Performance of Marine Vehicles At Sea

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Lecture No. # 17

Propeller Experiments

Good afternoon. Today we will be talking about experimental techniques in propeller testing and what we can derive from testing propellers in an experimental tank. We have seen so far that, when the propeller works in an open water, we can define the efficiency of the propeller has T V A divided by 2 pi n Q. This is what we have seen in open water.

Then when the propeller goes behind the ship, we have seen that certain characteristics change as we understand the behavior of the ship with respect to behavior of the ship, and that in turn changes the behavior of the propeller. We had defined certain quantities. For example, we had said wake.

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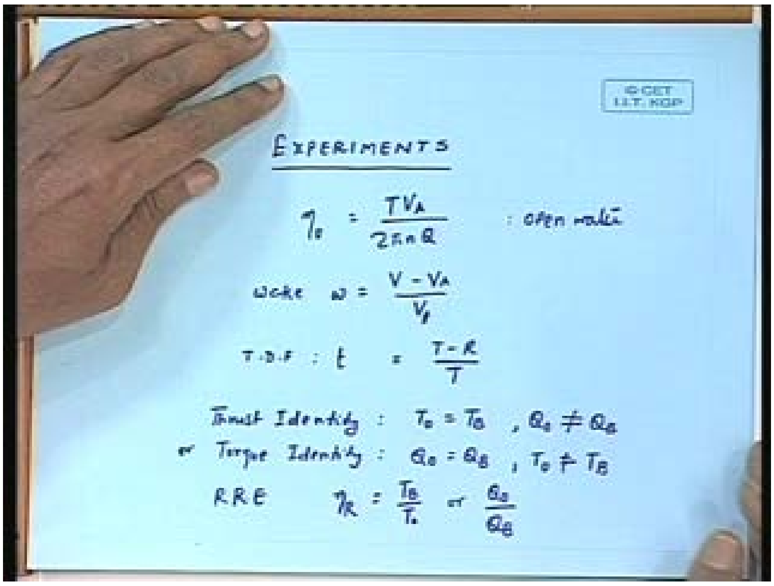

If you remember we had defined wake as V minus V A divided by V A, divided by V, that is, V being the ship speed, or if we are doing it on a model, it would be model speed.

Then we had defined thrust reduction fraction T is equal to T minus R divided by T. We had defined these quantities. And then we had said that to determine wake or thrust reduction fraction, we may have to consider thrust identity or torque identity, that is, we had said the thrust identity means open water thrust is equal to behind thrust, and open water torque not equal to behind torque, that is, the torque generated by the propeller behind the ship with the same V A.

Can you recall? This we had discussed, and, or we had said torque identity. One of these identities has to be assumed for determining wake, that is, torque identity was Q 0 is equal to Q B. That is open water torque of the propeller is equal to behind torque of the same propeller at same speed and same rpm, but thrust is not same. Further we had said that this is, this should have been same, that is, open water thrust should have been equal to behind thrust and open water torque should have been equal to behind torque, but it is not so.

So, the ratios of the open water to behind conditions we had defined by means of another component of efficiency called Relative Rotative Efficiency eta R. Can you recall? eta R was given as thrust behind by thrust open with torque identity, that is, when Q open should be equal to Q behind or torque open to torque behind if thrust behind was equal to thrust open. So, this is what we have seen so far.

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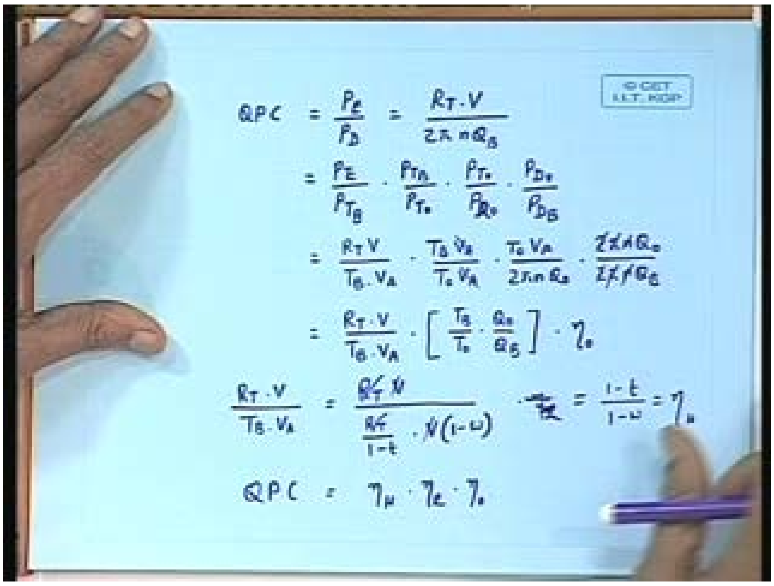

Now, suppose with these values we try to define what is the efficiency of a propeller behind the ship which we had called quasi propulsive coefficient or Q P C. Can you recall? We had said Q P C is equal to P E divided by P D and that is P E is R T into V. Remember, P E had nothing to do with speed of advance. It was calculated in base of ship speed and P D was 2 pi N Q behind actual torque that we get.

If we try to open this out, we could say this is equal to, that is, thrust power P T B is the actual thrust power. See what I am writing. I am just trying to expand that in terms of this is P D. It is the same thing as P E by P D. Is that right? This is equal to R T into V this quantity. The quantity below it is T B into V A. This if I expand this, it is goes like this. Now, this if you see this cancel and this cancel. So, you have R T into V divided by T B into V A into T B by T 0 into Q 0 by Q B into what is this quantity? Propeller open water efficiency eta o, and what is this quantity? If we take based on thrust identity or torque identity, this is the Relative Rotative Efficiency.

What is this quantity? Let see, R T into V divided by T B into V A. If I write this again R T into V divided by T B, we have seen this T; small t is equal to T minus R by capital T. So, T B will be, how much will be the T B? And V A. Is that right? Sorry, I have written this separately out. So, then this goes, this goes. This becomes 1 minus T divided by 1 minus w. Is that right? This quantity, this ratio if you look at it, it is a totally hull dependent ratio. It has nothing to do with the propeller. This is called the hull efficiency or eta h.

So then, we can write Q P C is equal to eta h, eta R, eta o. Am I clear? Eta R is Relative Rotative Efficiency this quantity and eta o. So, the only one which is propeller, which is based on propeller in open water, is the eta o, and these two quantities are due to interaction between the propeller and hull. The propeller behavior changes from that of open water. Now, what is this Q P C? Is it more than propeller open water efficiency or less than 1? What is the value of or scale of these efficiencies? Is eta h less than 1 or more than 1? Can you tell me?

For single screw ships, this is generally more than 1; it is about ten to twenty percent higher than 1, that is, hull efficiency parameter for normal single screw merchant ships is of the order of 1.1 to 1.2. Eta R on the other hand for single screw ships is of the order of

1 only. It may be 1.00 1.002 up to may be 1.01 that is 0.1 percent to 1 percent higher than 1 or lower than 1, that is, 0.999 to 0.99.

In twin screw ships as we have seen earlier, the effect of hull reduces because the propeller is out of the slip stream and away from the hull. The distance between the hull and propeller is large and it is also outside the boundary layer. Therefore, in twin screw ships, both eta h eta h reduces drastically. It may be just above 1 may be 1.05 or something like that 5 percent more, and Relative Rotative Efficiency is generally slightly less than 1, about 1 to 2 percent less than 1.

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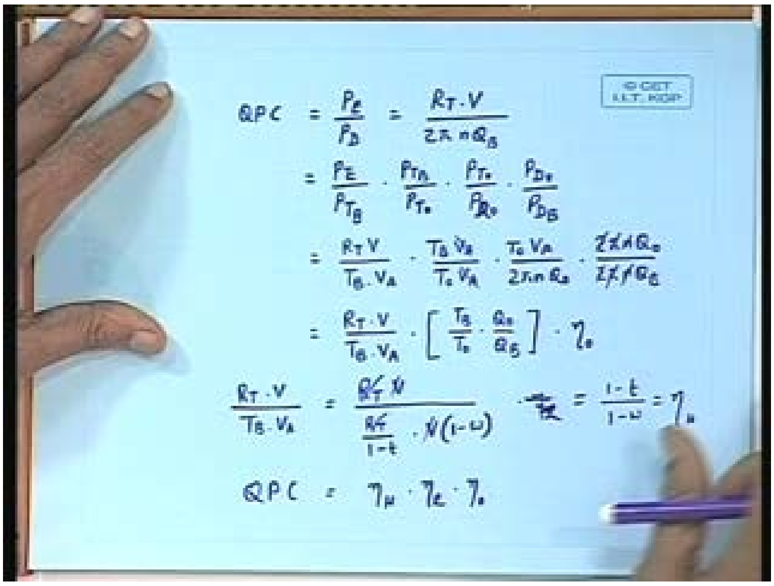

What about propeller open water efficiency? What is the scale of this? Propeller open water efficiency will depend largely on propeller diameter propeller pitch and propeller loading, that is, how much thrust that is expected to give at particular rpm's and speeds. So, this propeller open water efficiency is of the order of 60 percent for conventional merchant ships. A well designed propeller may give slightly higher efficiency of the order of 0.65 and a heavily loaded propeller with small diameter we will have a propeller efficiency between 0.5 and 0.6.

So, you see the Q P C which is our ultimate objective to attend a high Q P C would be largely dependent on the hull efficiency parameter, and for single screw ships, this hull efficiency increases the overall efficiency of the propeller and the quasi propulsive coefficient of the propeller. Does that give you an idea why the propeller of a ship is behind the ship and not in front? This is a very common question asked by people outside the marine area as well as people inside the marine area.

That why is it that in a aero plane, the propeller is in front and a ship it is in the back. Some of the answers, some of the reasons you can, you obviously know that being in front, the propeller is open to attack; it is not protected and any the debris, phase, etcetera can jam into the propeller and cause damage.

And behind the ship, the propeller is of course protected, but there are two other reasons hydrodynamic reasons for which the propeller is fitted behind the ship. One of them I have just mentioned that we take a advantage of the ships behavior, so that by fitting a propeller behind the ship, we increase the hull efficiency component of Q P C which therefore, increases the overall efficiency of the propulsion system. That is one reason.

Second reason, equally important is that, propeller if you, you can imagine that propeller is basically pushing a lot of water from ahead of it to behind it. So, the water on to the rudder is increased, the speed of water on to rudder increases. So, therefore, the rudder behaves much more efficiently than if the propeller was not there, if the propeller was in front, the rudder could not have behaved as efficiently as if it is just behind the propeller. Agreed yes or no?

Now, with this knowledge to design a propeller, we would like to know what would be the values of the individual items that are required for designing a propeller, such as we would like to know these three components - eta H, eta R, eta o, so that we can calculate the Q P C. Eta h we can calculate if we know the thrust deduction fraction and weight fraction. So, basically I have to know the thrust deduction fraction, the wake fraction, Relative Rotative Efficiency and the propeller a open water efficiency. This is the quantity that are, that are required to be known to know the overall performance of a propeller.

I have mentioned before that it is possible to conduct a propeller model test in a towing tank or in a cavitations tunnel where we could give a rpm to the propeller and move the propeller forward or conversely the propeller being stationary and moving at a constant rpm and the water flowing in the opposite direction which is the same effect. We could measure the thrust torque and rpm and the speed of water and we can calculate the propeller open water efficiency. How can we do that? There are two ways where such experiment can be conducted to obtain the propeller open water efficiency.

We have already seen before what are the conditions for kinematic similarity and geometric similarity for testing a propeller and kinetic similarity also, that is, forces, ratio of forces must be same we have seen. We have, what else we have seen? We have seen that it is easier to maintain Froude similarity, but Froude similarity will be strictly not required since propeller is immersed in water. Reynolds similarity is very difficult to maintain, and the pressure similarity, particularly dynamic pressure similarity if we ignore the static pressure rather pressure similarity if we ignore the atmospheric pressure is automatically obtained if Froude similarity is maintained.

We have seen this. Is not it? Euler number becomes equal if I ignore the atmospheric pressure component from the total pressure, and we have said this does not cause any error if the propeller is not in a cavitations condition. A non cavitations condition this is a good enough assumption for model experiments. So, this is what we had decided. So, based on this, the speed of the, speed of advance corresponding to that of ship would be in the ratio of 1 divided by square root of lambda, V lambda being the model scale. Am I right?

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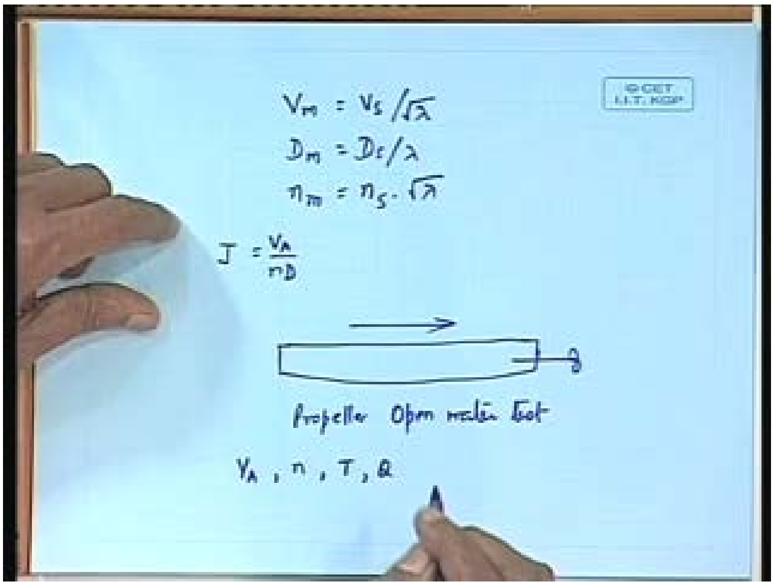

That is V m is equal to V S divided by root over of lambda, and the geometric similarity tells us diameter of model is equal to diameter of ship divided by lambda all linear geometries. What about rpm? What did we see for rpm? Can you tell me?

Multiplies by root lambda

Multiplied with root lambda; that means, propeller rpm, model rpm will be more than propeller rpm. You please look at your notes of the previous class, this was discussed. If we have this, then through dynamic dimensional analysis we had said that the thrust and torque coefficients would be same for the same j. Do you recall? We had said the advance coefficient J is equal to V A by N D, and for the same J, K T ship and K T model will be same and K Q ship and K Q model would be same. Do you recall?

Yes sir

Ok.

Now, the question is how do we run such a model in a towing tank, where it is easy to maintain Froude similarity by moving the model. I can attach a propeller below the carriers immersed in water and move the carriers forward. Then I can measure the thrust torque and rpm. The propeller moving into undisturbed water is not being affected by any hull in front. So, it is a really the open water condition, but then how do I give power to the propeller, so that it can rotate at particular rpm, and how do I take the measurements of thrust and torque?

So, the device that houses the motor as well as the dynamometer to measure the thrust and torque on the propeller along with a propeller shaft is called a propeller dynamometer. A propeller dynamometer consist of a driving motor, a shaft on which the motor is mounted. So, at the end of the dynamometer, you have a rotating shaft. You could fix your propeller to that, and inside the dynamometer itself, the torsion meter and the thrust meter are embedded and you can take out electrical output to measure the thrust and torque. This can be calibrated and preserved for further experiments.

Now, this dynamometer must be housed in a boat. Other is how, how, does it move the propeller. So, the boat, such a boat which conducts which is used for conducting the propeller open water test is called a propeller open water boat. So, this boat is in front, if this is the boat and the propeller is in front and the ship moves in this way. So, the propeller is actually in undisturbed water, is moving into undisturbed water, and the speed of the carriage will be the speed of the model and that is equal equivalent water speed in the opposite direction.

If the ship is moving like this, the water is consider moving like this is equal to V A which we have discuss speed of advance. Is that right? So, this is called propeller open water test, in which I measure V or V A, rpm, thrust and torque and I can calculate J K T and K Q knowing the propeller diameter and I can plot J versus K T K q. Now, when I extrapolated to full scale, my propeller scale may be 1 is to 25. When I extrapolate to full scale, I have said that K T and K Q will be same as K T and K Q of the ship; however, that is one major assumption in this.

That flow similarity has been obtained. We have discuss this we have said that the propeller, model propeller blade should be slightly mat finish, and if necessary, further sand strips may be given. So, that at least you generate turbulent flow. But we also know even in turbulent flow, the drag due to friction reduces as the scale goes up as the Reynolds number increases at least the coefficient of friction. We have seen the ITC line if you remember.

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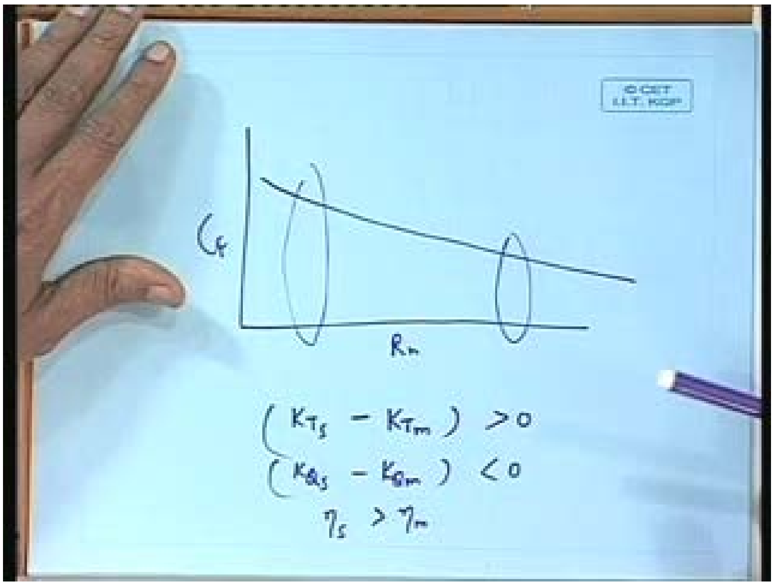

We have seen the ITC line which says or any frictional line for that matter. If I have Reynolds number here and the coefficient here, then it reduces as the Reynolds number reduces. Similar to ship case the propeller model propeller will be somewhere here and ship propeller will be somewhere here. So, you can see there is a change, a lot of change in the coefficient of friction.

Now, obviously we are not measuring the coefficient of friction as such the drag separately in a propeller. What we measuring in a propeller? We have measuring thrust and torque; we are not measuring drag of a propeller blade. Please remember the propeller geometry that we have talked of the scale, the section that is at a particular radius, because the water impinges on in at a particular angle. We had said perpendicular to flow there is the lift force and in opposing the flow is the drag force.

Then that drag force we are not measuring as drag as such. That drag force is giving a moment equal to the torque. So, since we do not know the drag, even if you know the, know the Reynolds number, you cannot make this correction. So, to get back to drag and make a correction from the propeller test data is very difficult; however, ITTC in 1978 as recommended a correction factor to thrust and torque values or K T and K Q values of the model when they are expected to be a extrapolated to full scale.

So, the effect is that in full scale, K T ship is just slightly more than, if write K T ship minus K T model is slightly more than 0, that is, K T ship is slightly higher than K T model and K Q ship minus K Q model is slightly less than 0, and you can see propeller efficiency eta ship is more than eta model because efficiency is a ratio of thrust to torque T into V A divided by 2 pi n Q. So, basically is a ratio of a K T to K Q. So, K T is more, K T ship is more; K Q ship is less. So, this increases, eta S is increases.

So, if we ignore the Reynolds number correction also and we get a lower efficiency predicted for the full scale. We are on safer grounds. Is that clear? One more care has to be taken during the propeller experiments. I have told you earlier that experiments are generally plot with a lot of experimental errors. Sometimes we do not know how much is the magnitude of error. We assume that error is less. For example, you run a propeller which is about 10 centimeters in diameter; get the thrust torque values.

Now, make a propeller of 20 centimeters diameter with the same geometry and run it. Two year surprise you will find K T and K Q do not match which should have been. So, beyond the Reynolds correction, they do not match considerably. Why does this happened? One of the reasons is that, when you fit a propeller to a shaft and it is run by a motor, sorry, yeah, yeah, the same shaft you attaching a small propeller as well as a big propeller. Propeller dynamometer is one; in that, you have added a ten centimeter propeller. You have remove that and fitted it 20 centimeter propeller.

But that change is the proportions.

That is right.

should be in proportion with the propeller

All those things you cannot make in model scale; you cannot make a shaft exactly in proportion to ship shaft. That is not possible. Not only that, if I rotate the shaft alone without the propeller, the boss is still rotating in water. I do not know what is the condition of the Barings inside that. So, the, in idle condition itself, when there is no propeller, the shaft can generate some thrust and torque. So, I have to measure that and call it something like idle thrust and torque, which I must correct when I measure the thrust and torque of propeller. This is one source of error.

So, this idle thrust and torque, how it behaves with variation of speed of water and variation of speed of rpm must be known, so that the proper correction can be applied. So, these are some precautions you can take during an open water propeller test. Now, we are finish the open water propeller test; we know the K T, K Q of the propeller and how it would be in the full shape. Now, our aim is can we find out the thrust reduction fraction, the wake fraction relative hortative efficiency.

For which purpose, we must test the propeller behind a model. If we want to maintain geometrical similarity of the model and the ship, please understand that we have already tested the model for resistance. We have discussed the resistance model test; we have already tested the resistance a, model for resistance. We know what is it is resistance; V versus R T is known to us for the model. Now, I using the same model I, can make a, sorry.

Arrangement

Make a arrangement for mounting the shaft with the propeller and the dynamometer can be housed in the model itself. Propeller is now behind the ship. Now, I can run the model. How do I run the model? Now, the propeller is generating thrust forward, so the model will be pushed forward. Now, I am moving my carriage at a particular speed. The model will be moving at that speed. If that resistance are that speed and thrust generated by propeller match, then there is no need for the carriage pulling the model any more. Do you get my point?

That is, the model will not require any force from the carriage. In other words, if I did not have the carriage, I run the propeller; the ship should go, model should go at a particular speed. I still run the carriage because I cannot let the model go here and there; I have to guide it. So, I have to run the carriage; the model has to move forward, but let us say for the timing, there is no force between the carriage and the model. If there is no force, that is, the carriage is not imparting a force in the model, the tow rope pull as we called it earlier, is not being applied by the carriage, but we know what will be the resistance if the speed is known.

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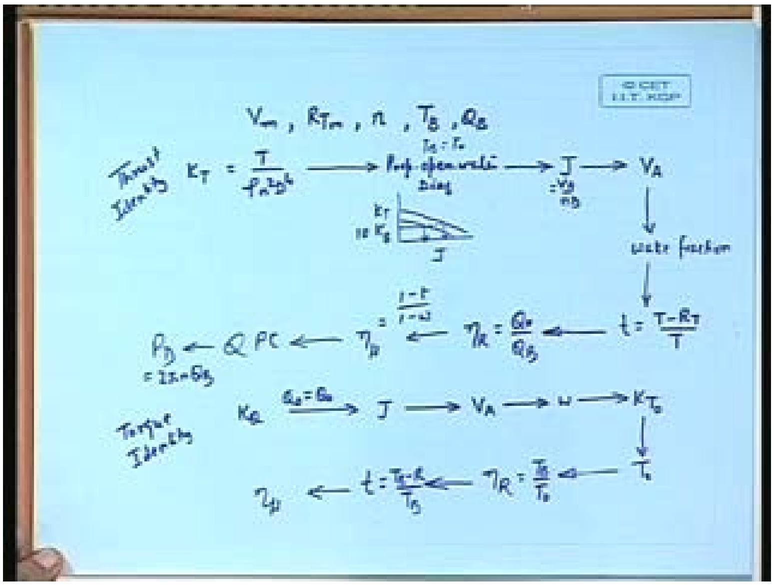

So, I know what I know. I know the speed of the model V m let me call it; I know it is R T model because I have done the resistance stress before and I know the propeller R P m because my dynamometer is giving me. I know the thrust behind condition and torque behind condition. The propeller dynamometer is giving me rpm thrust and torque. Let us take this simple case. Is it possible for me to calculate all the quantities that I had started to find out for which purpose I did the experiments? So, what do I get? I can calculate K T t by rho n square D 4.

From this K T, I enter the propeller open water diagram. What do I get? J; remember the diagram J K T 10 K Q add this diagram with me. So, I entire with the K T value and get the J. Now, what is J? J equal to V A by N d. So, that gives me V A. If I get my J, I can calculate V A. What does this give me? Wake fraction. Now, if I, at this stage, I have to know whether I am taking what, what, have I assumed here. Can you see what I have assumed? T B equal to T 0. Otherwise, I cannot go up to here. This T I have used as a open or I have enter the open water diagram here.

By entering here, I have assumed here T B equal to T 0 thrust identity. Am I correct? If I did not assume that, I could not enter into the propeller open water diagram. From here, I can calculate thrust deduction fraction also. I have already assumed thrust identity. My torque identity eta R is now known, and eta h is equal to all this I know, and therefore, I know Q P C or P D 2 pi n Q B.

Now, suppose I assume torque identity. Instead of thrust identity, I could also assume torque identity. Then what do I get? K Q from there, that is, Q B equal to Q 0. Then J from propeller open water diagram into 2 K Q. Is not it? And from there, V A similarly wake; then, I can get K T 0 from the propeller open water diagram K T 0, and from there, T 0. Same thing I do here. I have not written it here and eta R is equal to T B minus T 0; t is equal to T B minus R by T B and eta h. Am I clear? Are you happy or is there a doubt somewhere? I have a big doubt. May I push the doubt to you?

See, this procedure that I have listed out. There is no mistake here a standard procedure followed by all tanks, but there is one problem here which I would like to tell you. You remember when we talked about model experiments, we said that there should be kinematic and dynamic similarity, that is, forces, proportion of forces must be same; not only proportion of velocities, but also proportion of forces must be same.

Velocities we know that the there is a difference in wake between the propeller, the model and the ship. This we have discussed because of the Reynolds number effect, and we have said perhaps it is not much and it can be ignored or we can make some corrections for Reynolds number.

But when we talk of propeller testing, there is another disadvantage that creeps in; origin is definitely due to Reynolds number, but the fact is that forces are not similar. Just imagine what is the R T of the ship. The total resistance of the ship if we want to extrapolate these values to ship values, the force similarity must be maintained. What is the force? What, what, has force similarity given us that the forces must be proportional to lambda cube. Is not it? Yes or no?

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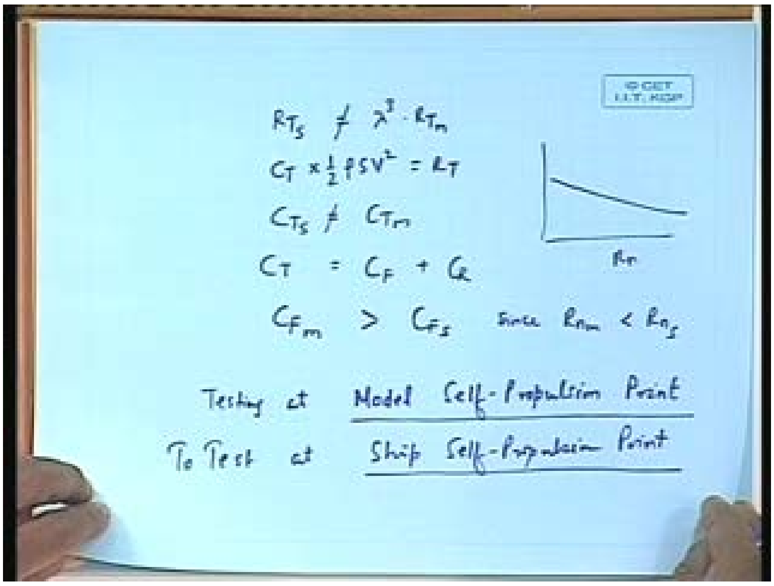

Now, is R T proportional to, is R T S equal to lambda cube into R T m. Is it so? Can you tell me? Let us go from the C T. C T into half rho S V square is equal to R T. If you compare between model and ship, this is proportional to lambda square and this V square is proportional to lambda. So, this is lambda cube proportional to lambda cube between the ship and the model, but is if C T ship was equal to C T, C T, model, then this would have been valid, but is C T ship equal to C T model. Why not? Why it is not? Why C T ship is not equal to C T model?

Because C F S is not equal it is not equal to…

That is right. So, anyway, let me correct my first line that they are not equal because C T S is not equal to C T m. Why? We have seen C T equal to very approximately C F plus C R; C R S is equal to C R m, but C F S is not equal to C F m which is higher.

So, higher is a ship C f.

No C F model is higher than.

C F S

C F ship since R n model is less than R n ship. Remember this diagram.

(( )).

Yeah, the IT TC line.

So, you see since C T S is not equal to C T m, where actually running the model at a different condition than the ship. So, if you are doing that, whatever we are measuring is valid for the model, but it is not valid for the ship. Am I being understood? R T S and R T m are not proportional to lambda cube which they should have been if kinematic similarity was maintained, but unfortunately it is not proportional to lambda cube as we have now seen, because C F m is greater than C F S. Therefore, R T m cannot be just lambda cube times less than R T S.

So, for extrapolation purposes, kinematic similarity are not being maintained, not kinetic similarity is not being maintained. Do you understand? We have maintained the V A similarity; the kinematic similarity has been maintained. The ship we have propeller is below water, no pressure differences. The speed is proportional to root over of lambda rpm also we have seen is geometrically similar ship and model. All conditions have been satisfied expect this one major condition.

If I want to satisfy this condition, what do I have to do? When I ran the model without any pull from the carries, the model ran with its own power at a particular speed. The testing that I did is called testing at model self propulsion point, that is, model is self propelling itself. Now, my purpose is to run the model at ship self propulsion point then only the similarity will be maintained. So, I must test at, to test at ship self propulsion point. Is that clear?

So, how do I do that? What is the ship self propulsion point? Ship self propulsion point will be that point where the thrust generated corresponds to the resistance of the model as lambda cube times less than that of the ship.

Sir, one more thing.

We know that the force similarity to be maintained. The force should be in proportion to lambda cube; so that means the thrust that we generate by the propeller should be enough to overcome the resistance which would have been require if the model resistance was lambda cube times less than that of ship. No, not clear.

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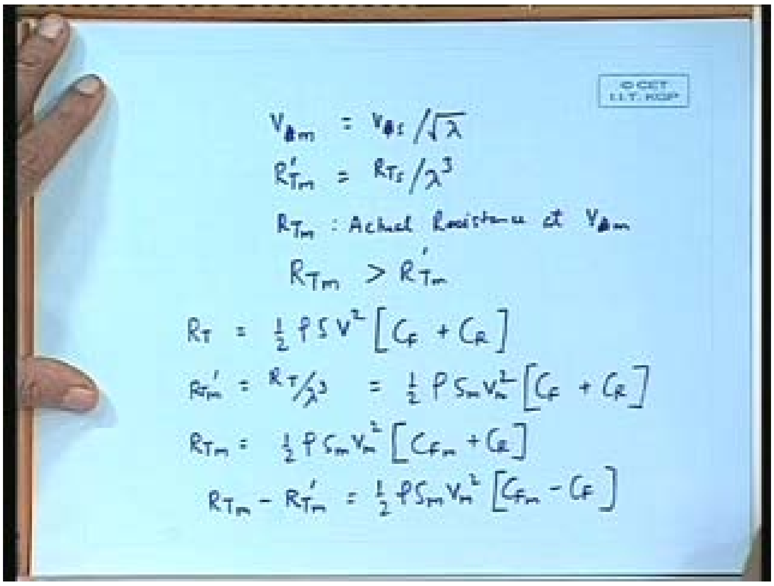

Let us see. I want the kinematic similarity and kinetic similarity to be maintained. So, what is the kinematic similarity tells me? V A model is equal to V A ship divided by square root of lambda. What else it says it says? R T m should be equal to R T S divided by lambda cube. This is what it should have been.

This kinetic similarity

Yes.

Kinematic.

Kinetic similarity, kinetic similarity says that R T m should be lambda cube times less than R T S, but at model self propulsion point as I have seen this cannot be achieved. If the model was allowed to be propelled by the propeller alone, then this cannot be achieved. Now, my point is, if I move the model as V A m, I know let me call this for the a dash donation, yeah, RT m dash is equal to RT S by lambda cube should have been now the resistance at this is not RT m dash, but RT m. So, I cannot achieve this. So, to achieve this, what do I do? Which one is higher - RT m dash or RT m?

Sir, R T m dash is your this thing.

Ship resistance divided by lambda cube. Which is higher?

Sir, it should be much higher.

RT m

Actual resistance at V A m, in fact not V A m, V m. Why I am writing? V A, V A here. Which one of these is higher? Tell me, tell me, common, you know this.

Sir C T m dash

Yes C T m dash is higher or C T m is higher?

C T m dash is higher.

Why? You seen this. Let us go over this again. We have just gone over it. Let us go over this again R T is equal to half rho S V square C T which is C F plus C R. Let see RT m dash is equal to RT divided by lambda cube is equal to half rho S model V model square C F plus C R. I have just divided by lambda square these by lambda nothing else I have done. Is that correct?

Yes sir

Now, R T m actual model resistance is equal to half rho S m V m square C F model plus C R. Now compare these two this side is same as this. This is, this is C F equal to C m no which is higher.

C F m

C F m is higher, is not it? So, if C m is higher, R T m is higher. Is this absolutely clear? Now, how much is it higher? What is this value by which R T m is higher than R T S, R T m dash? We can see now.

Yes sir.

So, this value is higher; that means the resistance of the model is higher by this quantity in proportion to that of the ship, very simple. I can very nicely overcome it. I have got a carriage with me. I apply this tow rope push pull to the model and move it at this same speed V m. Matter is over. Have you understood? No?

Sir, in move, they carrying V m, that V m.

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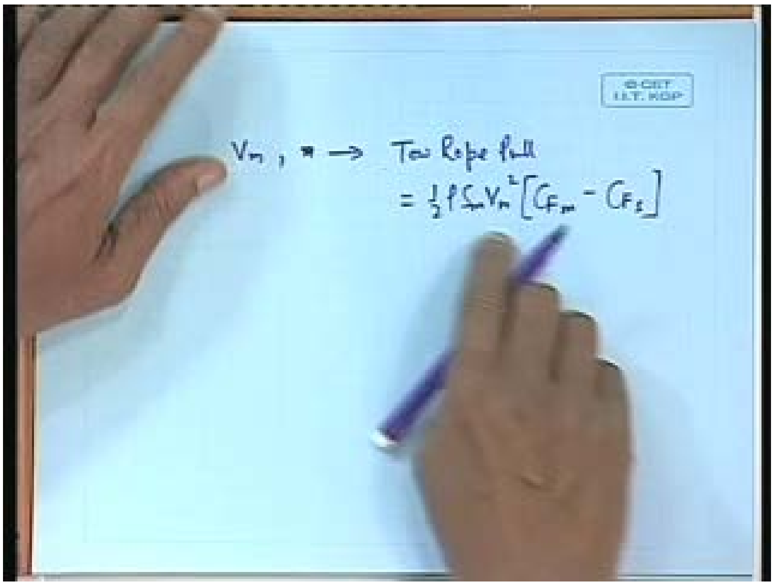

Yes, now I have a carriage I move the carriage as V m and R P m and thrust and torque I measure, but I also apply a tow rope pull equal to half rho S m V m square.

C F m minus.

C F m minus.

C F

C F ship let me put right.

If I apply a pull like this, my thrust that I generate from the propeller will only overcome the resistance of the ship divided by lambda cube, because this I am supplying separately in this way. I can maintain the kinetic similarity. This is why this is called ship self propulsion point, that is, I move my model corresponding to the ship's self propulsion point and not its own. So, there are many ways of doing this experiment. You can vary the R P m's; you can vary those model speeds and you can vary the tow rope pulls.

And you can have a whole grid of data points from where you can actually calculate what is the ship self propulsion point at various speeds and correspondingly get the thrust and wake fraction values.

Now, these experiments, these two experiments that is propeller open water test and propeller behind model test, that is, self propulsion test are the two most important model test for conventional propeller and hull system design. And there are many other tests for further investigation of flow around the propeller such as wake such, such, as measuring the velocities as various points along the propeller disc or testing the propeller in a cavitations tunnel and many other tests.

We will not bother about this test now we will finish with concentrating our attentions on these two tests - propeller open water test and propeller self propulsion test.

Thank you.

Preview of Next Lecture

Lecture No. # 18

Propeller Theories Part - I

Good afternoon. Today we will talk about propeller theories, that is, how a propeller works in water. The, there will be two lectures in this and the intent of these two lectures is to understand the basic principles of propeller action rather than going into details and trying to design propellers based on the theories. In case you are require to design a propeller using these theories, you have to go deep into the subject and study further, so that you can use it for design purposes. Now, we will try to understand the basic principles of how a propeller works in water and how it generates thrust, that is, a forward force which propels the ship forward.

Beginning, in the beginning of nineteenth century, propellers came into being used in ships screw propellers. They are conventionally called screw propellers because the principle of propeller action is like that of a screw. The theory of propeller action at that time was not understood at all, but it seem to work. Today we understand propeller theories, and therefore, propeller action in water in a much better perspective, but I must also add that perhaps our knowledge of propeller action in a fluid medium is still incomplete.

One of the earliest theories of propeller action was proposed by Rankin and also by R E Froude somewhere around the beginning of nineteen century. Surprisingly even that, even though that theory was very simplistic in nature, the conclusions drawn from that theory still hold good and this as shown the way to go move into higher theories later on.

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So, the first theory that was proposed by Rankin and R E Froude was called the so called axial momentum theory. Can you see?

Yes sir.

Axial momentum theory where the propeller was considered as an actuated disc instead of consisting of blades. The propeller was considered as if it was a circular disc which was rotating in water. This action of the actual actuated disc was suppose to increase the pressure field in the fluid across the propeller disc, and therefore, generate a thrust. What was not explained in this theory is how does the propeller change the pressure field. It was just assumed that there will be a change of the pressure filed across the propeller disc.

Now, just imagine that there is a propeller, a disc moving in water like this, and if the propeller moved forward, then we could assume as if the propeller is standing still and water is moving backward such water is the propeller was just moving forward like this and we considered it to stand still.