Lighter-Than-Air Systems
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Lecture - 83
History of Propulsion Systems on Airships

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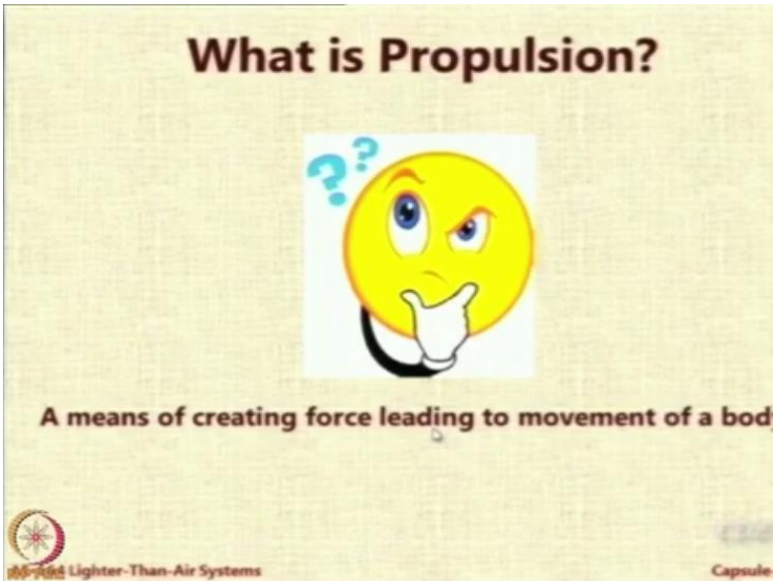

Today we look at the various options available for propulsion systems on an airship. So, this presentation has been made with some inputs by an intern called Agnit Mukhopadhyay who had come over to LTA lab. So, first a question about what exactly is propulsion?
"Professor – student conversation starts." Can somebody help me start the discussion? Ritwik, what is propulsion? Something that helps you propel is using the same word.

Then what is meant by propelling? so you have got a new word called trust, simpler language. You answer in a way that there is no need for me to ask you further questions, simple language, Cannot you simplify this further? That is exactly the point. **"Professor – student conversation ends."** Propulsion basically is some way of creating force and the purpose of this force is it should result in this body moving.

It could be forward, it could be backwards. It could be upwards and even downwards. For round in motion you might use gravity itself. But propulsion need not be overcoming gravity. Propulsion overcomes a drag. So any means of producing a force by which a body can move forward. So, then there are two sub elements. One is that you necessarily have to produce a

force and that force has to overcome the inertia of the body or the resistance offered by the body and allow the body to move forward. Move, move ahead.

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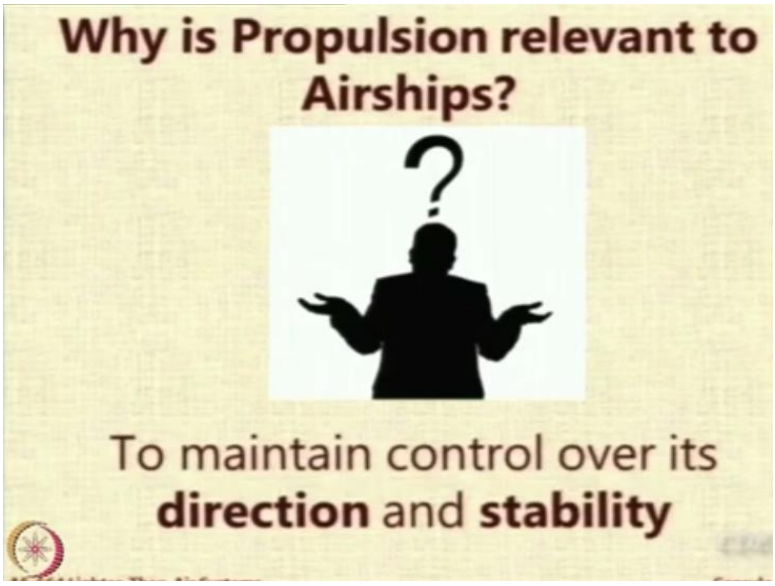

Now as far as airships are concerned, what is the relevance of propulsion? You know this is very simple. Basically by providing a source of propulsion, you can give direction to a body. You can take it to a particular direction or allow it to move in the direction, bu you can also use it to give it some stability because it is a force and that force can also be used to give some stability.

So, can you give me an example of how a propulsive force can be used to give stability or control to an airship? So, I will once again come back and ask you what is meant by stability? I think we have discussed this in the class, right. So, if you understand the meaning of stability, it could be static or dynamic, we are not differentiating now. Then if you are able to give stability or if you know what is meant by stability, then how can you use a propulsion device to give stability?

So, you can use it to overcome the moments or the imbalanced moments that the principal function of propulsion will always remain to provide the propulsive force. So, let us look at the various types of propulsion systems which have been used on airships. We will go back into history slightly as we always do and then we quickly move forward to the current and then I will present to you some things about the future.

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The simplest mechanism of providing propulsive force to an airship is to use a propeller or an air screw as it is called. So, what is the working principle of a propeller? How does a propeller work? Or how does it give you the forward of the propulsive force? Let us see if somebody can start the discussion. **"Professor – student conversation starts."** Very good. It sucks in air and throws it behind. So very good.

The blade is designed in such a fashion that it sucks air and throws it back. Therefore, it will be making a hole because there is a change in momentum of the air. Across the propeller, there is a change in momentum. So, if it throws air backwards the air throws it forwards by the Newton's third law, so it will create propulsive force. **"Professor – student conversation ends."** Now, let us get a little bit deeper.

So, obviously our aim would be to arrive at the largest possible propulsive force for the minimum possible fuel consumption or energy consumption, correct. You will size a propeller or a propulsive system in such a way that you are able to generate the required amount of force with least amount of consumption of fuel, am I right? Everybody agrees. In other words, you need to have a very efficient conversion and one important parameter would be the efficiency of the power plant.

So, you can call it as power input and power output is a power plant. And then the next thing is this energy which the power plant is generating we need to extract it using the propeller. So, you may have a very efficient engine, but the propellor will be very poor or very inefficient,

therefore you will get less power. A large amount of power that the engine generates may not be usable by you, it will be lost.

So, there is a mechanical efficiency or propulsive efficiency of the system and then there is an efficienty of the propeller. So, let us first look at only the propeller. So, I want you to tell me what aspects of the propeller can improve its propulsive efficiency? But only propeller right now. One answer we already got the shape of the blades. Shape of the blades that is the airfoil cross section of the blades.

What are the other parameters about the propeller that improve its efficiency? **"Professor – student conversation starts."** Yes, please. Weight. Weight of the propeller. So, where do you want it to be? You want it to be low or high? But how does the weight. It depends on the requirement like. It depends on the requirement he says. So, I am talking about the propulsive efficiency of a propeller. How will the weight play a role in that?

If I make the propeller 2 kilograms lighter, will it affect the propulsive efficiency? It will affect the aircraft weight. Aircraft weight and the engine weight, Agree. It will reduce the aircraft weight that will reduce the engine weight that may reduce the thrust required, but that is a third order effect. And if the weight is too much like if the weight is too light then it also deflect the, okay structural. I agreed, very nice.

If the blades is very light, then it will start deforming under the loads and that will reduce its efficiency. So, rigidity of the blades should be sufficient so that it can withstand the forces acting on it, agree. Any other thing about the propeller? Yes Preetham. Diameter, pitch and material. So one is the blade shape. The other is the diameter. So, should diameter be more or less? It depends on requirement. Yeah we are doing for a given power plant.

Now I am saying here is a power plant attached to it a propeller, will you go for high dia or low dia for propulsive efficiency? Base diameter affect propulsive efficiency. Some people are saying no. See these are very basic questions about aerospace propulsion. Very basic issues about aerospace propulsion. So, I would encourage you to go and read about it. I do not wish to spend too much time here in teaching basic propulsion.

But I just want to sum up by saying that propeller diameter, propeller rpm, propeller blade angles and the angle variation along the span as you can see in these two propellers, they are all going to affect the propulsive efficiency. But with the best possible design, what is the maximum η_p that you can expect to get? What do you think? 0.7 to 0.8 **"Professor – student conversation ends."** 0.7 to 0.8 is a very reasonable limit. By very careful design you may even go up to 0.9 in some cases, but rarely beyond that and difficult to sustain it beyond that.

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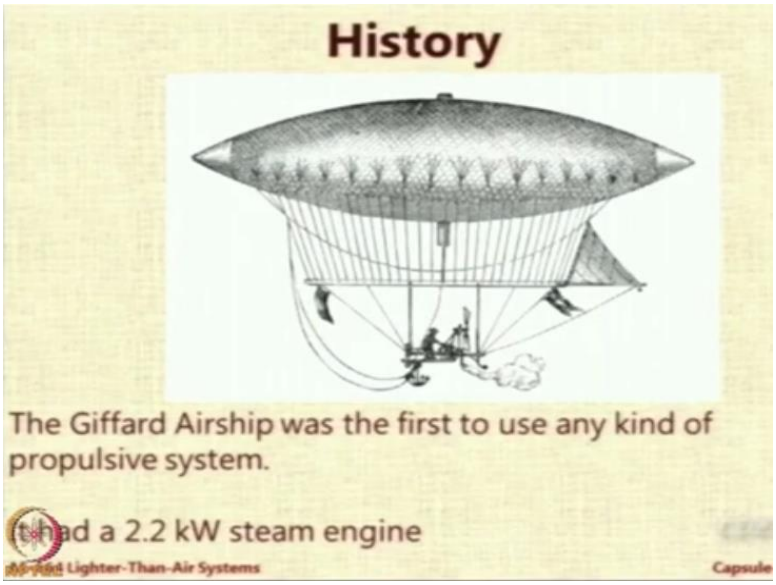

So let us look at some historical information. The first airship that flew with a propulsive device was by Henry Giffard and that airshipo used a steam engine 2.2 kilowatt steam engine. So, why they use a steam engine? Because steam engines were the only reliable source of propulsive force available at that time, but very heavy. They are very heavy for airship applications. But still, Henry Giffard managed to fly an airship. So you can see it is a nice simple tapered envelope.

And suspended below that is the gondola where he is standing with some control lever and the propeller. Even the propeller is also a flat plate kind of a thing with an angle. It is not a contoured propeller. It is flat plate kind of a thing with an angle and you can notice that there is a long exhaust pipe so that the steam can go below so that the steam does not start creating problems to the person flying it. We will see a little bit more about steam and there was a very interesting experiment about which I will talk to you.

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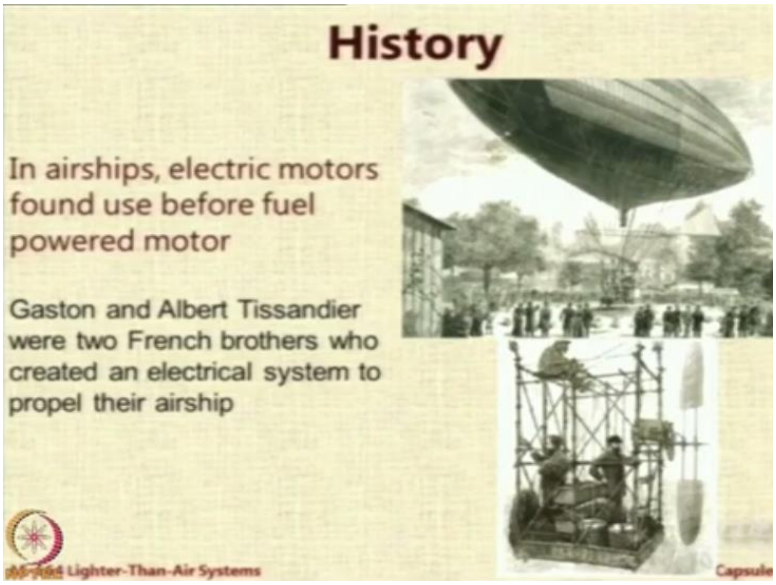

So this is the history. Interestingly, contrary to popular belief the use of electrical motors on airships was attempted before the use of IC engines. And this is something which is not very commonly known. So there were two French brothers and they made the first electric airship but as you can see there are these two big buckets lying here. These two huge buckets, what are these meant for? No, I thought they are the batteries that is a ballast.

Remember we need to carry disposable ballast for buoyancy control. So these are water buckets containing ballast and one of them contains fuel. And the batteries are here, these huge racks they are the batteries. And you can see we have one jacker sitting here setting all the connections, electrician and then the other two brothers. And this is the electrical motor with a huge propeller with a kind of pulley or wheel drive. So the first attempt to use other than steam was electrical on airships.

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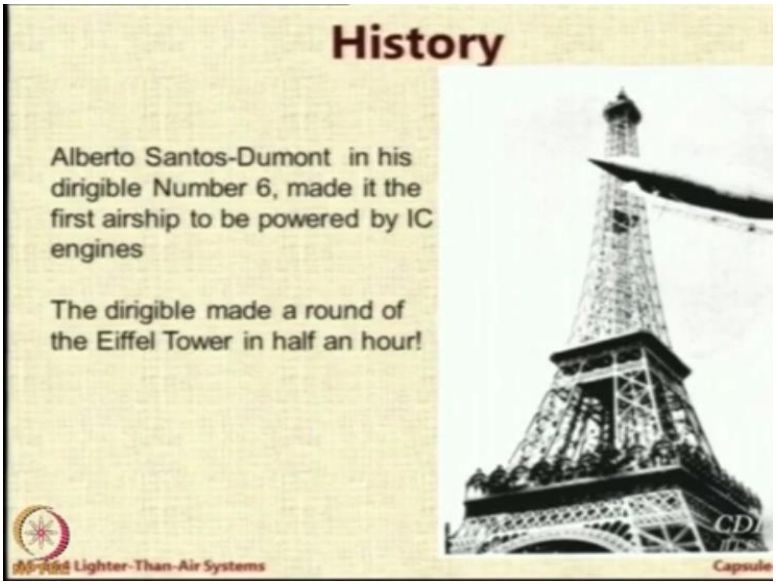

And then the first person to fly an airship with the IC engine was the Brazilian Alberto Santos-Dumont. He also has a record, yes 2-3 records. First record that he has is the first person to encircle the Eiffel Tower using an airship. So demonstration of controllability of the airships. At that time aircraft were struggling to fly around the Eiffel Tower because the maneuverability needed was much larger or better than what aircraft could actually offer at that point of time.

So, he said look we have a more maneuverable system called as an airship which can fly around the Eiffel Tower. It sounds so silly now an airship is more maneuverable than an aircraft at that time. So but he was the first person and to make it very maneuverable he went for a very lightweight engine and that was the IC engine. So, the use of IC engines with this particular historical airship it became almost a standard after this. So people did attempt other systems, but IC engines became propulsion of choice.

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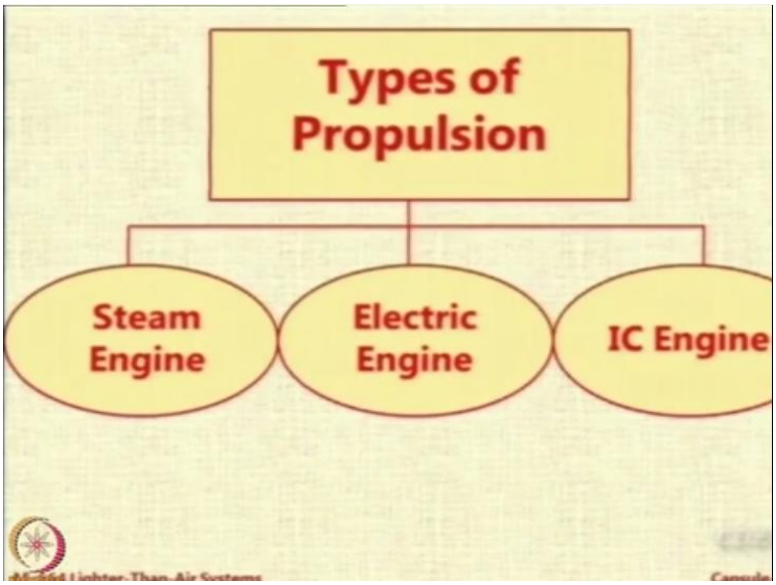

So broadly speaking if you leave out the some unconventional engines which we talked steam engine, electrical engine and IC engine are the 3 basic types of engines, which have been attempted on airships.