinal waves (the particles move back and forth in the direction of the wave). Then, when the vibrations reach the end of the cup, they turn back to sound. Essentially, Antonio Meucci's is the same. The sound waves are inputted through one end, and the sound is converted into electrical signals, using the magnet and coil. The signals travel through the wires, then get converted back into sound waves!

Between 1856 and 1870 (14 years), Antonio Meucci developed more than 30 different kinds of telephones based on his prototype!

In 1871, Alexander Graham Bell, started working on a harmonic telegraph, which was a device where multiple messages could be transmitted over a wire at the same time. While experimenting with this technology, Bell wanted to find a way to send human voices over wires. Over the next 5 years, Alexander Graham Bell invented his ‘speaking telegraph’, as he called it. In 1876, he earned the first US Patent for his phone. In 1877-78, the first telephone line was created, the first switchboard (s a manual system where operators connected phone calls by plugging wires) was constructed, and the first telephone conversation was a success! In the next three years of this invention, almost 49,000 telephones were in use!

His phone was constructed in a very similar way to Meucci’s. There were two main parts. A transmitter and a receiver. The transmitter consisted of 3 parts. A needle, a battery and a device that worked like a drum, which was a cylinder with a closed end. When Bell spoke into the open end, the diaphragm and the drum-like device made his voice vibrate the paper and needle. The vibrations changed into electric currents and travelled down the wire into the receiver (like Meucci’s phone), where the sound came out. On the left is a diagram explaining Bell’s phone.



Some decades ago, there were corded phones (landline phones), and later cordless phones. Landline phones originally used dials, but phones with buttons became popular later. The corded phones sent electrical signals, after you dialled a number, through copper wires to a telephone exchange (a telephone system which was normally operated by multiple people in an office, for one small area). Then, the electrical signals would get converted back into your voice, to the receiver.

With the cordless phone, you first had to dial a number on the handset. This sent a radio signal to the base station. The base station, connected to the landline through a phone jack, transmitted the call through the telephone network. When you spoke into the handset, your voice was converted into a radio wave and sent wirelessly to the base station, which then transferred the signal through the landline to the recipient. Sound from the other person travelled back through the phone line to the base station, which converted it into a radio signal and sent it to the handset, allowing you to hear the other person.

Nowadays with cell phones, a person dials a number, and the phone converts that to electric signals wirelessly to the nearest cell tower. The cell tower links the call to the other person. On a smartphone, calls are handled via cellular networks (4G/5G) or Wi-Fi, while internet-based calls (like WhatsApp or Zoom) use VoIP technology. On a smartphone, calls are handled via cellular networks (4G/5G) or Wi-Fi, while internet-based calls (like WhatsApp or Zoom) use VoIP technology.

And that’s the history of the telephone, from a small trinket to a corded phone to the newest iPhone!

Emaan Khan

THE HISTORY AND PRACTICAL APPLICATION OF SOUND WAVES IN ENGINEERING

Sound waves are a type of mechanical that propagates through a medium, caused by the vibration of an object. They are longitudinal waves that move in compressions and rarefactions.

When an object vibrates, it moves forwards and backwards, disturbing nearby air molecules.

Due to the forwards movement, the air molecules around the object group together in a region of concentrated air molecules to become a compression. As these air molecules move outwards from the object, they collide with other air molecules and their energy is transferred to them. This causes the region of compression to move outwards, away from the object, and the energy is transferred through the air.

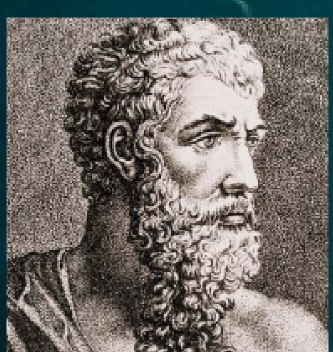
Additionally, the backwards movement causes a region of lowly concentrated air to form, where fewer air molecules are present in this space, which is called a rarefaction. These molecules have less energy so when they collide with other air molecules, they also move with low energy.

History of sound waves

PYTHAGORAS – GREEK MATHEMATICIAN AND PHILOSOPHER

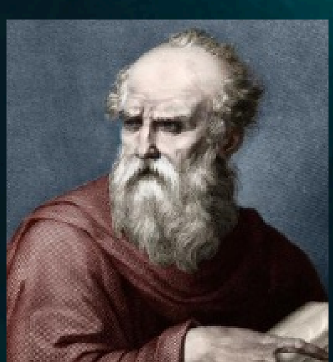
- Discovered the 1st law of strings (law of length): the fundamental frequency of vibrations of a string is inversely proportional to the length of the vibrating string, if tension and mass per unit length are constant.
- 500 BC

ARISTOTLE – GREEK PHILOSOPHER AND POLYMATH



- Correctly suggested that sound waves propagate in the air due to the motion of the air itself.
- 340 BC

VITRUVIUS – ROMAN ARCHITECTURAL ENGINEER



- Contributed to the acoustic design of theatres, enhancing propagation of sound waves by constructing curved rows, sloped theatres and masks with megaphone-like qualities.
- 500 AD

GALILEO GALILEI – ITALIAN POLYMATH

- Credited with the modern study of waves and acoustics.
- Elevated the study of vibrations and the correlation between pitch and frequency of the sound source.
- 1600 AD

MARIN MERSENNE – FRENCH MATHEMATICIAN

- Conducted the first experiments to determine the speed of sound in air.
- Discovered the 2nd law of strings (law of tension): the fundamental frequency of vibrations of a string is directly proportional to the square root of its tension, if the vibrating length and mass per unit length are constant.
- Discovered the 3rd law of strings (law of linear density): the fundamental frequency of vibrations of a string is inversely proportional to the square root of mass per unit length (linear density), if the tension and vibrating length are constant.
- 1640 AD

ROBERT BOYLE – IRISH SCIENTIST

- Demonstrated the transmission of sound requires a medium, by performing an experiment involving an alarm clock being placed under a glass jar and removing the air inside using a pump to show that the sound could not be heard.
- 1660 AD

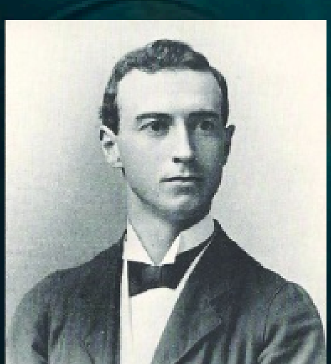
ERNST CHLADNI – GERMAN PHYSICIST

- Invented a method to visualise sound waves using the "Chladni Plates" (metal plates that can be caused to vibrate using a violin bow), which create patterns of sand due to the formation of standing waves.
- Conducted some of the first research of tuning forks in order to revolutionise musical and scientific instruments.
- 1800 AD

JEAN-BAPTISTE JOSEPH FOURIER – FRENCH MATHEMATICIAN

- Curated the Fourier spectrum, which mathematically transforms sound waves into a sum of sin waves.
- 1800 AD

WALLACE CLEMENT SABINE – AMERICAN PHYSICIST



- Discovered Sabine's Law: the reverberation time multiplied by the total absorptivity of the room is proportional to the volume of the room.
- Designed the first building with scientifically formulated acoustics (Boston Symphony Hall).
- 1800 AD

The history and practical application of sound waves in engineering

Room acoustics

- Used to enhance sound quality by understanding and influencing reflection, absorption and diffusion of sound waves in performance spaces.
- Knowledge of propagation of sound waves can assist with optimising microphone placement to capture the desired sound without unwanted background noise.

Testing and measuring

- Detecting flaws and defects in materials such as metals, concrete and composites, known as non-destructive testing (used in aerospace, automotive and construction).
- Measure the thickness of materials, such as pipes.

Communication

- Used in aviation by pilots and air traffic control towers in order to communicate to each other regarding air travel.
- Used in alarm systems or as warning signals.
- Used in walkie-talkie systems for many professions, such as in construction, for communication.

Music

- When guitars are plucked, the vibrations in the string cause sound waves to be produced and the length and tension in the string generates the exact frequency and amplitude needed to manipulate the sound waves into creating harmony and melody.
- Used by sound engineers in the music industry to create music by adjusting frequencies to create a balanced mix.

Infrasonic

- Used in seismology in order to detect earthquakes and volcanic activity.
- Weather forecasting as some weather conditions generate infrasound which can be detected.

Ultrasound technology

- Can be used to measure distances.
- Medical imaging in order to penetrate tissues and provide detailed imaging in order to assist with medical diagnosis.

Lucas Nixon

THE IMPORTANCE OF VIBRATION ANALYSIS IN ENGINEERING

Vibration analysis is a crucial aspect of mechanical design, used by engineers to ensure the safety, longevity, and efficiency of structures. It is utilised in many fields such as aerospace, civil, or mechanical engineering, to predict, control, and prevent failures, reduce repairs in the future, reduce noise and discomfort for users, and prevent catastrophic failures such as bridge collapses.

In physics, vibrations occur when a system oscillates back and forth at an equilibrium point due to an external or internal force. It can occur due to many factors, including recurring forces, an imbalance, bearing faults, resonance, or misaligned machine parts. The vibration is usually measured by the displacement magnitude of the oscillation, which is then used to calculate the velocity and acceleration of the vibrations. There are two major types of vibrations: forced and natural.

Forced vibrations happen when an external force is applied to a system, causing it to vibrate. Internal combustion engines of cars are a source of forced vibrations from the grinding and rotating of the pistons in the engine. Engineers use the vibration analysis of the component in designing, developing and testing components. For example, in Formula 1, an experimental vibration measurement system was implemented on the 2006 Ferrari 248F1 model, which was used to improve electronic component reliability, reduce maintenance time, and more importantly spot mechanical imbalances in the set up (suspension), which can be the difference in a race.

Natural vibration (also known as resonance) is when a system vibrates at its natural frequency. This amplifies the vibrations in the system which can lead to greater structural stress and potentially catastrophic failure. A special case of when resonance led to mechanical failure was in the 1940 Tacoma Narrows Bridge collapse. Whilst under construction, the structure was already facing vibrations from the wind, so strategies such as tie-down cables and hydraulic dampers to control the oscillations. However, the wind would cause the bridge to face resonance as it caused the bridge to vibrate at its natural frequency. This amplified the oscillations and vibrations which meant the structure was not able to withstand the movement, and it eventually collapsed. This disaster underscored the necessity of proper vibration analysis in the future civil engineering.

To monitor vibrations, engineers utilise accelerometers attached to key vibration sites to measure high-frequency accelerations in multiple directions. A mathematical frequency analysis called the Fast Fourier Transform (FFT) is then used to process the data and identify frequencies at which mechanical faults occur. Modal analysis is a more advanced technique focusing on a machine's natural frequencies, mode shapes and damping characteristics. Studying these helps assess the dynamic behaviour of a machine and identify potential structural problems or resonance conditions.

In the design phase, engineers use various tools to ensure products withstand vibrations. Finite Element Analysis (FEA) is a widely used simulation method to predict how a design responds to vibrational forces before manufacturing. Computational Fluid Dynamics (CFD) is used in aerospace applications to analyse and reduce vibrational forces on aircraft and spacecraft components. Wind tunnels help study aerodynamic effects like flutter and turbulence, with results guiding design improvements. These simulations allow engineers to make informed decisions to maintain structural integrity against vibration.

Recent technological advancements have greatly improved vibration analysis methods. Laser Doppler Vibrometry (LDV) allows non-contact, high-precision measurement of vibrations using frequency shifts in reflected laser light. The integration of artificial intelligence (AI) and machine learning enables real-time fault detection and predictive maintenance, revolutionising industries such as aviation and manufacturing. Engineers also now use digital twin technology, creating virtual replicas of structures or machines to simulate vibrational behaviour, aiding in proactive maintenance and design optimisation.

In conclusion, vibration analysis is a vital part of modern engineering, ensuring structural integrity, machine efficiency, and overall safety. By applying physics and advanced technology, engineers can predict and mitigate harmful vibrations, preventing failures and improving performance. As engineering evolves, the integration of AI, digital simulations, and real-time monitoring will continue to enhance vibration analysis, ensuring safety and reliability across industries.

Jiawen Zhu

THE RETURN OF SUPERSONIC FLIGHT

Supersonic flight, thought to have been unfeasible to use in commercial flight after the retirement of the Concorde in 2003, is making a strong comeback. The Concorde, a symbol of high-speed air travel, achieved speeds of Mach 2, cutting flight times in half, and was seen as the future of aviation (Pjnkolo, 2023). However, the Concorde brought to light several significant issues that have long hindered the widespread adoption of supersonic air travel. These issues, most notably sonic booms, fuel inefficiency, and high operating costs, forced the supersonic era to come to an end. But now, recent advancements in aerodynamics and propulsion technology have begun to address these issues, leading to the revival of supersonic airliners.

The most significant issue with supersonic flight is the sonic boom; the thunderous noise caused by shockwaves as aircrafts exceed the speed of sound. As an aircraft flies, it creates a series of pressure waves that radiate in all directions out of the aircraft's leading edges, such as the nose and wings. Sonic booms occur when an aircraft accelerates faster than the speed of sound (Mach 1), compressing the air in front of it and creating shockwaves. These shockwaves coalesce to form a shock front that propagates outwards in a cone-like shape, called a Mach cone, with the energy being released in the form of a loud sound when they hit the ground (NASA, 2022). The noise is what made supersonic flight over land impractical; the Concorde's booms were as loud as 100-110 decibels – equivalent to a nearby explosion (Loubeau, 2018).

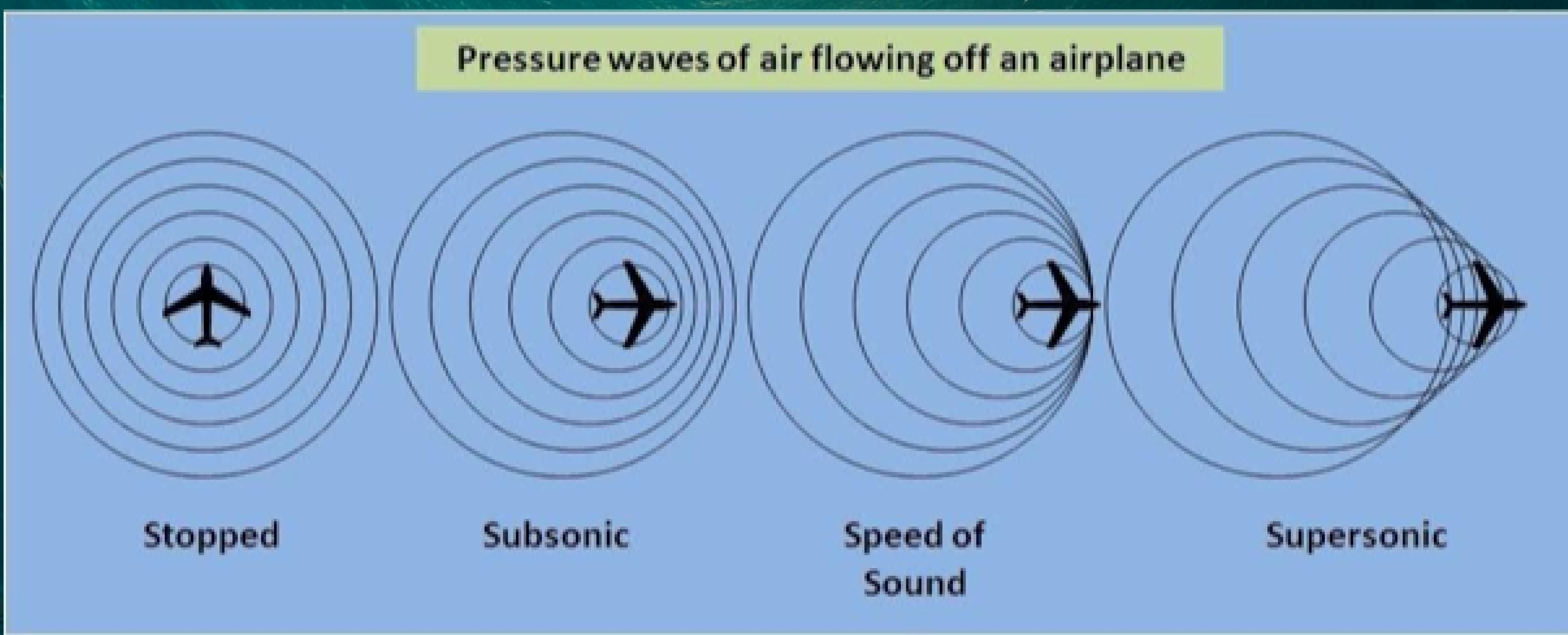


Figure 1: Supersonic aircraft shockwave distribution (Pjnkolo, 2023)

Current engineers are exploring many different solutions to this problem, one of them being the aerodynamic design. Prior aircrafts, like the Concorde, used blunt, wide nosed aircrafts, leading to more intense sonic booms, but modern aircrafts are opting for a slender, pointed nose instead. The sharpness of the leading edges causes smoother airflow around the aircraft and allows for the shockwaves to be generated more progressively, reducing the suddenness of the pressure buildup. The gradual build means that the shockwaves don't form at once, but rather over a longer distance. Therefore, each shockwave will be more dispersed and will interact less with one another leading to less constructive interference, which is when these shockwaves interact with one another to create a stronger overall shockwave. This significantly reduces the intensity of the sonic boom heard on the ground (Loubeau, 2018; NASA, 2023).

Another innovative method to reduce sonic booms involves shockwave cancellation. Rather than mitigating constructive interference, engineers are designing the aircraft's fuselage and wing configuration is such a way that the aircraft's aerodynamics create a balanced distribution of shockwaves. For instance, shockwaves generated from different sections of the aircraft – such as the nose and tail – can be aligned in such a way their pressure peaks and troughs are opposite to each other, so that they neutralise in overall intensity and cancel one another out, this process being destructive interference. This concept is central to the design of the next generation of supersonic airliners, allowing for a quieter flight even at speeds greater than Mach 2 (Boom Supersonic, 2025; Loubeau, 2018; NASA, 2023).

A further approach to diminish sonic booms is taking advantage of the Earth's atmosphere. The atmosphere has a natural temperature and pressure gradient; the farther from the ground one is, less pressure is applied, and the colder it gets. This gradient causes a phenomenon known as refraction to occur, where waves bend as they enter different mediums of different refractive indices. As the shockwaves travel downward, due to temperature gradient, they will tend to bend away from the perpendicular to the surface. Therefore, at certain altitudes and speeds the shockwaves generated will never reach the surface of the Earth and instead will dissipate in the atmosphere as seen in the diagram below (Boom Supersonic, 2025).

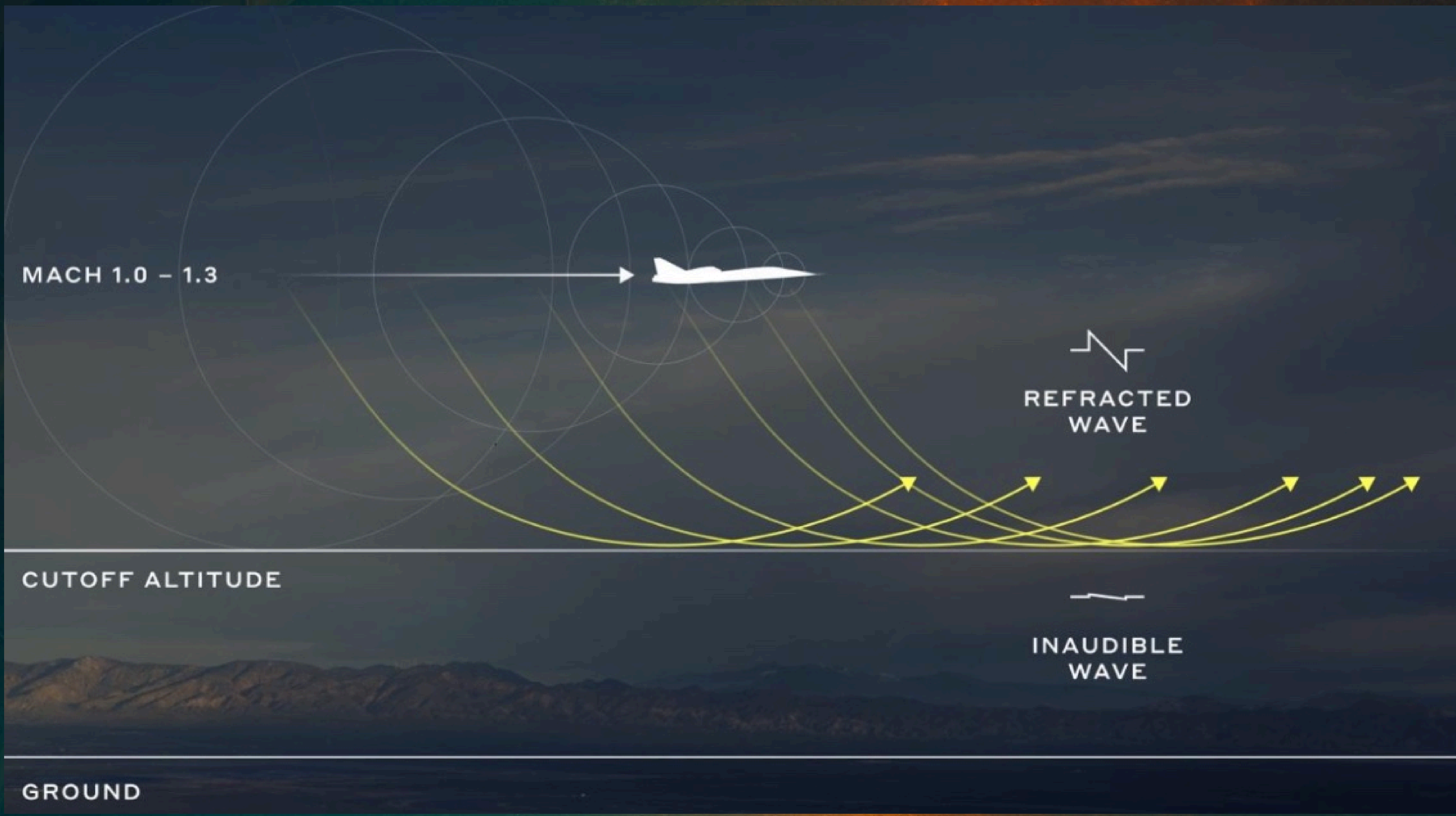


Figure 2: Boomless cruise mechanism (Boom Supersonic, 2025)

While the reduction of sonic boom intensity is critical for future supersonic flight, another fundamental challenge is the drag caused by air resistance. As an aircraft travels faster than sound, it generates wave drag, which results from the formation of shockwaves around the aircraft. Wave drag increases exponentially with the aircraft's speed, especially as it reaches speeds of Mach 2 or more. At supersonic speeds, the drag force can be expressed as:

$$D = \frac{1}{2} P V^2 C_D A$$

(NASA, 2023)

Where D is the drag force, ρ is the air density, V is the velocity, C_D is the drag coefficient, and A is the reference area. An important factor is the drag coefficient, where the smaller it is the less energy is required to over air resistance. At higher speeds, the drag coefficient increases, making supersonic flight less fuel-efficient. To reduce drag, the shape of the aircraft is paramount. The integration of delta wings, and sharply tapered fuselages into modern aircraft designs helps reduce drag while maintaining lift, reducing fuel consumption making aircrafts more efficient (NASA, 2022).

The revival of supersonic flight hinges on more than just the reduction of sonic booms and drag – it also involves the integration of these technologies into commercial aviation in a way that is both practical and sustainable. The next generation of supersonic aircraft, such as those being developed by companies like Boom Sonic, who are aiming for commercial flights by 2030 with their Overture aircraft, aim to offer Mach 2.2 flight and to be more fuel-efficient, economically viable and environmentally responsible (Boom Supersonic, 2025). These aircrafts are designed with the innovative designs discussed above, and many are exploring SAFs (sustainable aviation fuels), which are produced from renewable sources and provide a cleaner alternative to traditional jet fuel. The integration of AI and automation into supersonic flight management is also on the horizon. The techniques stated above all work in idealised settings, but adverse weather, varying climates, and fluctuating turbulence all require real-time adjustments for them to work properly. These technologies will allow for optimised flight paths, better fuel management and real-time adjustment of operating parameters, reducing fuel consumption and costs.

To conclude, the challenges that led to the retirement of the Concorde are being addressed, and as these technologies mature, supersonic flight is set to make a comeback, offering passengers the ability to travel across the globe faster than ever before.

Lev Mert

THE HISTORY OF AVIATION: ENGINEERING ADVANCES THAT REVOLUTIONISED THE WORLD

Introduction

Flight is one of the most famous and significant engineering accomplishments in the history of mankind, revolutionizing transport, war, and globalization. The history of aviation, from the first attempts at gliding to the supersonic flight of today, is defined by a series of engineering advances that led to the development of air travel in the contemporary era.

Early Concepts and Inspirations for Flight

The dream of our flying to the skies and being seated among the stars dates centuries back. The ancient Civilisations, including the Chinese, experimented with kites, and Greek mythology had told the myth of Daedalus and Icarus who flew on wax wings. However, it was only during the Renaissance era that scientific thought began to influence aircraft design. Leonardo da Vinci came up with intricate designs for flying machines, including the "ornithopter," through the observation of birds in flight (Anderson, 1997).

The Age of Balloons and Airships

The first manned flight was in 1783 when the Montgolfier brothers flew a hot air balloon in France. This opened the way for lighter-than-air flight, which culminated in the airship. In 1852, Henri Giffard flew the first powered airship, proving that powered flight was possible under control (Gibbs-Smith, 1970). Rigid airships such as the Zeppelin were being used for passenger travel and military surveillance during the early part of the 20th century.

The Wright Brothers and the History of the Airplane

The most famous breakthrough in aviation was realized on 17 December 1903 by the Wright brothers, Orville and Wilbur, using the successful Kitty Hawk flight of the Wright Flyer. They possessed a lightweight internal combustion engine, three-axis control, and wing plan-driven propellers. The systematical method of the Wright brothers toward engineering, testing with wind tunnels, and improvement incrementally set the foundation of modern aerodynamics (Crouch, 2003).

Innovation During World War I and the Interwar Years

World War I drove innovation in airplanes: combat aircraft being built were more agile and faster. Fighter planes like the Sopwith Camel and Fokker Dr. I were infamous during the era. Commercial aviation began to emerge after the war, however, with aircraft like the Junkers F.13 initiating the innovation of metal airframes and cabin enclosures (Gunston, 1995).

In the 1920s and 1930s, the most significant aviation breakthroughs were:

- All-metal aircraft: Boeing 247 and Douglas DC-3 possessed aluminium bodies and superior aerodynamics.
- Pressurized cabins: Aircraft such as the Boeing 307 Stratoliner allowed higher altitudes, with less bumping and greater comfort.
- Theory of the jet engine: British engineer Frank Whittle and German engineer Hans von Ohain came up with the jet engine independently, which would later revolutionize aviation (Kay, 2007).

World War II and the Jet Age

Like its predecessor, World War II saw the intensified development of aircraft speed, firepower, and range. The most symbolically representative aircraft of the war were:

- The Supermarine Spitfire: Renowned for its manoeuvrability in dogfights and elliptical wings
- The Boeing B-29 Superfortress: The first pressurized cabin and gun turrets operated remotely aircraft.
- The Messerschmitt Me 262: The world's first production jet-powered fighter, proving the feasibility of jet propulsion. (Francillon, 1988)

Jet engines were the norm for both military and commercial aviation following the war. The de Havilland Comet, the first jetliner, and the Boeing 707, the prototype for today's airliners, arrived in the 1950s (Proctor, 2002).

The Space Age and Supersonic Flight

During the 1960s, the gateway to supersonic and space flight had opened. The Concorde, a Franco-British joint project, was the first ever supersonic passenger aircraft, with a capacity to travel across the Atlantic in less than three hours. Although retired in 2003, it is still one of the most impressive engineering achievements in the history of aviation (Heppenheimer, 2001). And while simultaneously, the technology of aviation helped to enable space exploration: NASA's Apollo program, in turn leading to putting men on the Moon, was founded upon advances in rocketry, materials technology, and aerodynamics made by aviation engineers.

Modern Aviation and the Future

Aviation continues to advance today with better fuel economy, composite materials, and fly-by-wire flight control systems. The Boeing 787 Dreamliner and Airbus A350 are the state-of-the-art engineering wonders, with more comfort and efficiency. In the coming times, new technologies such as hydrogen fuel, electric airplanes, and autonomous flying planes will revolutionize aviation once again. NASA, Boeing, and new startups have concepts for urban air mobility (UAM), such as electric vertical take-off and landing (eVTOL) aircraft in development, which would revolutionize personal transportation (Bilstein, 2003).

Conclusion

The history of flight is an acknowledgment of engineering ingenuity and human creativity. From the initial flight by the Wright brothers to the imagination of space tourism, flight has constantly pushed beyond what can be imagined. With every technological advancement, the future of flight will be set by the next group of engineers that will propel air travel faster, cleaner, and more affordable to everyone globally.

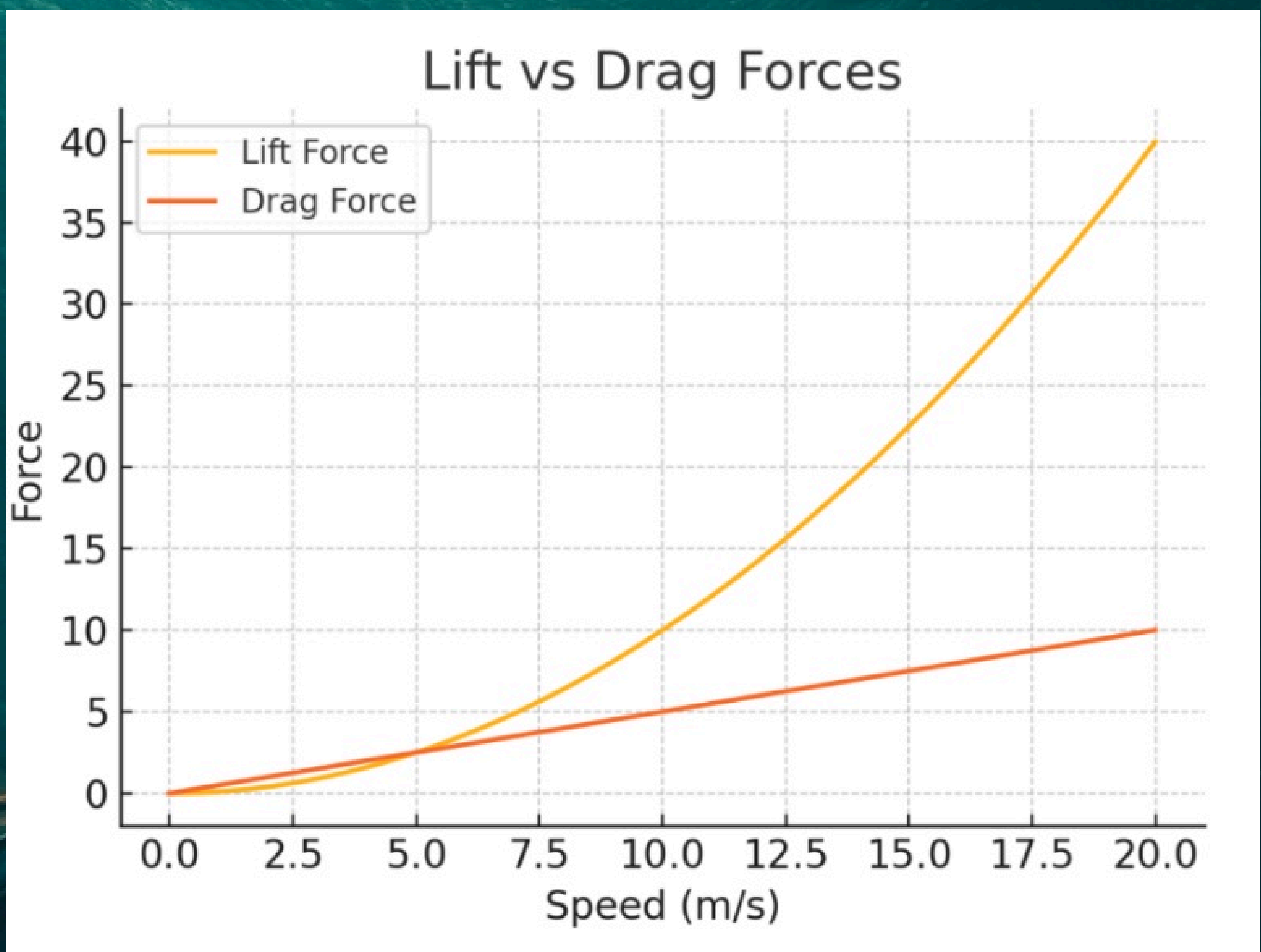
Taran Nambiar

MAXIMISING AERODYNAMIC EFFICIENCY IN AIRCRAFT

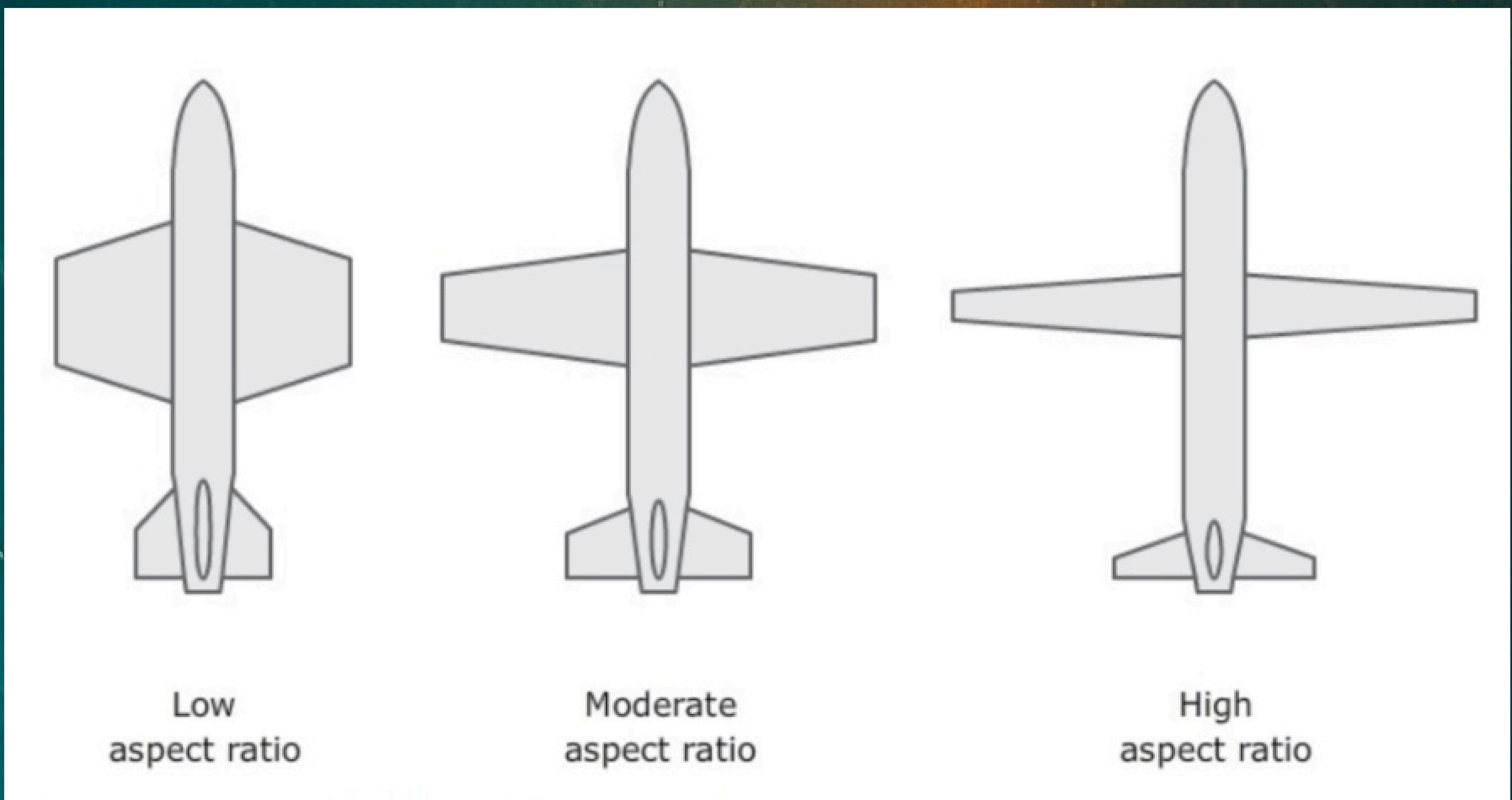
When watching an aircraft glide smoothly through the sky, it may seem effortless. However, that smooth motion is the result of precise engineering, careful planning, and a deep understanding of aerodynamic efficiency. At its core, aerodynamic efficiency is the aircraft's ability to generate the necessary lift to stay in the air while minimizing the resistance, or drag, that slows it down. It is about getting the most lift for the least amount of drag, allowing aircraft to fly faster, farther, and more economically.

To understand aerodynamic efficiency, it is essential to focus on two opposing forces: lift and drag. Lift is the upward force generated by the wings as air flows over and under them, enabling the plane to rise off the ground. Drag, on the other hand, is the force that resists the plane's forward motion through the air. The balance between these two forces defines how efficient the aircraft is. A key metric used by engineers to measure this is the Lift-to-Drag Ratio, often abbreviated as L/D ratio. A higher L/D ratio indicates that the aircraft is producing a significant amount of lift relative to the drag it experiences, which translates into improved fuel efficiency and performance.

To visualize this relationship, imagine a graph plotting lift and drag forces against airspeed (Diagram shown below). Typically, as the speed increases, the lift also increases because the faster-moving air exerts greater pressure differences over the wings. However, drag also grows, especially at higher speeds where air resistance becomes more significant. The optimal aerodynamic efficiency occurs at the point where lift is maximized while drag remains relatively low. Engineers aim to design aircraft to operate near this "sweet spot" to achieve peak efficiency during cruising flight.



One of the most critical aspects of enhancing aerodynamic efficiency lies in wing design. The concept of wing aspect ratio is particularly important here. Aspect ratio refers to the ratio of a wing's span to its chord (or width). Mathematically, it is calculated as the square of the wingspan divided by the wing area, but more importantly, a high aspect ratio wing is long and narrow, while a low aspect ratio wing is short and wide. Aircraft like gliders and modern passenger planes feature high aspect ratio wings because they reduce drag significantly and help maintain steady, efficient flight. In contrast, fighter jets typically have low aspect ratio wings to maximize agility, though this increases drag.
A helpful diagram illustrating wing aspect ratios shows two wings side by side: one long and slender, the other short and broad (Diagram shown below). The long, thin wing minimizes the formation of turbulent air at the tips, reducing drag and conserving energy. Modern aircraft often further enhance this design with winglets—small vertical extensions at the wingtips. These winglets act like barriers, reducing the swirling vortices of air that form at the tips and cause additional drag. By controlling this airflow, winglets contribute significantly to better fuel efficiency.



Beyond wing design, the aircraft's overall shape plays an important role in its aerodynamic performance. The fuselage, which is the main body of the aircraft, is carefully shaped to cut smoothly through the air. The nose is rounded and tapered to reduce resistance, while the cockpit and fuselage are blended seamlessly to prevent abrupt edges that might disturb airflow. Even small details, such as the fairings that cover joints and landing gear, are designed to smooth out airflow and decrease what is known as form drag—the resistance caused by the aircraft's shape.
Another area where efficiency gains are made is in the choice of materials and the reduction of aircraft weight. Heavier planes require more lift to stay in the air, and more lift typically leads to more drag. To combat this, modern aircraft are constructed using advanced materials like carbon fiber composites and titanium alloys. These materials are incredibly strong yet much lighter than traditional metals, allowing engineers to design sleeker, more efficient shapes without compromising safety or

durability. Reducing the overall weight of the aircraft enables it to operate at lower drag levels, saving fuel and increasing range.

A lesser-known but equally important factor affecting aerodynamic efficiency is skin friction. This is the resistance caused by air rubbing against the aircraft's surface as it moves. Even minor imperfections—such as dirt, chipped paint, or uneven rivets—can increase skin friction, leading to wasted energy. For this reason, airlines and maintenance teams place great importance on keeping aircraft surfaces clean and polished. Historically, some aircraft even featured flush rivets and specially smoothed surfaces to ensure minimal friction, an approach that continues in modern aviation.

Before any aircraft ever takes flight, engineers employ powerful computer simulations known as Computational Fluid Dynamics (CFD) to optimize every design feature. CFD allows them to simulate how air will flow around every part of the plane, from the wings to the fuselage to the tail. By testing different shapes, angles, and materials in a virtual environment, designers can identify and correct areas of excessive drag before manufacturing even begins. This digital process has become indispensable in ensuring that each new generation of aircraft achieves higher levels of aerodynamic efficiency.

In summary, maximizing aerodynamic efficiency in aircraft is the result of carefully balancing multiple factors. Engineers must design wings with high aspect ratios, incorporate winglets, streamline the fuselage, choose lightweight materials, maintain smooth surfaces, and ensure optimal operational speeds and altitudes. Each of these elements contributes incrementally to reducing drag and improving lift, ultimately leading to fuel savings, greater range, and a more environmentally sustainable aviation industry. The principles of aerodynamic efficiency are not only grounded in sound engineering but also in the elegance of physics, where every curve and contour is meticulously crafted to help the aircraft conquer the skies with minimal resistance.

ARE ELECTRIC PLANES THE FUTURE OF AVIATION?

The three main types of electric planes and how they work

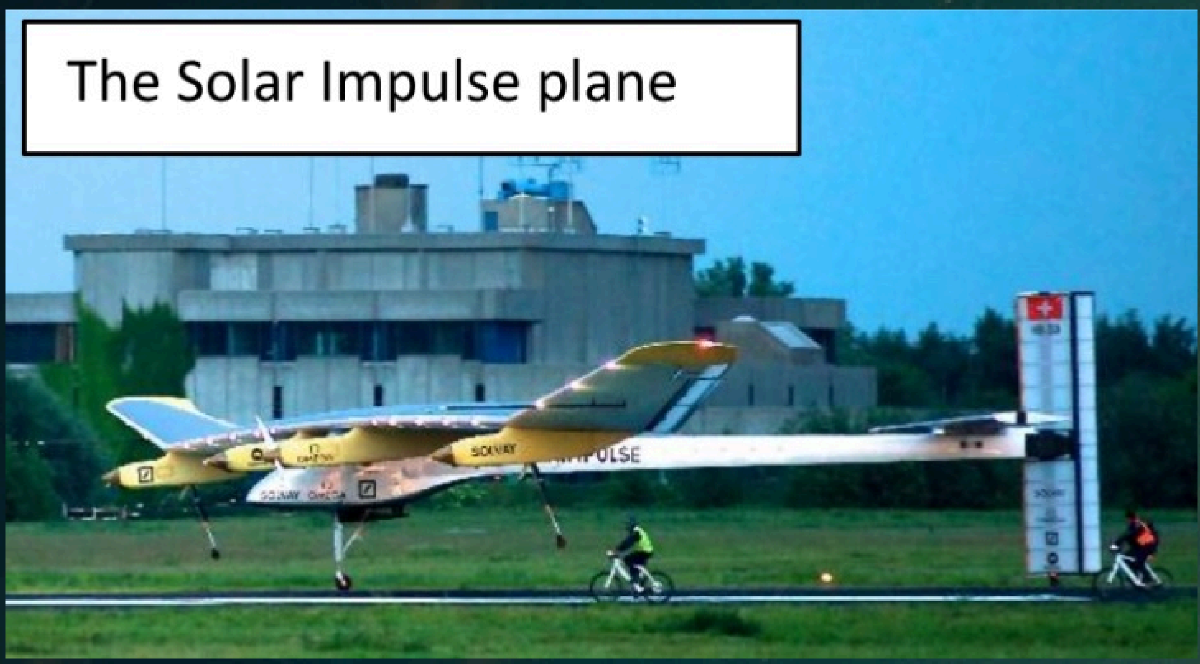
There are currently three main types of electric aircraft: battery-powered planes, which store energy in onboard batteries; solar powered planes, which are powered by the sun; and aircraft powered by wireless power transmission, which allows aircraft to receive power from energy directed from a source on the ground. As the aviation industry faces increasing pressure to tackle their immense carbon footprint leading up to 2050, when it was globally agreed to reach net zero CO2 emissions, electric planes have the potential to drive forward a cleaner and more sustainable future for the aviation industry.

Battery powered planes use power from rechargeable onboard batteries, which typically use lithium-ion battery technology, to drive electric motors that propel the aircraft. For commercial aviation applications, rechargeable batteries are not ideal due to it taking significantly longer to charge the extremely large batteries required to power an aircraft compared to traditional refuelling. Currently, most prototype electric planes use a hybrid system where the fuel on board is used to generate electricity which powers the electric motors. Alternatively, a company called ZeroAvia uses a hydrogen-electric hybrid system to power their flights.

The first manned, all-electric passenger jet, Alice, completed her maiden flight in 2022 which demonstrated her capability to carry 9 passengers up to 250 miles. This was a crucial step in demonstrating that all electric commercial flight is feasible for the future. Since then, battery technology has continued to play a crucial role in aviation, particularly for remote control plane hobbyists who usually power their lightweight, unmanned aircraft using rechargeable batteries. However, one of the main challenges for battery-powered aircraft in the future is the weight of the batteries, which still supply less energy per kilogram compared to regular jet fuel. This means that although they are currently being successfully tested for smaller aircraft, it will be difficult to support larger commercial planes until new, more efficient battery technology is developed.

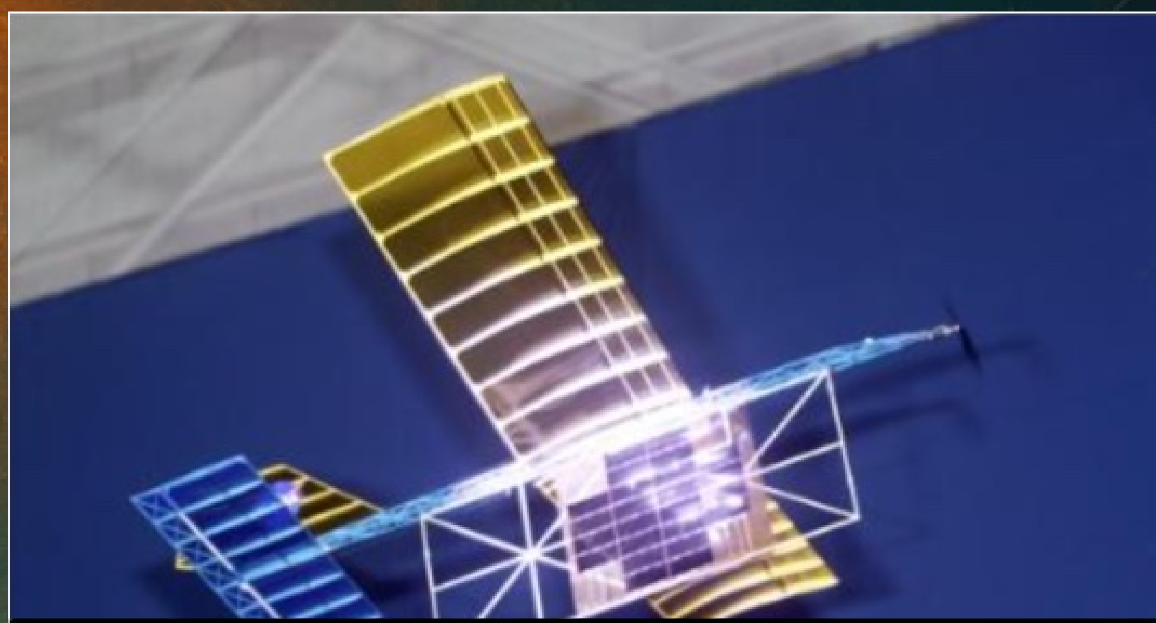

Alice, the first manned all-electric passenger jet

Solar powered flight makes use of the energy from the sun and converts it into electricity to power the plane’s motors, allowing the aircraft to stay airborne for prolonged periods of time. This can be useful for applications such as unmanned surveillance aircraft for the military or for low flying satellites. However, currently, solar powered flight is only used on slow and extremely light aircraft since the fuel consumption has to be minimal. This is because solar cells provide a tiny amount of energy compared to jet fuel. The current record for a manned flight fully powered by



The Solar Impulse plane

solar power is held by the Solar Impulse plane which travelled for 117 hours and 52 minutes and 7212km using its photovoltaic cells. The key to developing solar powered technology for aviation in the future would be to develop lighter and more flexible solar cells which can capture more energy per surface area, enabling a longer range and greater efficiency. Wireless power transmission involves using a ground based laser or microwave emitter to send energy through the air to the plane which will be equipped with a receiver. This was successfully demonstrated by researchers at NASA in 2002 who used laser beams to provide a small, unmanned solar craft with necessary energy by centering a laser beam on a panel of photovoltaic cells. In the future, wireless power transmission technology could be beneficial since it could allow solar powered planes to fly through the night more easily.


NASA's wireless power transmission demonstration on a model plane

Although this sounds like a new idea, Nicola Tesla proposed theories of wireless power in the late 1800s when he managed to remotely power lights at his Colorado Springs experiment station. Also, this technology is used every day to charge products such as electric toothbrushes, and to send and receive TV signals through radio waves.

The Benefits of Electric Aircraft: Why They Are The Future of Aviation

Electric planes are currently being researched and developed by world leading establishments such as NASA due to the possibility of them being able to reduce the carbon footprint of the aviation industry and reduce noise pollution in urban areas surrounding airports. Moreover, their lower operating costs, despite the greater upfront cost, could be beneficial to airlines in the future. Finally, they can be more efficient since energy is not lost through the conversion of fuel to mechanical energy like in a traditional plane.

The Biggest Challenges Holding Back Electric Planes Today

Even though electric planes have lots of potential, there are still some major challenges that are holding them back. Firstly, and most importantly, not only are electric batteries extremely heavy, they cannot supply nearly as much power as it's weight in jet fuel making them much more inefficient. Also, due to the limited capacity of batteries, the range is limited to usually about 120 miles on a single charge meaning that developments must be made for electric planes to be used in a more global commercial setting. Advancements would also need to be made to the speed of battery charging for electric planes to be efficient in the commercial aviation industry since it is currently much faster to refuel a plane as opposed to charging large batteries. This could make short turnaround times difficult to achieve.

ZeroAvia: Pioneering The Future of Commercial Electric Flight

ZeroAvia was named ‘America's top Greentech company of 2024’ by Time Magazine and continues to strive towards promoting more sustainable air travel. In 2019, they completed their first zero emissions flight of a six seater aircraft, and since then, have had numerous successful zero emission flights. The company focuses more on a hybrid system of hydrogen fuel and electricity to power their aircraft, and with this technology, they are aiming to have raised funding for and developed a 50+ seater zero emissions aircraft.

ZeroAvia’s initial Dornier 228 flight test - 2023

Erin Keenan

HOW THE SP80 AIMS TO ACHIEVE RECORD-BREAKING SPEEDS

History

Can a sailboat be faster than a car? This may seem like a strange question to many, as most traditional sailboats do not exceed 20 knots (37.04 km/h). Historically, sailboats have taken their recognisable shape (see Figure 1) only in the 18th and 19th centuries, thanks to the Dutch innovations in rigging and the use of stronger materials. Before these advancements, most ships employed square rigging, which was effective for sailing downwind and on reaches but less so when sailing upwind, making the boats less versatile. However, the 21st century has brought about numerous new technologies that enable sailboats to achieve significantly higher speeds. Water is approximately 830 times denser than air, meaning sailboats face considerable resistance as they glide across its surface. Thanks to advancements in composite materials, the hulls of boats have become much lighter. Additionally, new foil designs have replaced traditional daggerboards, allowing these boats to lift out of the water and “fly” above the surface. This technology helps them overcome much of the water's drag, enabling remarkable speeds of 90-100 km/h.

Mechanics of a Sailboat

You may be wondering how a sailboat moves with the wind. While a sailboat might seem complex, its mechanism is quite simple at its core. It consists of a hull to which a mast and sail are attached, and a daggerboard is placed in the water. This daggerboard counteracts the lateral force created by the lift of the sail, converting it into a forward motion that propels the boat as shown in Figure 2. Additionally, the daggerboard or centreboard serves as a pivot point, allowing the boat to turn using the rudder. Fun fact: The daggerboard or centreboard does not need to be as large as the sails because water is approximately 800 times denser than air, meaning it requires a much smaller surface area.

Cavitation

Cavitation is a phenomenon that occurs at speeds around 60 knots (100 km/h). At these speeds, pressure differences can cause water to boil at room temperature. This significantly increases drag and makes the foils unstable. As a result, most foiling boats that "fly," as illustrated in Figures 3 and 4, are limited to a maximum speed of 100 km/h. To minimize the effects of cavitation, specialized super-cavitating foils have been developed, as shown in Figure 5.

These foils differ from the traditional tear-drop design by utilizing a sharp wedge shape. This design creates a cavity on only one side of the foil, which is then funnelled to form a stable air cavity, resulting in much less drag than conventional cavitation bubbles.

Vestas Sailrocket 2

The Vestas Sailrocket 2 holds the current sailboat speed record. Its innovative design features a solid wing counterbalanced by an angled hydrofoil (see Figure 6), enabling the boat to reach a top speed of 65.45 knots (120 km/h). The hard wings used by the Vestas team are currently the most efficient type of sail for straight-line speed and closely resemble aeroplane wings, as shown in Figure 7. The team realised they could not depend on foils to "fly" above the water, so they opted for three small hulls to plane across the water's surface. This planning hull design has a flat bottom, allowing the boat to skim over the surface at high speeds. By doing so, the boat has a smaller contact area with the water, which reduces the effort needed to displace and move through it.

The SP80

A new contender aims to set a world record with a more traditional design—the SP80. This vessel has adopted a displacement hull design to prioritise downforce, as high-speed flight over water can be challenging to control and carries a significant risk of accidents. For this reason, most foiling boats that "fly" are limited to a speed of 100 km/h. However, the SP80 team is targeting an impressive speed of 80 knots (150 km/h), which necessitates a different approach. Therefore, the SP80 features a planning hull design similar to that of the Vestas Sailrocket 2. Additionally, the SP80 team has embraced a more radical kite-sailing boat design, as seen in Figure 8. This design allows the forces generated by the kite to be concentrated at a single point, resulting in greater stability. In case of an emergency, the kite can be released, enabling the boat to come to a quick stop naturally.

Summary

As technology advances, it is only natural for humans to push the boundaries of what is possible. We continuously strive to reach new milestones and set speed records on land, at sea, and in the air. Numerous projects devoted to this goal, such as the Vestas Sailrocket 2 and the SP80, are testing new innovations that can later be implemented for broader use. With sailboats like the formidable Sailrocket and the up-and-coming SP80, it is evident that a sailboat can indeed reach high speeds, akin to those on a highway.

Victor Mosanya

FIRST HUMAN MOON LANDING APOLLO 11

On July 20, 1969, a whole nation tuned in to see astronauts Neil Armstrong, Buzz Aldrin and Michael Collins take one small step on the surface of the Moon, ushering in a new era of space exploration. But how did Armstrong and the Apollo 11 astronauts get to the Moon in the first place?

The Apollo 11 is made up of three main components, the Command Module (CM), the Lunar Module (LM) and the Service Model (SM). The crewed Apollo missions were each launched aboard a Saturn V launch vehicle. (The "V" comes from the five F-1 engines that powered the first stage of the rocket.) At that time, the Saturn V was the United States' largest and most powerful launch vehicle ever built. The Saturn V had three different stages. The Saturn V's third stage (S IVB) was responsible for placing the Apollo spacecraft on a trajectory towards the Moon. The Instrument Unit was also a crucial part of the Saturn V, its job was to serve as a guidance system.

First Stage

The five F-1 engines, producing nearly 7.7 million pounds of thrust. These powerful engines were required to lift the heavy rocket fast enough to escape Earth's gravity. The first stage engines were burned at liftoff and lasted for about 2.5 minutes, taking the vehicle and payload to an altitude of 38 miles. Then, the first stage separated. It fell back to Earth and landed in the Atlantic Ocean.

Second Stage

The five J-2 engines. After the first stage was discarded, the second stage burned for approximately 6 minutes, taking the vehicle and payload to a 115 mile altitude. The second stage was then discarded.

Third Stage

The one J-2 engine. This engine burned for 2.75 minutes, boosting the spacecraft to an orbital velocity of about 17,500 mph. The third stage was shut down with fuel remaining and remained attached to the spacecraft while in Earth orbit. The J-2 engine reignited to propel the spacecraft into translunar trajectory, which brought the spacecraft to the Moon.

The Command Module, named Columbia, served as the living quarters for the three astronauts during the mission and was the only part of the Apollo 11 spacecraft to return to Earth. It housed the crew during launch, the journey to the Moon, and re-entry into Earth's atmosphere. The blunt-end design for the Command Module was chosen to build upon experience gained with the similarly shaped Mercury and Gemini spacecraft. The spacecraft re-entered the atmosphere with its protective heat shield (the widest end of the spacecraft) facing forward. Layers of special "ablative" material on the shield were purposely allowed to erode during re-entry to help dissipate the extremely high temperatures caused by atmospheric friction.

The Service Module, attached to the back of the CM, provided essential support functions such as propulsion, electrical power, oxygen, and water. It carried the main engine used for major manoeuvres, including the trans-lunar injection to leave Earth orbit and the trans-Earth injection to return home.

The Lunar Module, named Eagle, was designed specifically for landing on the Moon and returning to lunar orbit. It consisted of two stages: the descent stage, which landed on the lunar surface; the descent engine supplied the power for the complex manoeuvres required to fly the lunar module from orbit down to a soft landing on the Moon. The engine was fired as a retrorocket to slow the lunar module, allowing a controlled descent to the surface. The ascent stage contained the crew compartment and a rocket motor to return the astronauts to the orbiting command module. To rejoin the command module, the astronauts fired the ascent-stage rocket engine and lifted off, leaving the descent stage on the Moon. The ascent stage met and docked with the command module in lunar orbit.

Several materials cover the spacecraft to protect its inner structure from temperature and micrometeoroids. Specially designed materials maintain temperature balance inside the craft. The ascent stage of the lunar module features heat-resistant nickel steel alloy, 0.0021072 millimetres thick. Sheets that are painted black absorb heat when exposed to the Sun and radiate to the blackness of deep space. On the descent stage of the lunar module the material is not metal foil, but plastic films that are thinly coated with aluminium, which reflects the sun's heat and insulates the spacecraft. The thin, gold-coloured films are used in "blankets" of up to 25 layers. All the plastic films protect the spacecraft from micrometeoroids.

Hadi Azim

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NOTES FROM EDITORS

The calibre of articles received in this volume of the DC Hydraulics magazine was outstanding. We are very thankful to all the contributors for the enthusiasm and passion they brought to their work. The quality of writing, analysis, and research have been truly impressive. It is clear that each piece was crafted with care and expertise.

We also extend our appreciation to our readers for taking the time to engage with this volume. Whether you flipped through a few pages or read cover to cover, your support means everything.

We look forward to welcoming you back for our next volume. As this was our very first edition, thank you for joining us at the beginning of this journey and for being part of the DC Hydraulics community

DC HYDRAULICS

This magazine is volume 1 of DC Hydraulics and consists of articles related to motion and mechanics written by you. Topics of articles range from the history of mechanical engineering and sound waves to glimpses of the future exploring electric planes and record-breaking sailboats. Explore a wide variety of engineering articles inside, we hope you enjoy and learn something new

-The editors

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