Performance of Marine Vehicles at Sea

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Lecture No. # 11

Propeller Geometry Part - II

Today, we will continue with propeller geometry. We have seen there are three outlines that can define a propeller: the expanded outline, the developed outline and the projected outline.

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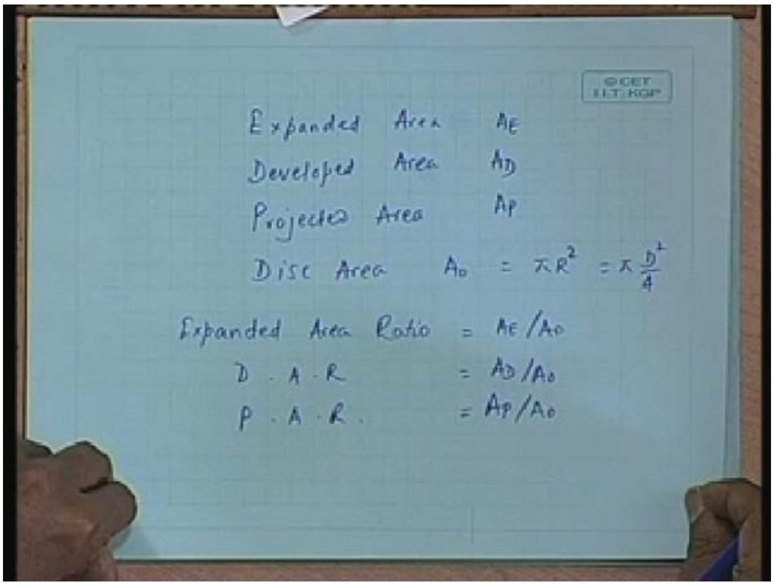

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Expanded Area A_E
Developed Area A_D
Projected Area A_P
Disc Area $A_0 = \pi R^2 = \pi \frac{D^2}{4}$

Expanded Area Ratio $= A_E / A_0$
D . A . R $= A_D / A_0$
P . A . R . $= A_P / A_0$

Correspondingly, there are three areas that we can define that is: expanded area, developed area and projected area. Now, the area that is covered by the circle with radius R that is, propeller radius, R is the radius up to the propeller tip, that is called the disc area, A0, which is equal to pi R square or pi D square by 4, if D is the propeller diameter. Expanded area normally is represented by AE; developed area AD; and projected area AP. So, non dimensionalising this we have three area ratios that is, expanded area ratio, which is equal to AE by A0; similarly, developed area ratio is equal to AD by A0; and projected area ratio, which is equal to AP by A0. So, this is the definition of area.

Propeller diameter is given by D, and propeller pitch as we have seen is given by p. Now, this pitch will be constant at all radii if the propeller face formed a single helicoidal surface.

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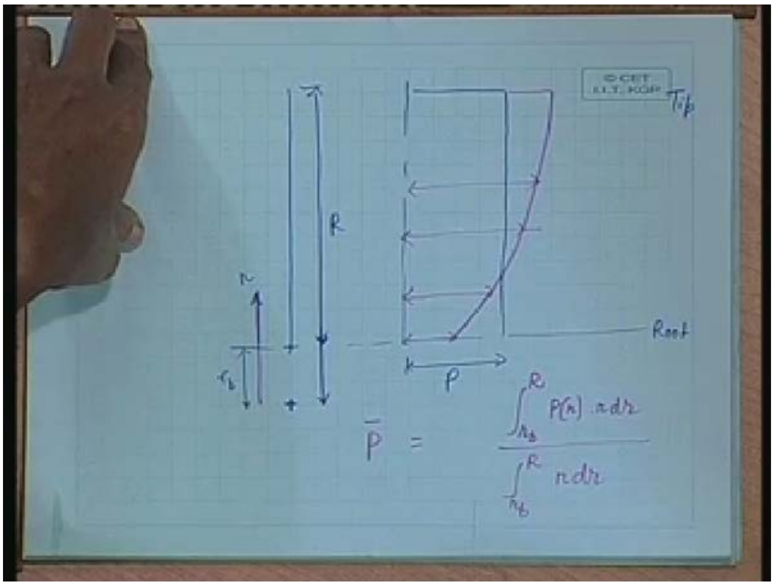

$$\bar{P} = \frac{\int_{r_b}^{R} P(r)\, r\,dr}{\int_{r_b}^{R} r\,dr}$$

But sometimes we may not give a constant pitch across the radius that is, the pitch may vary like, if this is the radius R- this is full radius- then your pitch distribution may be constant; if it is a constant pitch, then the pitch distribution will be like this to the R, this is the pitch, at all radii the pitch is constant. On the other hand, I may decide that this pitch distribution is not ok, I can reduce pitch at the root and increase pitch at the tip, so in that case I can also give a pitch distribution, which may look like this; I can give a variable pitch distribution to the propeller blade. In that case, what will be the resultant pitch?

If I give a variable pitch distribution, the resultant pitch of the propeller if I want to designate it by a single quantity, then in the variable pitch case, resultant pitch, you will, you can see, can be given as mind you, the pitch is starting only after the root, the boss, the blade is starting from the root till the tip, so this point is the root, this is the root and this is the tip and propeller centroid may be somewhere here where this distance will be Rb, or radius of the propeller up to the boss in that case, this will be Rb to R- I made a mistake here, this R is up to here. Pitch at any R into R d R divided by (No Audio from 5:40 to 5:48 min)- is that understood?- that is, I am taking moment about the axis of the pitch and averaging it by dividing by the R integral, capital R, bottom is nothing but capital R, r square by 2, capital R square by two.

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(( )) from the.

Any distance, here is R from the axis propeller axis. So, this is the so called resultant pitch of the propeller- propeller can be represented by one pitch, this is that resultant pitch.

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Why we are changing this, why you are changing the pitch distribution, why this particular one ?

Why we are changing the pitch distribution? How else will you do it, how will you do it? See, you cannot say my, when you give more description of your propeller you will say that propeller has a varied pitch, the nature of pitch is this, you may express it numerically at various radii; R equal to 0.2, let us say is so much, later on at some different, you can say like this, you can actually define the pitch quantity. But if you have to do calculation based on a single pitch, or you want to tell about your propeller geometry to a manufacturer, you have to give him some indication, you have to give one pitch because at that point of time perhaps variation of pitch does not make sense, when you are giving the information. So, the propeller will be defined by diameter and pitch.

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Actual pitch is this; that is not a constant pitch, it varies. We have already defined, I have already told you what is slip, I have already told you that, let us deal with slip then.

We have said that if a propeller is moving in a solid medium and it was a constant helicoidal surface, then in one rotation it will move a distance p, but since it is moving in a fluid medium it will not move a distance p, but something less than that- I have mentioned this to you. Suppose, the propeller had a resolution Rps and small n, then the distance that would, it would have moved if the medium was solid in 1 second would have been n into p that means, the ship would have also moved, or the water velocity would have been also equal to n into p, but since it is not moving n into p, it is moving something less.

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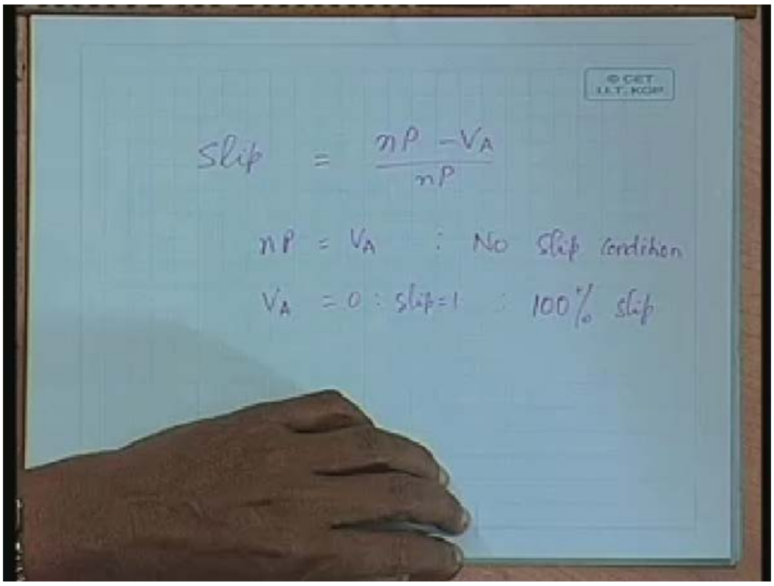

$$\text{Slip} = \frac{nP - V_A}{nP}$$

$nP = V_A$: No Slip condition

$V_A = 0$: slip $= 1$: 100% slip

We can define slip equal to np minus VA divide by np that is, this is the distance, np is the distance it should have actually moved, but it has moved a distance VA only- understand that VA is the velocity of water which is equal to as if the propeller has moved VA in the other direction- is it not? So, the slip, the amount of slip instead of moving np it is moved a little less, so how much it has slipped? Np minus VA; non dimensionalising this we get this as the definition of slip. So, if the slip was not there, then what you would have got here is np equal to VA then, you would have got slip equal to zero; np equal to VA- is no slip condition; VA equal to 0 would give slip equal to 1- that is hundred percent slip.

What is the meaning of hundred percent slip? I am holding the propeller, allowing it to rotate, but not free to move- that is hundred percent slip; though it is part of a helicoidal surface I am not allowing it to move, this will not happen on a nut and bolt case where this is always a no slip condition. In ships, now, suppose my ship is moving, my propeller is rotating, is it, if I had perfect helicoidal surface, would it move np distance in each, in each second? The answer is still no, because it is moving in a fluid medium, the fluid and propeller interaction would be such that it will not give a distance moved as np, but little less than that, which is equal to VA. So, we have got in actual free running condition a slip condition where the propeller does not move the distance np, but little less than that.

There are many other factors that come into picture like, when we look at the theory of propeller action, we will see that the propeller blades are normally aerofoil sections, which at a particular angle of attack generate certain amount of lift and that lift ultimately gives us thrust. Now, the generation of lift due to various constrains experienced from root to tip for example, a root section, the flow will be very much effected by the boss itself, a tip on the other hand will not be affected by the boss, but it will be affected by perhaps more vibration because the propeller has become thinner as it has gone up. So, there are other factors that come in to play, there may be gravitation, there may be strength problems. To avoid all this some propeller designers may give a variable pitch across the radius where each section will be designed for an optimum condition of speed VA at that radius that is, if the velocity is varying across the radius, each section will design for that corresponding VA and then the pitch will depend- as you have seen pitch and VA are very much related- so, pitch of that section will be designed slightly differently from other sections, it may be different- am I clear?

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We'll see the (( )).

We do not define slip as a variation across the radius; slip is the overall propeller slip for which you require to design an overall propeller pitch.

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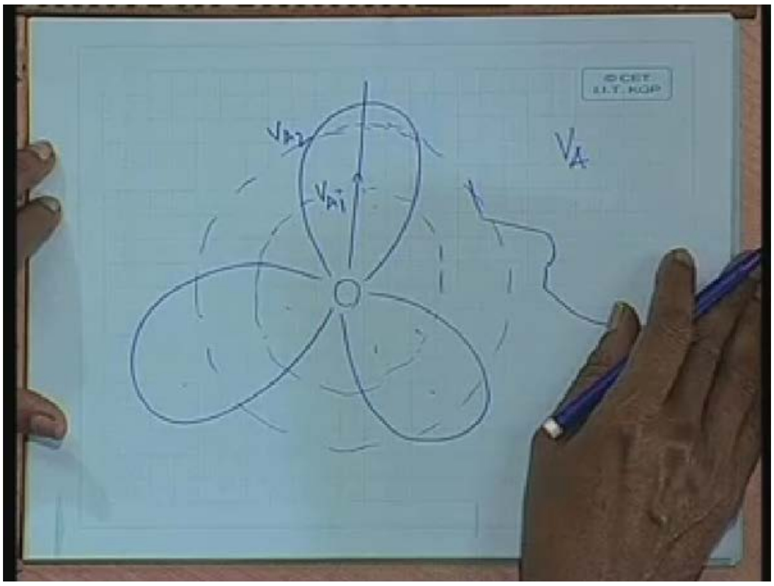

So, we have got a, let us see, there are three blades here- please see here- they are three bladed propeller, the ship at the propeller disc is somewhere here, this is the propeller, why the ship is here on top just like this? So, in the propeller disc if I take a section, the ship is somewhere here, there is nothing below- can you understand that section?- there is a restriction here, just see this little part, we will, when we come to wake we will see it in greater detail, which we will do, but right now to understand the propeller, how it works properly; see, there is a ship here, a ship here, but below there is nothing, so you can well understand thus, water that is coming past ship is not having a constant velocity all over the propeller disc- can you understand this, yes or no? Since it is not having a constant velocity across the propeller disc, the propeller cannot behave exactly similarly as if there was a constant velocity that is, each section will behave slightly differently with water than the other section because the speed is varying- can you understand that? So, when you say VA is constant, what are you saying, are you saying that each velocity is constant on each propeller disc, each point is it constant, or are you saying overall velocity VA, I am giving, what you are saying? When you say speed of advance VA it means you have made some sort of averaging this over this whole disc and saying VA, it does not mean VA is same at all points on propeller disc- is that clear? So, when we are saying VA, we are also averaging.

Now, it may so happen that in a well designed stern you cannot avoid variation of velocity in this direction, there will be a variation of velocity in this direction. Imagine the ship, the sections are very thin here, at this portion, the stern- if you remember the stern- the section goes like this and expands out. Lingra, the ship is full, a little forward of the aft, and suddenly closes in and then expands here. So, the geometry in this portion is very complicated, very highly three dimensional. So, when you allowing the water to flow past it, it is having a axial direction of flow that way, a vertical direction and also a it is closing in, so a transverse direction- there is three directions of flow, all x y and z directions, can you understand that?

So, highly non-linear nature of flow is there, we are trying to design a propeller there. So, by certain, adaptations of certain features in the stern it is possible for us to design the so called Isowake-lines, radially, concentric to the propeller axis. That is, if I take an axis here, I can have more or less a constant velocity- not exactly- but more or less. But if I take an axis a little away it will, it may also be constant, but it will be different from here- am I clear? Now, for that, so, if I have got say a speed which is I call VA1 and a speed here which I called VA2, then the design of my blade section here to utilize this velocity will be slightly different from the design of the blade section from here, and what is the design I am talking about? Mainly, pitch. So, I design a pitch here so that if this VA1 must prevalent everywhere, I would have kept the pitch constant, and similarly I will design a pitch here, which if VA2 was constant everywhere, that pitch would have this thing, but this pitch is not same as this pitch is different- do you understand?

(Audio not clear from 18:50 to 18:55 min)

Sir be that each section belongs to different required helicoidal.

Yes it does, it does, it does. So, it is not a very well geometrically defined surface, what ultimately it comes down to is it is nearest to a helicoidal surface, but not exactly helicoidal surface particularly, the helicoidal surfaces curvatures themselves vary if I have got a varying pitch- am I clear ? So, what I was telling is if this is the case, then how do I define my pitch? After all for a propeller, like we have defined an average velocity VA, then we must define an average pitch so that I can define my propeller for some simple calculations and that pitch is defined like this.

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Why we need it more (( )).

Can we delay answering this question? May be if you proceed with propeller theories a little bit this question will come out, this answer will come out itself. But I have given a hint; it is mainly the wake distribution for which we have designing this thing. And another point which you must understand is that the propeller blade is like a cantilever, connected at the root, but free at the top, so it has requirements of strength also; plus the root sections are very much affected by the boss, so you do not get more lift generated by the root sections, most of the lift comes on the top sections. So, we, our, the later half of the propeller blade that is, blade towards the tip is more important for us, but on the other hand thee root is very important so that propeller blade doest break off.

So, that way as you know in any design exercise these are all combinations of things; then, if you go to the manufacturer, you will say my propeller cannot cost me so much and the cost is on weight, how much material has gone in. So, you have lot of compromises you have to make so that everybody feels a little bit happy; the lift fellow thinks that enough lift is been generated, the strength fellow thinks that enough of strength is there because of root sections, the materials fellow feels that an reasonable material is there, so my cost is not too high, operator feels that this propeller can give him good operating characteristics-so, all these compromises have to be made for which reason in the design itself you have to take care. So, variable pitch is one such thing rather variation of pitch we will talk about variable pitch later

So, we have seen that this propeller parameters, some of these we have now defined by non dimensional quantities as the area ratios.

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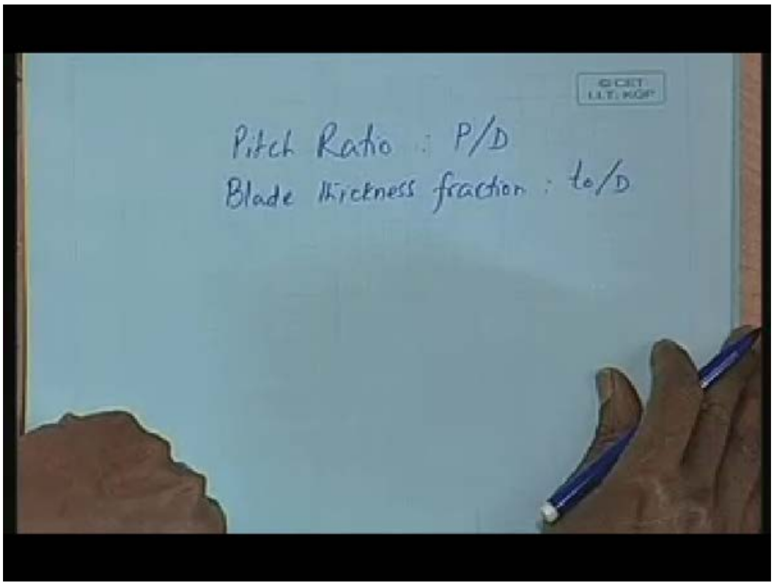

Pitch Ratio : P/D

Blade thickness fraction : t_0/D

Similarly, we can define some more quantities by various ratios which are non dimensionalised: One is pitch ratio, P divided by D- normally, all ratios are taken with regard to D, diameter of the propeller; Similarly, we have blade thickness fraction t0 by D, t0 be thickness at the axis.

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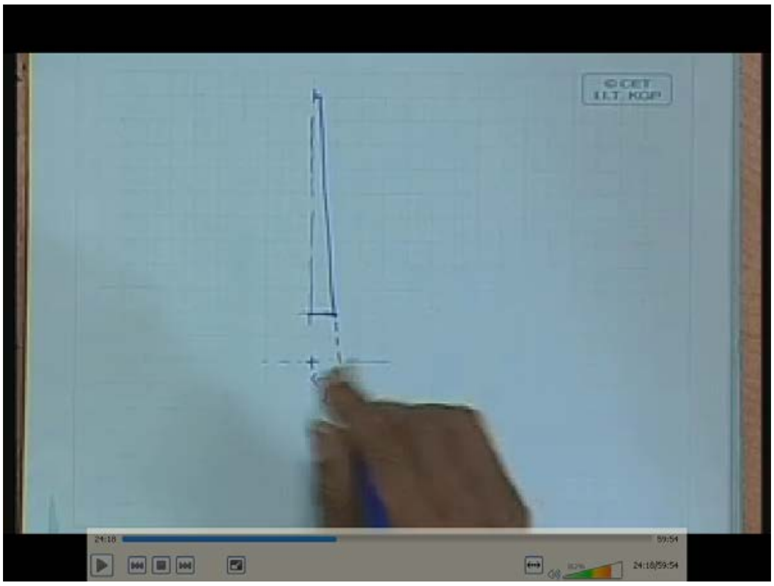

I will define this. I have, if this is my propeller axis and my propeller blade starts from here, let us say this is the boss, what will be the thickness at the root? We have just discussed the thickness of the root will be highest, have to be reduce to the tip. Normally, it is a straight line distribution, but you need not have a straight line distribution you can have a different distribution, but conventionally it is a straight line that is, if the tip thickness is so much, root thickness is so much, then we can join it by means of a straight line to get the thickness at any other radius. If this is the thickness distribution, I extend this line to the propeller axis, and this thickness at the propeller axis if the blade was extended to the axis is defined as root thickness, not root, thickness at the axis, t0.

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T is related to boss

T is the centre of the propeller, boss. No, that is not the root, root is here.

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Yes, if the line is extended to the axis. So, t is thickness fraction, blade thickness fraction is t0 by d where t0 is the thickness, extended thickness at the axis.

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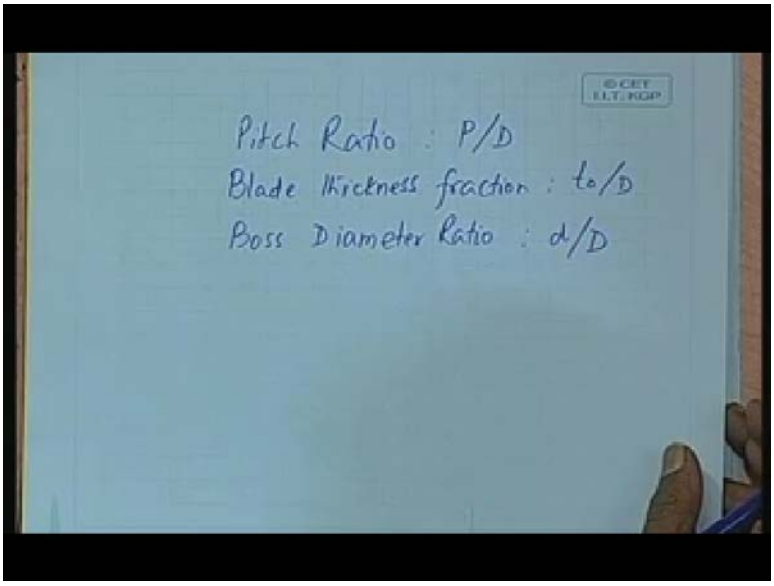

Pitch Ratio : P/D

Blade thickness fraction : t_0/D

Boss Diameter Ratio : d/D

Then, you have boss diameter ratio, d by D, where d is the boss diameter.

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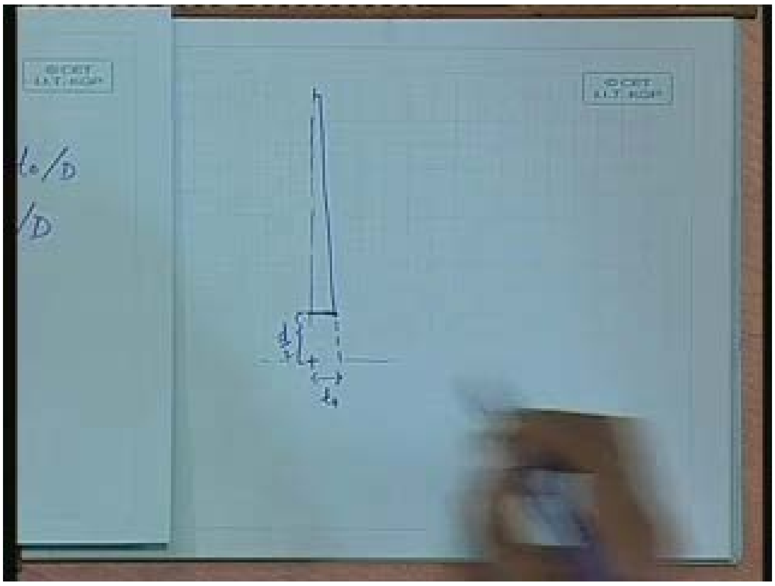

Diameter of the boss at the axis- that is this diameter, d.

Now, there are some more ratios may be required if we look at the various sections that are used in making propeller plates.

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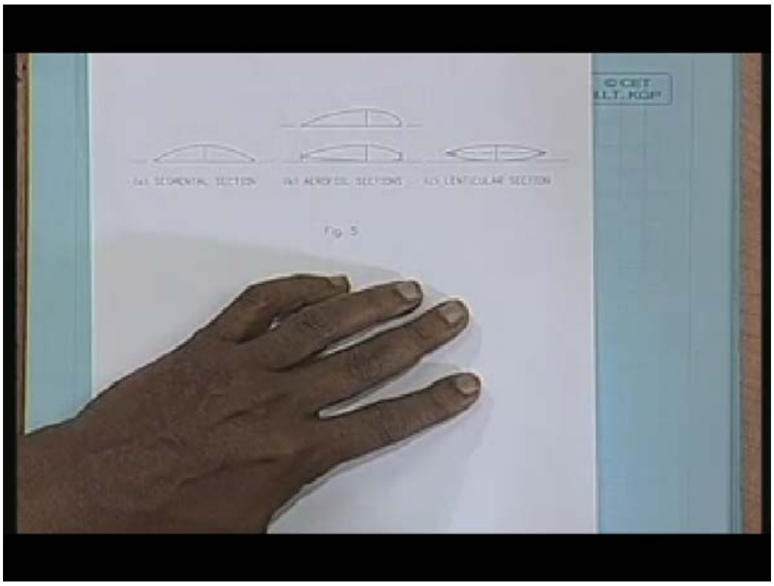

Let us see what are the sections propellers, blade sections? Can you see this, is it visible? The most commonly used propeller blade sections are the ones that are shown under b) here- aerofoil sections. Aerofoil sections have been very well studied over the years for their characteristics, for angled flow on to the aerofoil sections and how they behave, and large amount of data is available. These sections are considered to be just suitable for generation of lift; we will see how a lift is generated later on.

Here you can see, this top section, the face is lying on the helicoidal line, the expanded line is straight and the face is matching with it and the back is here, so this forms a part of a helicoidal surface. This sort of section shape is known as aerofoil section where you can see the leading edge is not really sharp, it is rounded and the trailing edge is sharp- that is how propeller blades are made- the leading edge has a curvature, but the trailing edge is sharp. There is another way of knowing for which is the leading edge- the one that is sharp is the trailing edge, the one that is blunt is the leading edge and that is the one that will be meeting a water first, so you can also decide which way the propeller rotates by just looking at the propeller if it has the aerofoil section.

Now, as we have seen later, earlier, you can also give some offset to the face from the straight line and still it would be an aerofoil section. This is the most commonly used section for majority of propellers available in the world. This on the another hand is called a segmental section where the back of the propeller section is a part of a circle- unlike an aerofoil section you can see it is not part of a circle, it is blunt forward and sharp towards the trailing edge-here in the segmental section the back is part of a circle, this is many times used where there is a requirement of a, typically these sections are used in propellers for trollers where you require not only free running speed, but also some amount of pull that one must exert such as, hauling a troll net or something like that. In many propellers there is a combination of both aerofoil section and segmental section that is, aerofoil sections up to a certain radius and then the section slowly change to segmental section- we will see some of these propellers later on.

Then, what you have is called a lenticular section where the section is symmetrical about its central line that is, more or less segmental section on either side. Can you tell me where such sections can be used?

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No, these sections are used in propellers where the propellers are required to work efficiently in either direction. No, not really, we do not want equal efficiency in normal merchant ships in forward speed condition or an astern speed conditions. Normally, we want some speed in the astern condition, but we want maximum efficiency in the forward conditions because the ship will be spending over ninety five percent of its time moving forward. So, the section is designed to give the forward efficiency high and so, therefore, you use these sections whether it is tugs, trollers, merchant vessels, naval vessels, whatever.

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(( )).

No, you do not require thrust on both sides.

(Audio not clear from 30:16 to 30:20 min)

(( )).

No, tug does both; first, and in any case it requires push only in forward direction.

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(( ))

We will discuss this little later. But there may be special occasions as Mr. Kumar is saying, tugs in general do not require it, but there could be vessels which required to be moved both forward and aft regularly- let me put that word regularly- that that is if fifty percent of the time is moving forward and fifty percent of the time is moving backward, then I would require a blade that is efficient both ways, but there will be a small compromise on maximum efficiency either way- do you get my point?

(Audio not clear from 31:13 to 31:18 min)

Sir if the river those carrying the lickers I am not saying.

Right.

Are they greater

Some of these vessel, some of the river craft may require lenticular sections similarly, some other vessel may be occasionally a tug or two, a dredger, they may require for this type of thing then you have lenticular (( )), you may require this sections for submersible vehicles, which are doing operations under water, and you require to move them in any direction if we like, then also you require lenticular sections.

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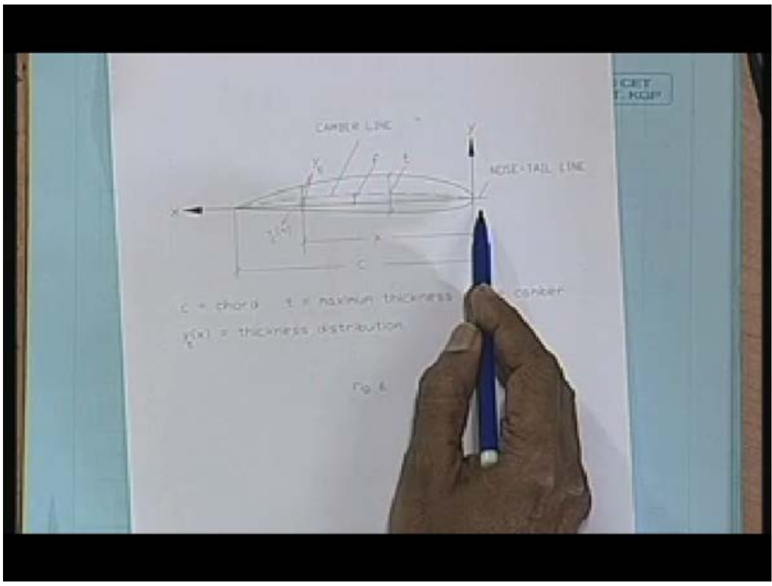

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So, we will now concentrate a bit more on the aerofoil sections, can you this diagram? We have started measuring x from leading edge towards trailing edge and y toward the back.

Now, the line that is the x axis is called the nose tail line joining the leading edge to trailing edge by a straight line- can you see that? The nose tail line is the one with reference to which the section would be defined; mind you, this is the face and this could be form the helicoidal surface, nose tail line is not a part of the helicoidal surface, the helicoidal surface is still the face, most of the face, and nose tail line is a line only for defining the section. You can see there is some area below the nose tail line and some area above and what you observed is that there is more area above than below, now, if I join the mean thickness line, I will get this chain dotted line; thickness at any section, t, this t if I cut it into two, this is the middle point of the section similarly, I define the middle points and join this line, this chain dotted line, this is the so called camber line

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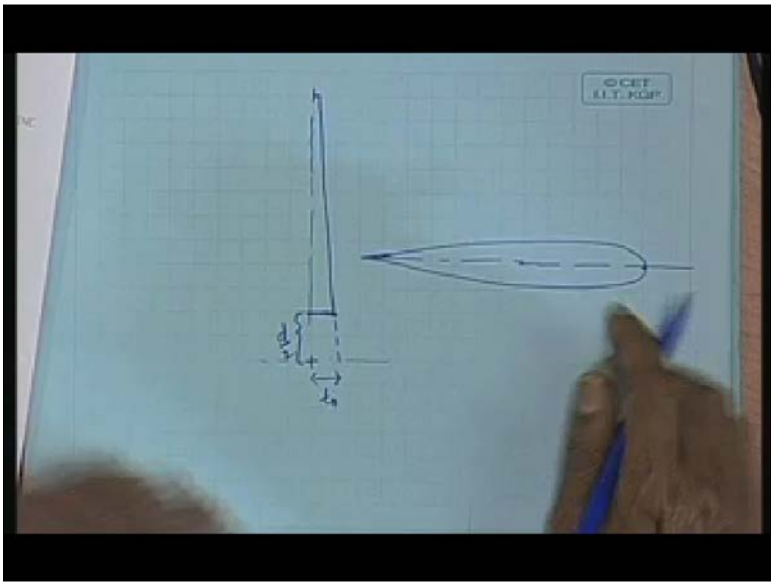

That means, if I did not have a camber line, or if this camber line was straight, then I would have had equal area on both sides that is, I would have got an aerofoil section which would have looked like this- do you get it?- this is still aerofoil section, blunt face, blunt leading edge, trailing edge this, this is my nose tail line and also the mean line, so there is no camber here, what does it mean? This side area is same as this side area.

Now, if I sort of push this blade- nose tail line remaining same, I only push the middle portion- then this blade will change to something like this and then the camber will form. Yes, so, that is the camber line and the amount of camber that this aerofoil section shown here has is the maximum offset from the nose tail line, that is this c here, which would occur somewhere in the middle of this nose tail line- so, this is called a cambered aerofoil section.

The, at any distance x we can define the back ordinate and the face ordinate from the nose tail line; this length, the total length on the aerofoil is called the chord, and from this nose tail line this distance and that this distance at the back ordinate and the face ordinate if there has no camber, they would be same, just defining one ordinate would define the section. But if we do not have a no camber aerofoil that is, if the aerofoil has a camber, then we have to define the back ordinate and face ordinate from the nose tail line, then the section is defined. Why I mention it is normally, as I mentioned a lot of studies have been done on aerofoil sections, so standard aerofoil sections are available for which all data is published and available in common domain; so, these data gets modified if you add camber, so using the camber you can modify the face ordinate and back ordinate.

This section thickness is, maximum thickness is t, wherever it occurs chord c chord, t maximum thickness, f camber, I have already defined, and ytx is thickness distribution that is, thickness at any point along the x- clear? Then, two more quantities are required to be known at this stage for a propeller. We have talked about mass, we have talked about mass, it is a geometrical feature of the propeller, if we know the entire geometry, we can calculate the mass, how can you calculate the mass?

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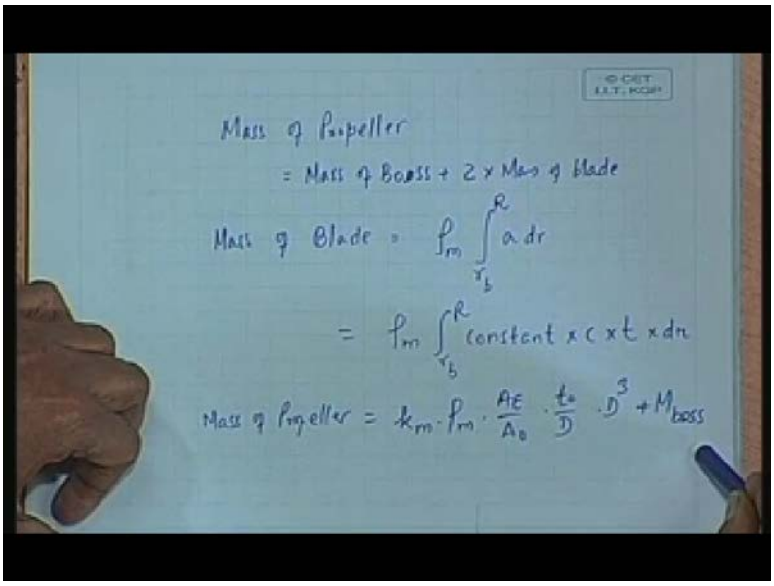

Mass of Propeller

= Mass of Boss + Z × Mass of blade

Mass of Blade = $\rho_m \int_{r_b}^{R} a\, dr$

$= \rho_m \int_{r_b}^{R} \text{constant} \times c \times t \times dr$

Mass of Propeller = $k_m \cdot \rho_m \cdot \frac{A_E}{A_0} \cdot \frac{t_0}{D} \cdot D^3 + M_{boss}$

Mass of propeller, how much will it be? Mass of boss plus z into mass of blade, z means number of blades, is that correct, and where is the mass of the blade? Density into volume. How do you get the volume? A is the area, area means expanded area, why expanded area? We have seen that that is the actual length at that section, straight line form, that same as if you measure the length this way on the level of trough line. So, this area would normally depend at each section on the chord and the radius and the type of section- if it is aerofoil, it will have some constant of multiplication, if it is a segmental section, it will have another constant of multiplication, so on so forth.

So, I can write rho m equal to constant into c into thickness into dr, c being the chord. So, again if I know the geometry properly, all this c, r, etcetera., can be reduced and I can write mass of propeller is equal to km rho m AE by A0 into t0 by D into D cubed plus Mboss- Mboss is same as here, mass of boss. This here- what I am getting?- this is the density of material, this is the expanded area ratio, which is giving me the area covered, this is thickness related to this t, I can relate it, and D cubed gives me a (( )) because I have divided by D cubed and multiplying to make it suitable to scale, and a constant, which is a constant based on propeller geometry, taking this a part of the constant based on thickness distribution, a part of constant based on blade (( )) ratio.

So, you see, if you know the propeller outline and the sort of propeller geometric fully, for that type of propeller this km can be calculated and you can get the mass of the propeller. One more quantity we require for propellers. You will appreciate that propeller is a heavy mass at the end of a supported shaft, which is rotating, so you have a thrust block here providing a bearing support to the shaft at one end then, there are intermediate bearings, stern ((bland)) at the end and then the propeller, a heavy mass rotating at a constant RPM.

So, because it is supported at number of points it will give rise to torsional vibration and that torsional vibration will be a function of, one of the main variables of the torsional vibration will be the propeller mass- will it be mass, when you talk about rotation will it be mass? It will really be moment of inertia, mass moment of inertia. So, it is necessary to calculate the mass moment of inertia, which must be supplied by the manufacture to that designer to do his torsional vibration calculations- longitudinal, sorry, torsional that is, what we call- shaft alignment calculations, which is related to torsional vibration.

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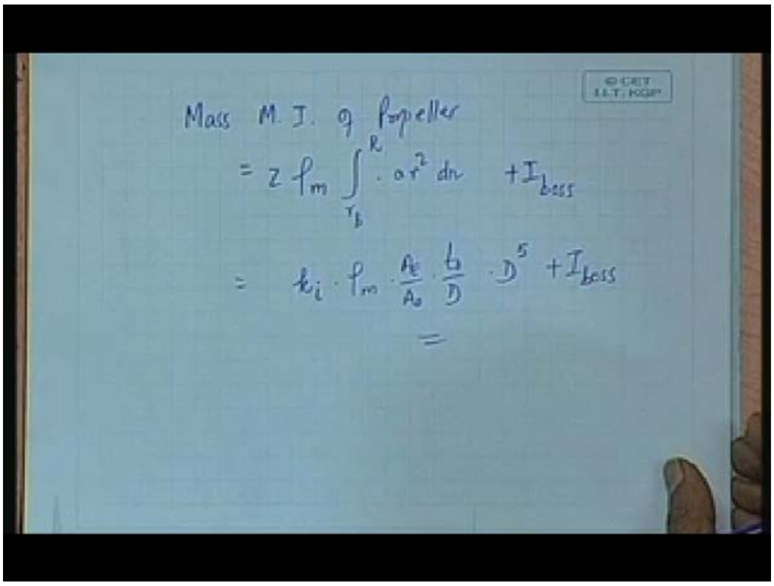

Mass M. I. of Propeller

$$= z\,\rho_m \int_{r_b}^{R} \cdot a r^2\,dr \quad + I_{boss}$$

$$= k_i \cdot \rho_m \cdot \frac{A_E}{A_0} \cdot \frac{t}{D} \cdot D^5 + I_{boss}$$

$$=$$

So, how do you get the mass, moment of inertia of propeller, how will you get? This we can say will be equal to rho m, I am writing for a blade only now- what will it be?- a into right into number of blades, I will put a z here, plus Iboss. So, going through the same system as we did for the mass we can come up with a final solution like this: ki- there we said km, here it will be a different constant- rho m into AE by A0 into to by D into D five plus I boss- there it was D cubed now, here this is r square is multiplied, so it will be D five. So, we can calculate the moment of inertia of the propeller about the shaft axis, rotating, which will be required for doing the calculations. The cost of the propeller will of course, depend on the mass; this is, mass of the propeller is very important parameter in defining your propulsion system because it is directly related to the cost and how well you make it- any questions?

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I will just introduce aerofoil section, its behavior. Let me, this part is important; we have got this propeller blade moving like this, each section, radial section is an aerofoil section now, this blade is moving like this and moving forward like this, so how is the water falling on this blade section if we take each blade section? Since, it is moving like this, we will assume that as if the water is falling in the other direction, at any point, any section you take as if water is falling tangentially on this; if it is moving like this, water is falling like this also, since it is moving like this water is falling like this- can you understand?- forget about water's own velocity, as if water is having a constant axial velocity equal to the movement of the propeller. Propeller is moving like this, tangentially, water is moving like this, and axially the water is moving like this, so what is the resultant water flow on to the propeller? And a component is like this, a component is like this, so the resultant is like this- can you understand that? Yes, if you understand this, I do not need to bring the propeller model next class. I have a velocity component like this, I have also a velocity component which is tangential to the axis, so I have got water, resultant velocity, which is making a very small angle to the face and falling on it.

(Audio not clear from 46:45 to 46:49 min)

But water is fall (( )).

No, you see, the propeller is moving like this, if the propeller is moving, it is as if the propeller is steady and the water is moving like this- do you understand?- so the flow of water is like this, tangential to the blade section.

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The resultant

That is for this. Also the propeller is moving like this, so, that is water velocity is equivalent to falling like this. So, the velocity of water with regard to propeller will be somewhat not exactly tangential not exactly axial, but somewhat like this, this is happening at all sections like that- understood? So, the velocity is like this, a small angle it is making with the face- can you understand that?

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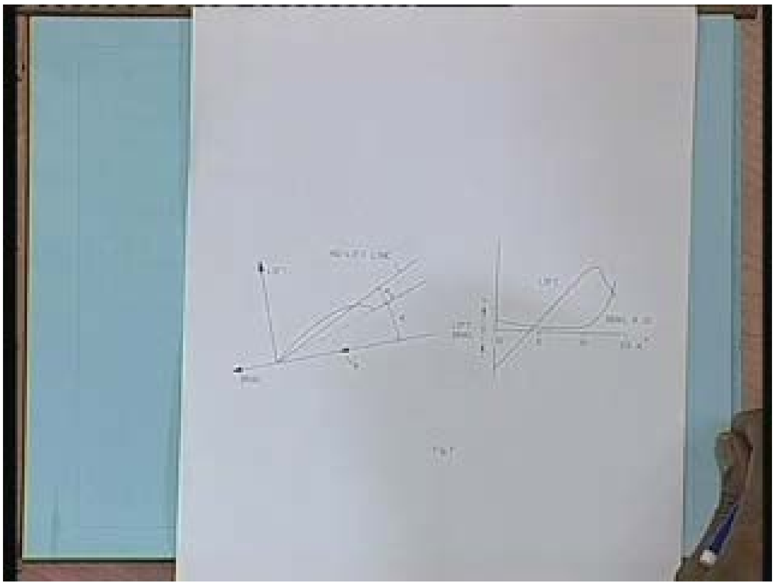

Now, I have this aerofoil section here- can you see this is, is it visible or not?- so, you have the aerofoil section here, you have this base line here, it could be the nose tail line also, and the water is falling at an angle alpha. The property of aerofoil section is that when the water falls at a small angle there is a force generated perpendicular to flow of water that is, if the water is falling like this, then there will be a lift force perpendicular to this- this is called lift. Can you understand that?

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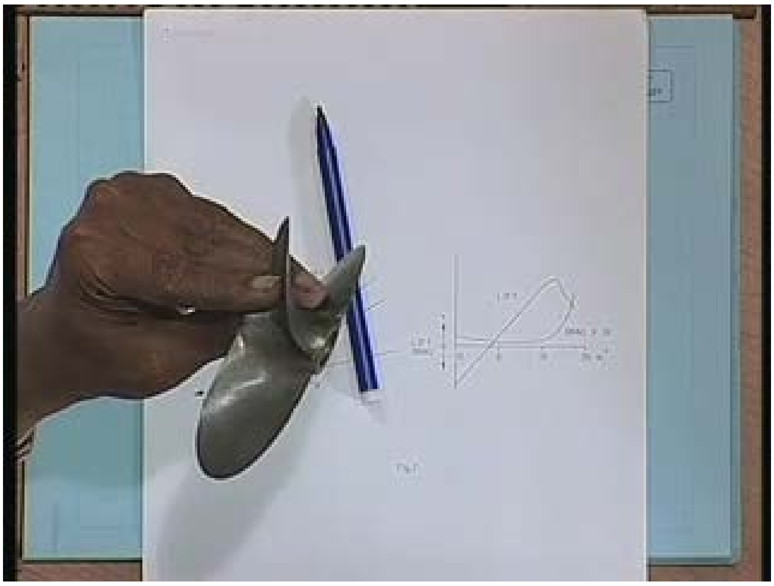

So, let us get back to our propeller. This is the one that we have to looking at. Water is falling like this, perpendicular to this you get a force like that, trying to push this propeller- can you understand that?- lift is coming like this and drag will be in, if the water is flowing like this, drag will be this way- there will be a drag in the same direction, but lift in the opposite perpendicular direction. So, if you look at this lift, which is going like this, most of its component is in the axial direction; if I now compute it, one is this direction, one is in this direction, most of it is this way because perpendicular to, perpendicular is very, making very small angle to the axis of the propeller.

(Audio not clear from 49:30 to 49:35 min)

That does not mean that the thrust and the lift correcting in the same direction.

Thrust and lift are not same, are not different, the axial component of lift is the thrust; otherwise, what is thrust, how do you get this axial force? This lift that I am getting, the component of that in the axial direction is what I call an element of thrust by any point here, that thrust integrated over the whole blades, all blades, gives me the total thrust on the propeller- is that clear? I am also loosing something in the form of drag, so, ultimately, the propeller efficiency will be, is a ratio between lift and drag- but have you understood how lift is being generated?

So, let us look at this diagram a little bit. We also know from aerofoil theory that if you go on increasing this angle- this angle alpha called the angle of attack- if I go on increasing this angle of attack, lift increases more or less linearly like this- as I have shown here- that is, I get small lift if the angle is small, and if my velocity angle of attack is more and more, I get more and more lift. But very strangely beyond a certain lift angle, certain angle of attack- this is angle of attack axis- lift suddenly drops that means, you do not get any more lift- this is called the stall angle, it is called the stall angle. So, we have to design your propeller that the lift is, the angle of attack is within this. Now, when you go reducing the angle, when it is at a particular angle to the propeller there will be no lift, so that angle is somewhat this- this is called the no lift angle; only when the angle is created with respect to that, start getting lift till stall angle; so, our aim should be to design the blade sections so that you stay between no lift line and stall angle- am I clear? We will stop here and next class we will continue with propeller theories. Thank you.

Preview of next lecture

lecture no. # 12

Introduction to high speed crafts part – i

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Good morning, gentlemen. Today, we will be talking on high speed craft. Basically, this will be an introduction to various types of high speed craft. Sometimes, this craft are referred as advanced marine craft. Why is it called advanced? Because the technology is used in these crafts are more advanced than the conventional technologies used in ships, also the hydrodynamic behavior in this crafts is quite different from the hydrodynamic behavior of conventional floating vessels- this has led to advances in equipment and materials with regard to their applications to such force.

In this lecture, which will be primarily an introduction to high speed marine craft, we will very broadly review the hydrodynamic behavior of various types of hybrid, high speed craft and I will make this presentation through power point projections.

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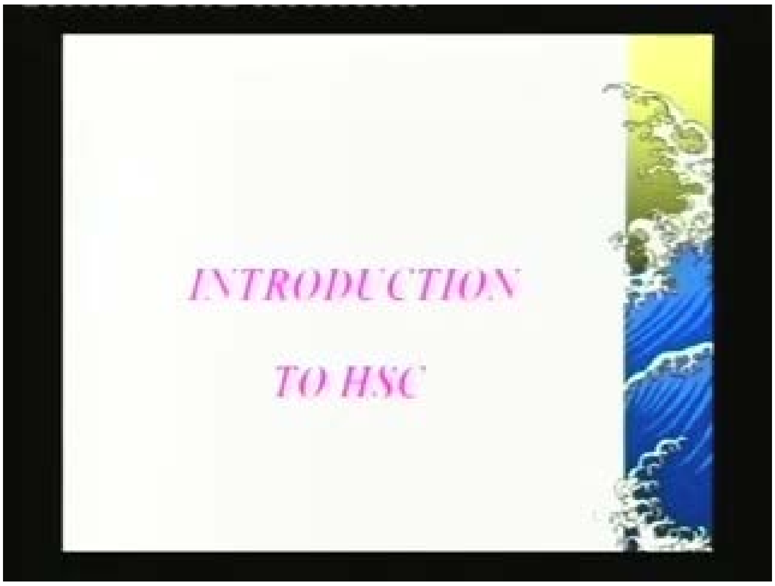

INTRODUCTION

TO HSC

So, as I said this is an introduction only and I will be covering (( ))

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APPLICATIONS

- Military
- Security
- Commercial

Examples

Patrol Vessels, Fisheries Protection,
Customs, Offshore crew transportation

- Considerations for design
  - Calm water resistance
  - Ride comfort

Where are they applied? Large application of all these crafts is of course, in military use where high speed is required, large amount of passengers and military hardware required to be moved across the seas quickly; and another area is security that is, BSF, customs and such parties, which guard the coast line, they require high speed movement to safeguard the source- military also includes coast guard mind you; commercial applications, we will see. What are the commercials applications you can have in these vessels? Passenger movement for one, large passenger movement on a commercial basis and the other one is of course, pleasure- the other two main commercial applications: passenger movement and pleasure.

Sometimes we use research vessels which may require some of this. Typical example would be a station keeping or watch keeping of some kind at sea, an example would be- a satellite is being launched and that has to be monitor during the launch process and till it is in orbit, the signals that the satellite sends may not be possible to obtain in a particular land based station and we may require a sea station to obtain this things then, we require a stable platform and such platforms normally provided by swath vessels, which are fairly stable. Customs, offshore crew transportation; considerations for design, you have to have, what is this, what are the design?

As the speed increase, we have seen this, we have studied this, we have also said that the forward shoulder, aft shoulder and stern will also generate similar wave patterns, and there may be interference between them then, we have said that at particular speeds this interference will add up to give humps in the wave resistance curve.

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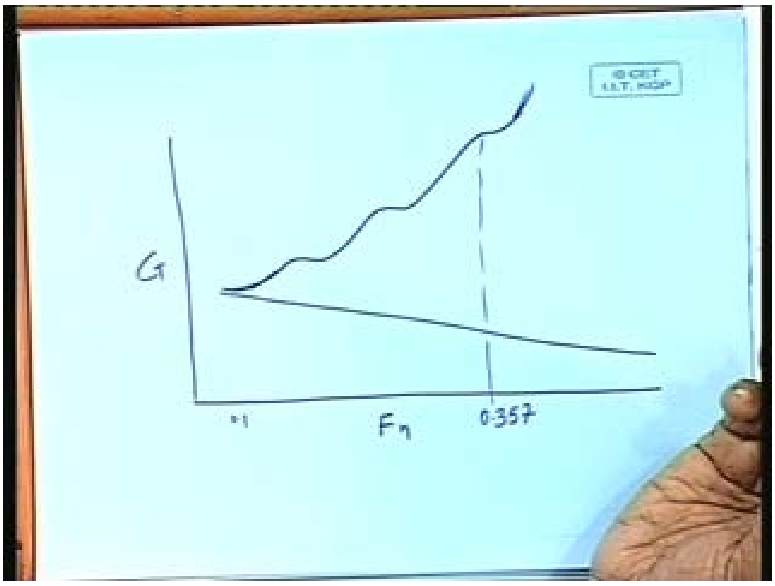

So, this is what will happen, hump will appear here then, this is the addition of resistance then, again it will go up like that- is it not- this is the, as the Froude number increases the wave resistance will become more and more prominent, and somewhere around 0.357, this should be something like 0.357, it can be shown by a simple calculation that this is the third hump in the wave resistance curve, which will be very high, you can see the magnitude here, the frictional resistance is only so much, wave making resistance is nearly 70-80 percent of the total drag, can you see that? This should occur somewhere around 357 and the I will say; it says that below 2, 0.268, which may be somewhere here, the frictional resistance is predominant and wave resistance is less; and between 268 to 357 the wave making resistance becomes more dominant; and then beyond 357 the wave making resistance rises at such a speed that it becomes virtually a barrier for the ships to cross the wave resistance phenomenon, and the displacement ships cannot move any more at a speed higher than Froude number of about 0.4.

So, what we do, or why is there a barrier on wave resistance? This has to be understood, this we will see in the next hour, we will stop here.