Introduction to Airbreathing Propulsion
Prof. Ashoke De
Department of Aerospace Engineering
Indian Institute of Technology - Kanpur

Lecture – 02
Introduction (Contd.,)

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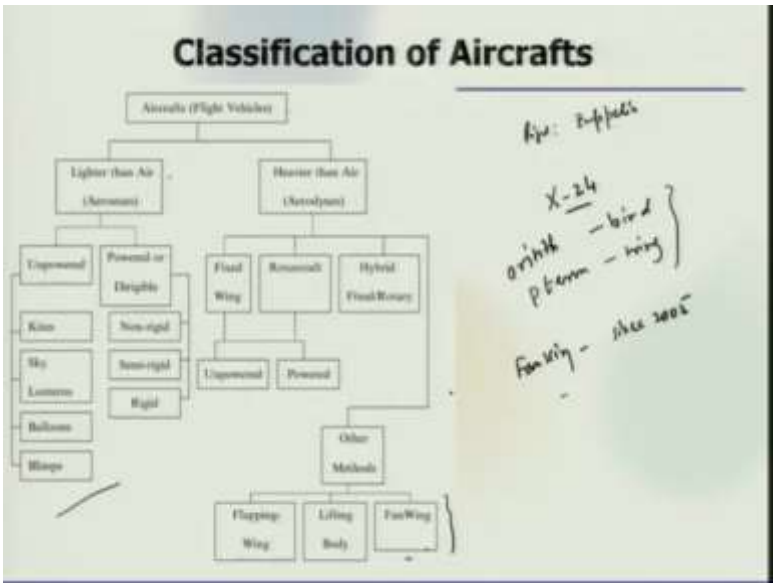

Okay, so let us continue the discussion on the introduction and this is what we have been talking about the classification of the aircraft and this is where we stopped.

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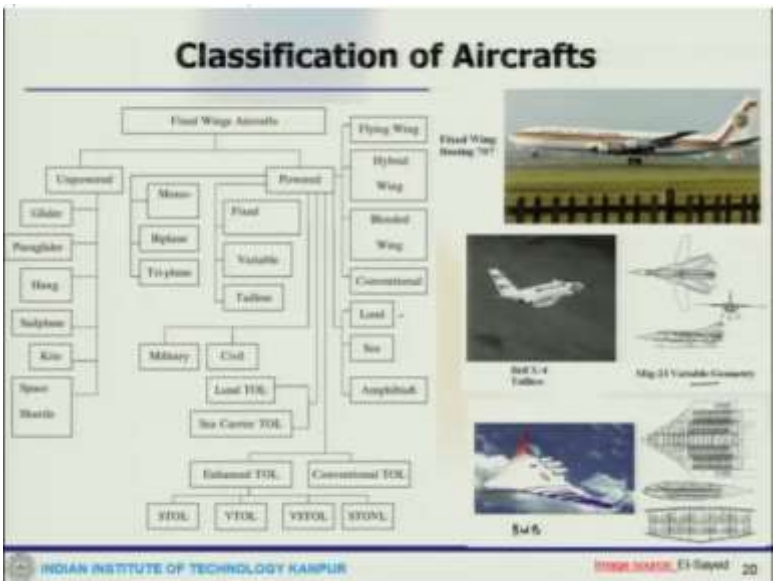

Now, we will take it to the next level like first start with the fixed wing aircraft and we talk about that and that also now, we can see these division of the fixed wing aircraft, it has two broader categories; one is powered and another is unpowered, now unpowered types it could

have again subdivision like glider, paraglider, hangs, sailplanes, kites, space shuttle and power aircrafts are there next classified based on several aspect.

So, it could have mono, biplane, triplane, it could be fixed, variable, tailless, now there could be application powered one could be military or civil, then it could have land TOL, which is take off landing, sea carrier TOL, then you can have enhanced TOL, conventional TOL, so enhanced TOL you can have short takeoff landing, vertical takeoff landing, vertical short takeoff landing, short takeoff vertical landing.

So, these are different cadre of these things and then finally a based on wing types; flying wing, hybrid wing, blended wing, conventional wing, so we have fixed wing, flying wing, blended wing, so hybrid wing bodies and then also you could have land, sea, amphibian, so that is another aspect. So, these are some example of the fixed wing aircraft, so you can see these are the tailless Bell X4 aircraft, this is MIG 23, this is one of the variable geometry military aircraft or fighter aircraft.

Then you can have this is a blended wing body, so one can see that blended wing body and this is some of the picture of that, so I mean this is nice to see different kind of what you call the aircraft which are in place because of the development.

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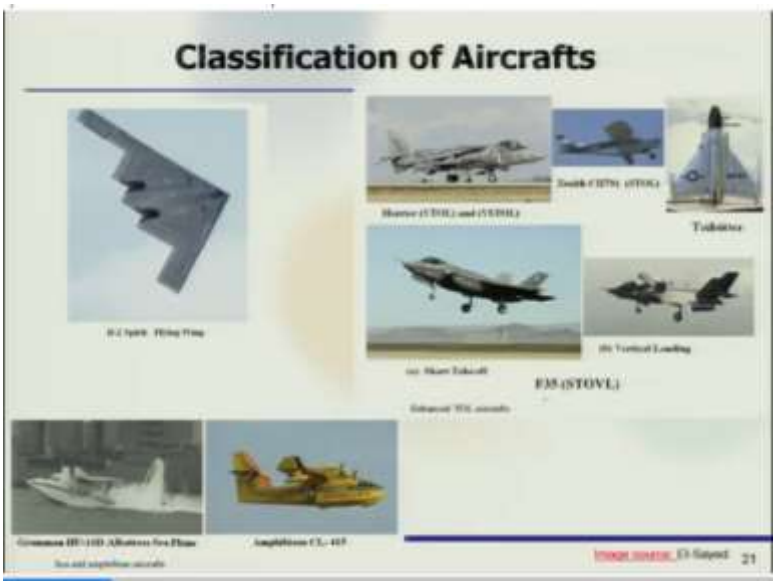

Now, when you talk about this based on the takeoff landing, there are these things, the land, sea and amphibian that we as we go along we can see that, so this is another B-2 spirit flying wing vehicle and now these are some other, so this is an example of Harrier, where you see

vertical takeoff landing or vertical short takeoff landing, it is capable of doing that, this is a short takeoff for F35, this is vertical landing, this is the tail sitter, this is short takeoff landing.

So, these are some of the examples and if you see across the globe, different countries, they have different sort of inventions and their capabilities. This is another one which is seaplane which is landing there then this is amphibians.

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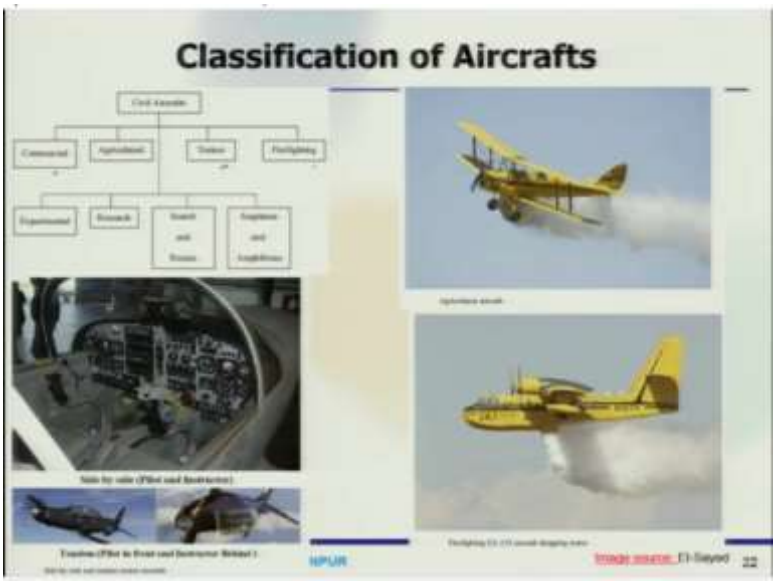

Now, when you move to the another segment of this division where you have civilian aircraft and then we will divide into another segment is the military aircraft. Now, the civilian aircraft there could be commercial which that will avail every day or there could be agricultural, so this is one of the picture of an agricultural aircraft which you can see that spraying some of this water.

Then, there could be trainer aircraft or firefighting, now this is a trainer aircraft what we can see when the training is given for the; so this is used to develop to piloting or navigational skill in flight crew. So, civilians pilots are normally trained in light aircraft with 2 or more seats to allow for student and instructor, the 2 sitting configuration for this trainer aircraft or pilot and instructor side by side or at random usually with the pilot in front and the instructor behind.

So, this has 2 phase training; one is basic and then advanced, now this is also firefighting aircraft which is dropping water, now these civilian aircrafts also could be some experimental research component, sea planes or amphibians and all these could be also.

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So, another example of this is the notable example of experimental aircraft is the Rutan Voyager, it is the first aircraft to fly around the world without stopping or refuelling, now so this is powered by a piston engine. Now, there are research aircraft also and there are search and rescue aircraft also, then these are example of some cargo aircraft which are big to carry lot of things across the globe.

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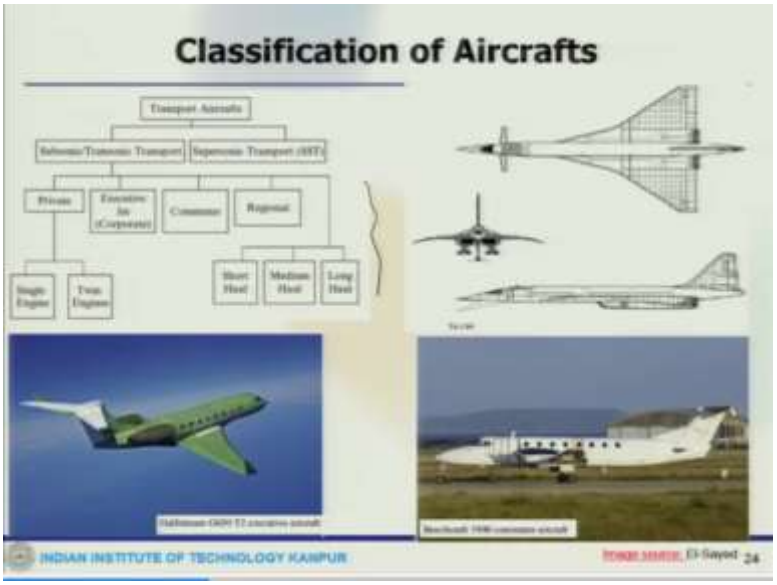

And so that we have sometimes, some transport aircrafts too which are used for now, this transport aircraft there you can have 2 segments; one is the subsonic transport aircraft, another is supersonic transport aircraft. So, this supersonic transport aircraft is the one which is designed and transport passenger at speed higher than the speed of sound and one is this Tu-144, this is the design of a Concorde.

These are I mean, Concorde was there, this is Tupolev Tu-144 and the first passenger flight of Tu-144 was in 1978 and the Concorde took his last flight on November 2003 and there could be some other categories as it is divided, so this is another example of that.

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Now, there could be small one, big one, now these are regional aircraft, this is an Airbus 380, this is also an aircraft which is there, now this is one of the latest development of Airbus which is a huge aircraft and more than 500 passenger carrying capacity, it has an upper deck, it has a lower deck and it is just noteworthy to mention, it is not all the airports across this world can accommodate this kind of aircraft.

There are only few airports like Frankfort, New Delhi, Jake Garn, they can capable of I mean taxing of this kind of big aircraft and also Dubai is one of them, there are few only which is there. Now the long-haul aircraft, there are medium haul aircraft that depends on how long is the flight.

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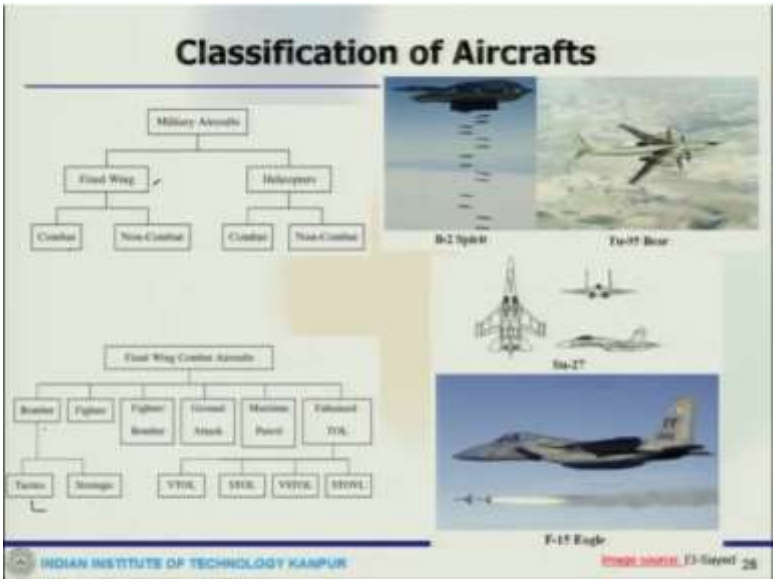

Now, moving to from the civilian, we can go to these military aircrafts and military aircrafts has also 2 different one; one is the fixed wing that is combat and non-combat and that would be helicopter combat and non-combat. Now, when you talk about combat or fixed-wing military aircrafts, so one of them is the call the Bomber, so this is designed to attack on the sea targets primarily dropping bombs on them.

And also strategic bombers are primarily designed for long-range strike missions, examples includes Avro Lancaster, Heinkel, so these are all fighter aircrafts which are designed. Now, there could be like I mean also in the bomber, there are different kind of bombing capabilities like tactical bombers which are small aircraft that operate in a shorter range in battle zone to attack troops, tanks military equipments, example of old ones like Ju 87.

Then, more recent one is the F-16 Fighting Falcon, Lockheed F-117, Sukhoi 25 like this, now then this combat, I mean this is what we are talking about in combat aircraft, so there could be bomber, where as I said there could be stactics and strategical, then you have fighter, so these are used for air to air come back with other aircraft, so these are called the fighters, they are small, fast and manoeuvrable.

Then, the fighter is also sometimes used colloquially for taking the ground attack aircraft, early fighter was used, they are very small and lightly armed but later standards were mostly biplanes, by World War 2, the fighters are predominantly all metal monoplanes with wing mounted batteries of cannons and machine guns, okay. Now, first generation subsonic jet fighters were from 1940s to mid-50s, then second generation came 1950s to early 60s.

Then third generation jet fighters in 1960 to 70, then 70 to 90s there is a fourth generation, then up to 2005 this is 4.5 generation and 2005 onwards we have all fifth generation aircrafts and this includes all different sorts of fighters starting your Boeing, F15 Eagle, Sukhoi 27, Su 30, all sort of different aircrafts.

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Now, there are also non-combat military aircrafts which are transport, tanker, there could be trainer and experimental and this non-combat military aircraft this could be used for firefighting, surveillance, glider and this has some features like UAV, reconnaissance, so obviously this guy, the fighter harrier II has enhanced, I mean takeoff landing capability, this is maritime patrol aircraft.

I mean, there are plenty different examples if one looks at it and you can come up with; now in the transport category, these are fixed-wing cargo aircraft which are used to deliver troops, weapon, military equipment by variety of methods to different places, some military transport aircraft which are also tasked to perform multi-role duties such as aerial refuelling like one of the example of you can see the Airbus 400m, it is refuelling the F 18 Hornet.

So, like some of these examples AN 24, C130, Airbus 400m, so like this now, as I said this could be used for multiple purposes, there are trainer aircraft as we all talked about that this is trained for military personnel which is several training phases are followed usually with turboprop trainers like other aircrafts. Then there could be surveillance aircraft which could be in terms of UAV, unmanned air vehicle or airborne warning and control system, AWACS.

And then there could be airborne reconnaissance which goes back to the early era of ballooning, so the first reconnaissance flight took place during the Balkan Wars in October 1912 by aircraft, one of the first aircraft used for surveillance was the Rumpler Taube during World War 1, Japanese built Mitsubishi Ki 46 twin engine reconnaissance aircraft in 1939.

Fighters such as British Spitfire, mosquito, the American P 38, there are others also but after World War 2, the low range aerial reconnaissance was taken up by adapted bombers like English Electric Canberra America D57, I mean like this.

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So and then if you come to the UAV cadres, these are some of the UAV flights and which has unmanned and these are largest uses are for the reconnaissance as well as attack missions, these are defined as essentially reusable, uncleared, vehicle capable and control sustained, level flight powered by jet and reciprocating engines, you could have airborne warning and control system like AWACS.

These are designed in such a way that to carry out surveillance or some command and control battle management C2BM functions okay, so this was in service with the UCAP and NATO, Russian Air Force, the RAF, French Air Force, Saudi Arabia, Pakistan Air Force and the Japan Air self-defence. Modern AWACS system can detect aircraft from up to 400 kilometres which is closely 250 miles away in air-to-air combat AWACS system can communicate with friendly aircraft extend their sensor range and gave them added stealth, since they no longer need their own active radar to detect threats. Examples are Boeing E3 Sentry and Boeing 767 AWACS

both are powered by turbo fan engines, so these are some of this real advancement that you can see.

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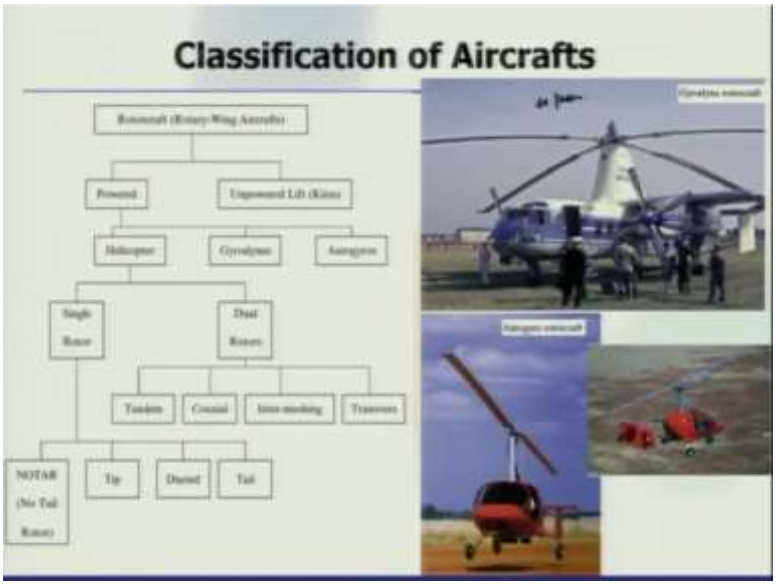

Now, with that we can I mean obviously, there are, here are the other things which are there like firefighting, surveillance and gliders or experimental aircrafts, so these are already we have talked out of the purpose, we can move to the rotorcraft. Now, when you talk about the rotorcraft also or rotary-wing aircraft, this has a wing which actually rotates, these are also powered and unpowered.

Unpowered is sort of in kites and powered includes 3 main category like helicopter, gyrodynes, autogyros okay and then helicopter could have single rotor, dual rotors and all other divisions as listed it out. Now, gyrodyne; this is an example of a gyrodyne which is a rotor craft with a rotor system that is normally driven by its engine for takeoff and landing, hovering like an helicopter.

Its forward thrust is obtained from separate propulsive device usually, 2 propellers are mounted in the tip of the short wing, so being able to fly in autorotation gives the gyrodyne all the advantage and simplicity of gyroplane okay, so this is a famous UK made gyrodyne, so this powered by the turboprop engines and it has capacity of 44 passengers. Now, there could be autogyro, so this is sometimes called the gyrocopter or gyroplane or rotor plane. It utilizes an unpowered rotor driven by aerodynamic forces in a state of auto rotation to develop lift an engine powered propeller.

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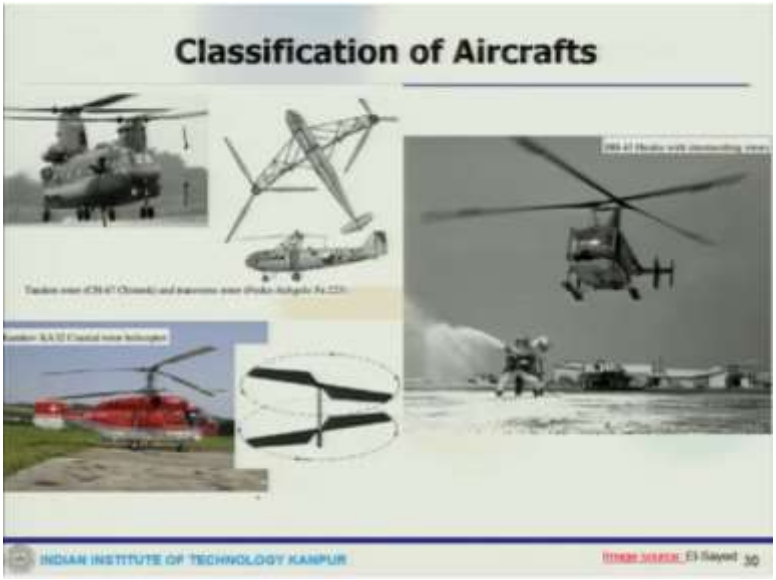

Then, finally we come to helicopters which has powered single and dual rotor, the rotors are driven directly just to push the air downwards to create the lifts, so there could be the rotors which are sitting there, now so that is allows the helicopter when the air is pushed towards the downward it creates the lift to take up vertically. Now, the first helicopter which flight takes back to 1907 and now there are single main rotor which is there, twin rotor has 2 discs usually 1 rotor in the opposite direction.

Then you have rotors which are arranged in tandem, one in the front then traverse all sort of things, the tandem rotor is you have this example of the CH-47 Chinook, so this has 2 large horizontal rotors which are mounted in front of each other, these are counter-rotating rotors, then traverse rotors, these are also traverse rotors are mounted on each wings, then coaxial rotors, this is an example of coaxial rotors where they are mounted above on concentric shaft with the same axis of rotator but they turn in opposite direction.

That means one goes in this direction, other goes in this direction, now then you have intermeshing rotor which is an example of this intermeshing rotor sometimes refer to a synchropter or a set of 2 rotors turning in opposite direction with each other must mounted on the helicopter with slight angle, so that the blades intermesh without colliding okay.

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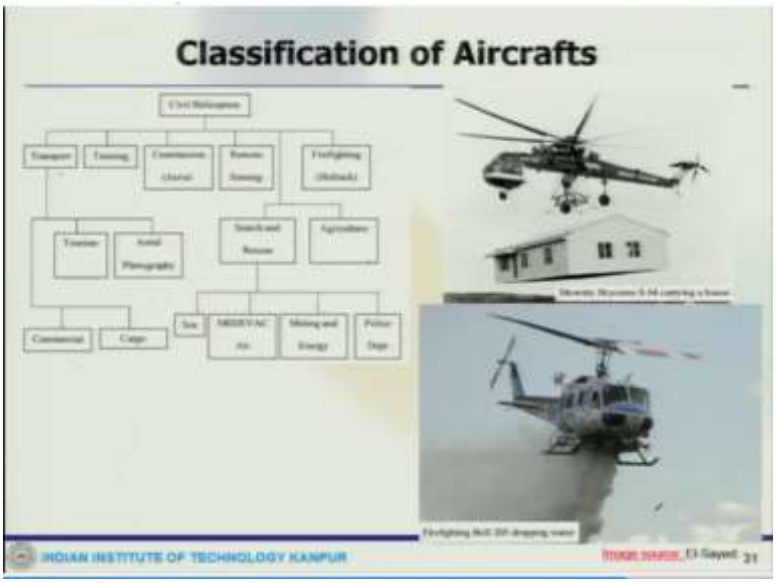

So, this allows to function without the need of a tail rotor, so this is an example of HH – 43, now there could be civil helicopters also which are used for civilian applications, like you have transport which can be used for tourism, aerial photography or this could be used for commercial or cargo, then training, construction, remote sensing, you have search and rescue operation which could be in sea, air, mining, police department or agriculture, firefighting.

So, these are all sort of applications one can think about, so this is an example of a fire fighting Bell 205 which is dropping water when there is a large area which caught into fire, then this is another example where the helicopter is carrying an almost built up house from one place to another place, so there is a plenty of applications are there where civilian aircrafts are also used, like this is another sea ground.

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Then, you come to the some of the military helicopters, so which are used for I mean, one category could be used for attack, another for training, then there could be transport, so there are different missions like which is used for, this is an Boeing's unmanned air vehicle, so now this is attack helicopter which is used to attack the field, this is a maritime helicopter which is this one, so that also uses for in the during the battle so, there are every helicopter has its own features and pros and cons and all these.

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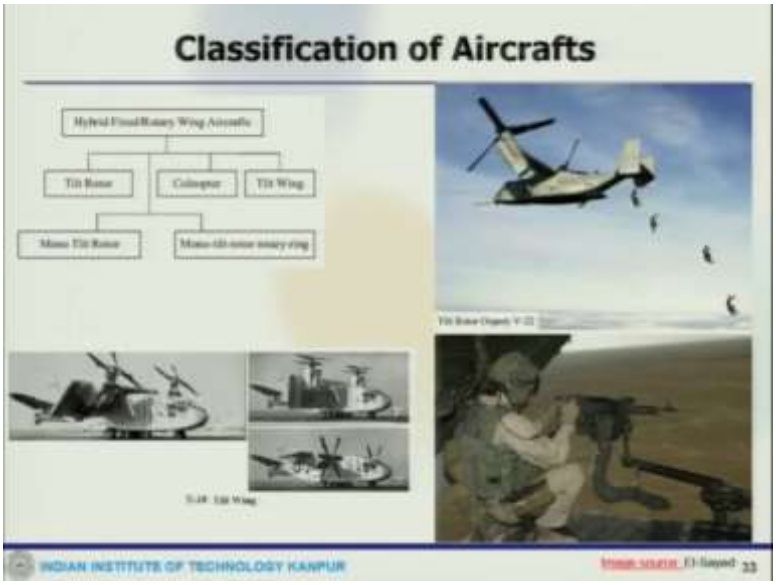

Now coming back to the hybrid or fixed wing helicopters, there could be tilt rotor, mono tilt rotor, mono tilt; coleopter, tilt wing, so these examples are like you can have Osprey V-22, you could have Bell XV3, Bell X 22, these are some of the; now so this is one of the example of tilt wing which is horizontal for conventional fight and rotates up for vertical takeoff and landing, tilting aircraft typically capable or fully capable of VTOL, that means vertical takeoff and landing.

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This design offers certain advantage in vertical flight relative to tilt rotor, now coleopter is a type which vertical takes off landing aircraft designs, so that is there, then you have mono tilt rotor and mono tilt rotor, rotary wing kind of things, now other methods for is this one of this ornithopter, one is this X 24 lifting body as I already said the ornithopter is like that.

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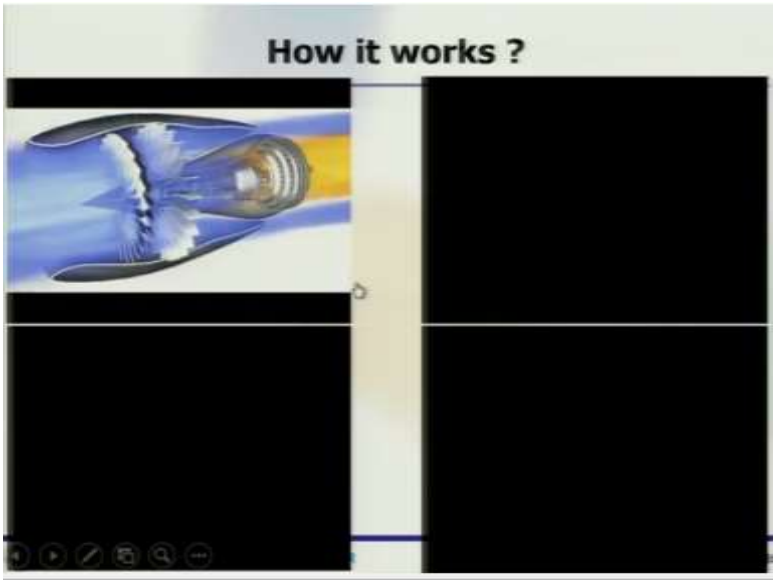

And just to see how these jet engine works, this would be nice to see this:

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Jet engine have been a successful drivers of aircraft for nearly a century now, in this video we will explain the technology behind a jet engine in a logical step by step manner.

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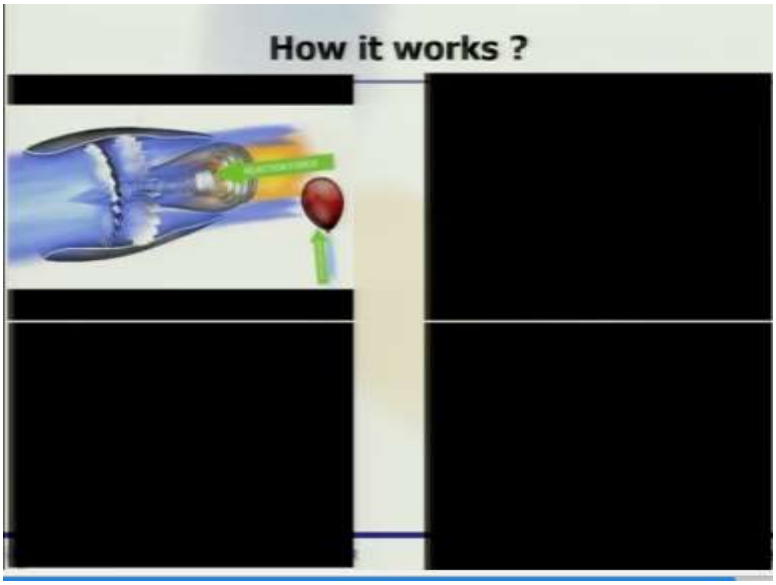

A jet engine keeps an aircraft moving forward using a very simple principle, which simply makes the air filled balloon move, yes Newton's third law of motion just like the reaction force produced by the air moves the balloon. The reaction force produced by the high speed jet at the tail of the jet engine makes it move forward.

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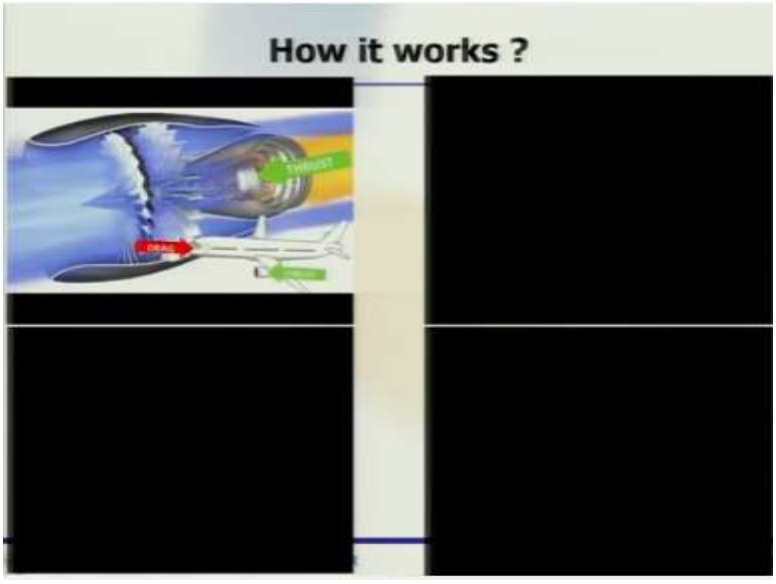

So, the working of jet engine is all about producing a high speed jet at the engine, the higher the speed of the jet the greater the thrust force. The thrust force makes an aircraft move forward, such high speed exhaust is achieved by a combination of techniques.

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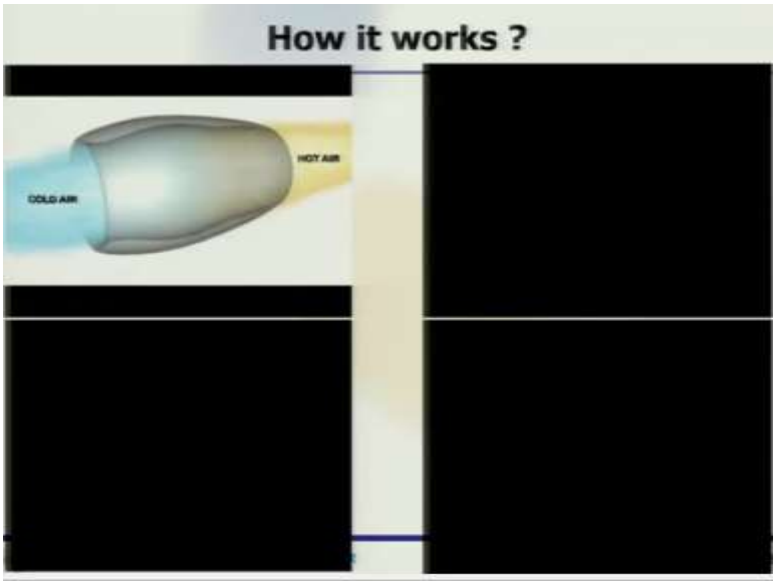

If you look into detail the incoming air to a high temperature, it will expand tremendously and will create the high velocity jet.

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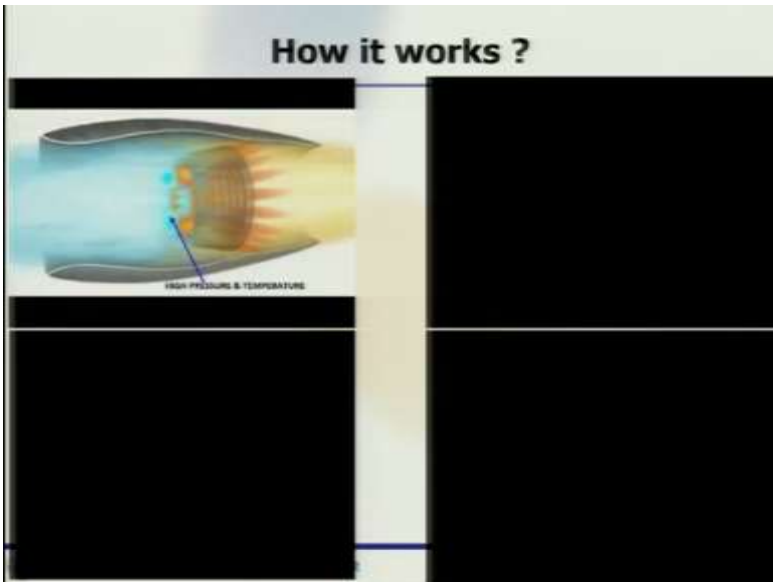

For this purpose, a combustion chamber is used, an atomized form of the fuel in the combustion chamber, effective combustion requires air to be at moderately high temperature and pressure.

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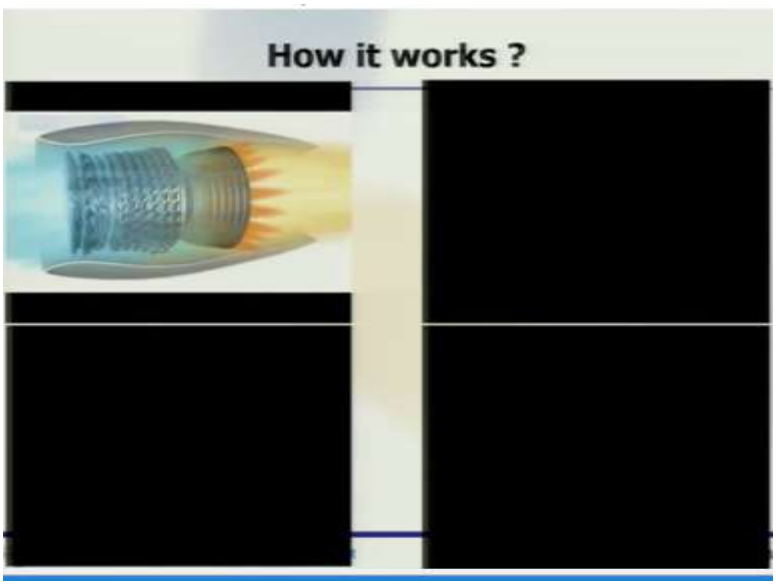

To bring the air to this condition a set of compressor stages are used, the rotary blades of the compressor add energy to the fluid and its temperature and pressure rise to a level suitable to sustain combustion. The compressor receives the energy for the rotation from a turbine which is placed right after the combustion chamber.

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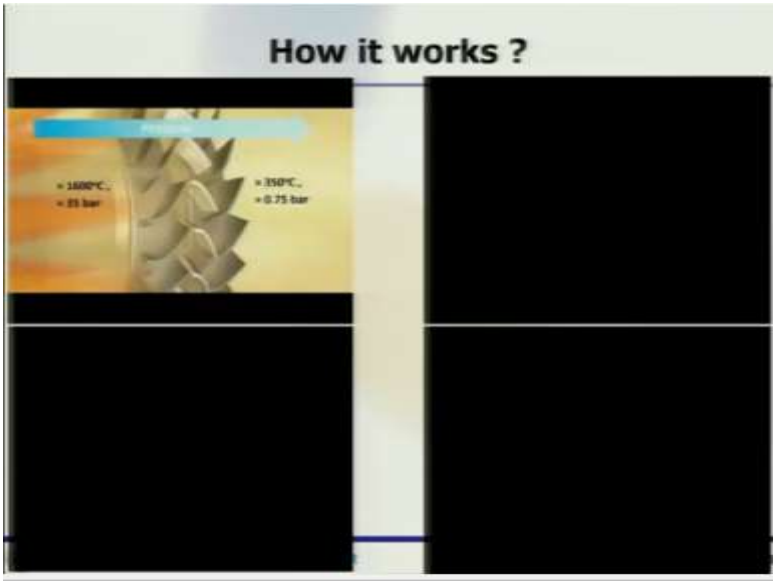

The compressor intertwined or attached to this same shaft, now high energy fluid that leaves the chamber makes the turbine blades turn, you can see that the turbine blades have a special air foil shape which creates lift force and make them turn, as the turbine absorbs energy from the fluid its pressure drops.

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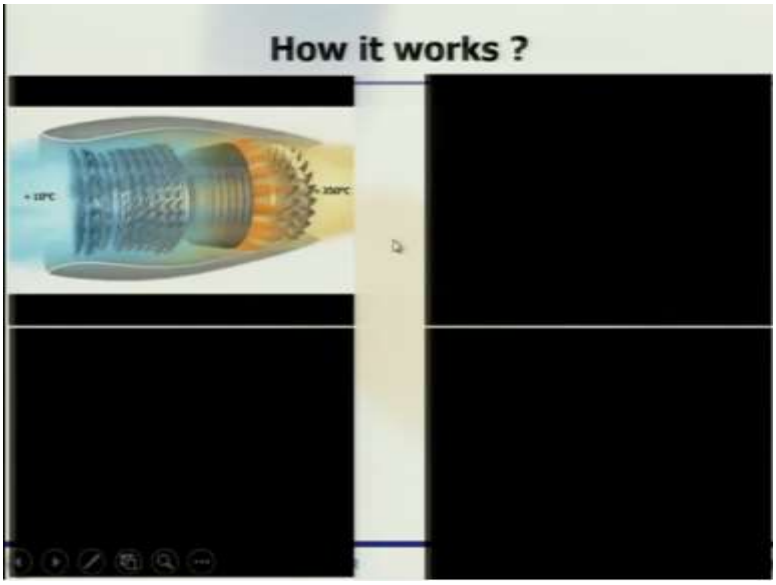

Through these steps we have achieved their objective, a really high, high-speed air leaves from the exit of the engine. The engine case becomes narrower towards the outlet which results in even greater jet velocity, in short the synchronized operation of the compressor combustion chamber and turbine makes the aircraft move forward. Modern aircrafts use a slightly improved compressor turbine arrangement called a two-spool.

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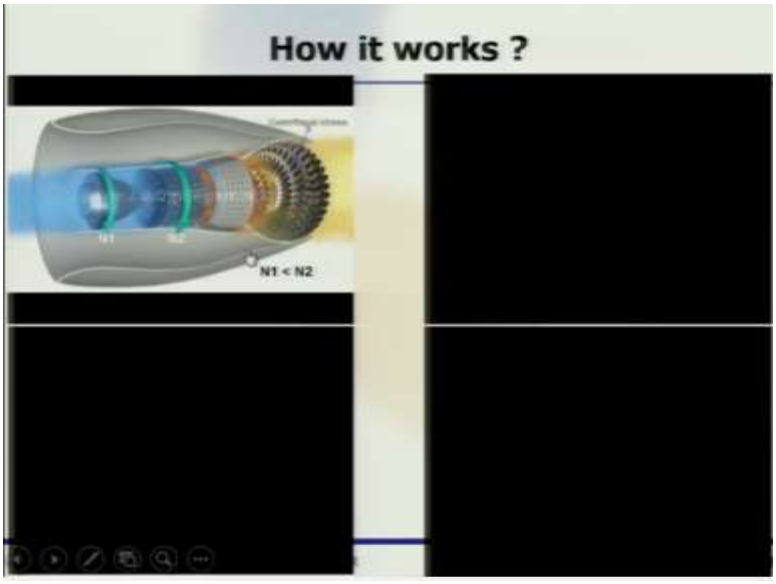

Here, 2 independent turbine compressor stages are used, the shaft of the outer compressor turbine passes considerably through the inner one, the outer turbine is subjected to a low energy fluid and will run at a lower speed than the inner turbine, low pressure blades are longer, this low speed helps to reduce the trip, okay,

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so what we will do that we will stop these things here and we will continue this thing in the next lecture and you will see how these things work, we will stop it here.