Seakeeping and Manoeuvring

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Module No. # 01
Lecture No. # 29
Definitive Manoeuvres – I

In the last class, we were just started discussion on what is called Definitive Manoeuvres.

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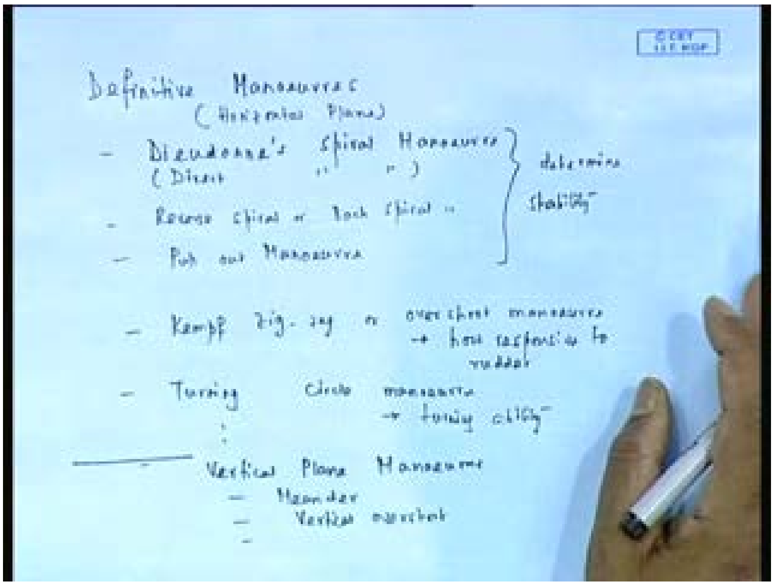

What we said, is that for any ship full size ship or even model ship in order to assess characterize determine its handling qualities, which may be you know manoeuvre control ability qualities. There are certain definitive manoeuvres, I mention some few of them for example, one was Dieudenne's spiral manoeuvre, this is also known as a direct spiral manoeuvre. Then, we had (No aud io from 01:22 to 01:33) then we have (No audio from 01:35 to 02:12), there are others (Refer Slide Time: 01:23). See, why I wrote all these excuse me I will tell you, there are many manoeuvers for determining many aspect different aspects.

Today we will for example, discuss will be discussing all of them eventually. So, there is a manoeuver called spiral manoeuver, there is also it is there is a version of it which is known as a direct spiral manoeuver, there is a version which is known as reverse spiral maneuver, then there is a manoeuver called pull out manoeuver. Now, this three primarily are trying to assess, if there is any lack of stability on the hull that is c, the index c is negative or positive; and if so how much (Refer Slide Time: 02:42). The full purpose of this test will I will discuss that would be to essentially determine stability, this one primarily meant for determining how fast and how quickly it respond to rudder action (Refer Slide Time: 03:09) (No audio from 03:15 to 03:25).

Then, this turning circle is of course, turning ability the one of the most important one, and there are other manoeuvers I was mentioning yesterday's topic etcetera. So, these are all in horizontal plane for obviously, applies for ship, for submarine etcetera. You have besides this also maneouvers in vertical plane; there is one maneuver call just to mention to you may be very briefly I will mention; one is called meander, one is vertical overshoot and there may be of course, other manoeuvers emergency recovery manoeuver for example, etcetera etcetera.

What we are going to do now today is going to start with this and try to tell you what how do you conduct the manoeuver? How what you measure?

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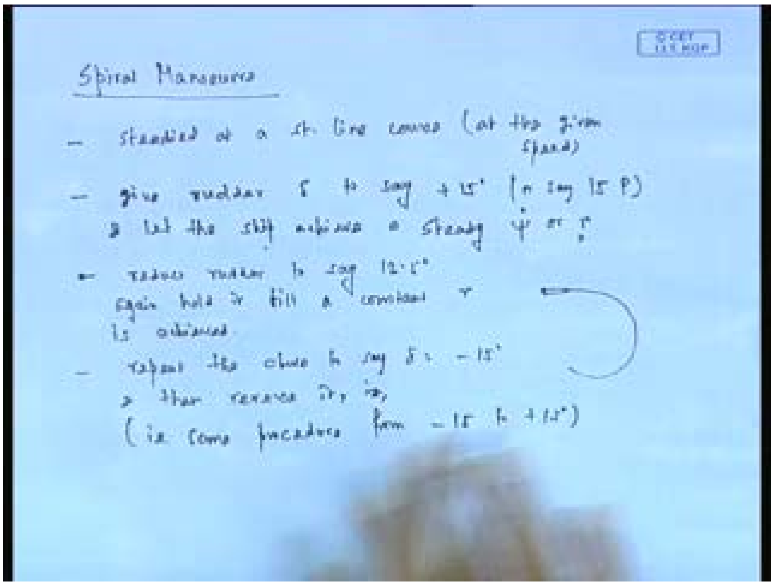

So, let us start with the first one that is spiral manoeuver. What you do here? Now, in all these manoeuvres, I will first describe the procedure, what you do you remember we have to remember all these are actual tests and trials in fact, you do that yes before delivery of the ship.

Always the ship has to be steadied at a course initially. Initially you have to always steadied at a straight line course at the at the given speed. Normally, what happen at this point let me tell you, you would have set the engine at a certain R P M, which is giving you certain speed. Once you set that, during the test you will not touch the engine, it will just be at that R P M; but obviously speed may slow down as in manoeuver, but the engine setting is remain same.

What you do is like that, you know after it is steadied first you give a rudder (No audio from 06:00 to 06:12), some degree let us say I will call plus as port minus as starboard or say(Refer Slide Time: 06:25), let me just call you know normally why I say plus and this port starboard is because, the practitioner has understand that a port starboard; we who are talking about dynamics with respect to access system; we may try to identify you know clockwise to be plus and anticlockwise minus etcetera etcetera because in our case, clockwise is plus because z is down.

Then, what you do? Give rudder to this thing and let the ship a steady steady psi dot or r means steady yaw rate obviously, if you give that, it is going to have a rate of turn is going to turn right. Obviously, when you give rudder 15 degree is going to turn eventually and you wait enough time, so that the rate of turn has become constant, hold it constant for about a minute, this what you measuring it.

Then what we do, we must understand this. See, if you look at this yard, the vessel is going to basically go on a straight line, then is going to begin to turn eventually in a steady rate. Rate of turn will become steady keep it holding hold it may be about a minute or so.

Then, reduce rudder well 12.5 (Refer Slide Time: 08:05) (No audio from 08:14 to 09:06). What I am saying you know here, if you see the description, description is very simple all that is being done here is to trying to find out for a given rudder angle, what is the steady rate of turn? But, you must start from one side, so we had a 15 degree it is turning, so it is turning like that. Now you see, if you look at this diagram I will tell you how it will look like.

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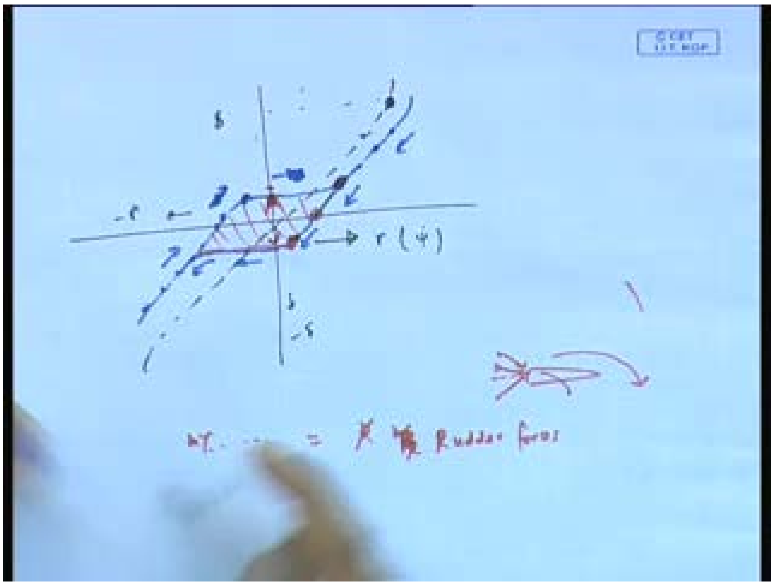

So, the ship was coming I am just doing the c g c g line coming as straight line, now you held it 15 degree, so it is going to eventually turn like that (Refer Slide Time: 09:43). So, (( )) steady, so up say by this time from here, it has started turning steady. Now, at this point you lower the rudder to 12 and half degree or some another smaller value, then it is going to have another turn eventually; but, it will have a larger rate of turn again you stop it after a while make it another larger rate of turn. So, what you are doing, essentially trying to measure delta verses r or psi dot, that is what you are measuring.

So, for each one now I come to that, now you will see what is what is a big thing remember I am achieving this always from one side I will just draw this diagram then we will see. So, what happen we have this (Refer Slide Time: 10:28), in this case say r delta or psi dot, so you start from some point. So, let us say I have this delta initially when I started first one 15 degree delta, so I got this r, I plotted this value. Now, next after a while I made delta to be 12 and half degree measure this value. So, what we expect is that, you should get a graph like that, this is my say minus r, this is my minus delta I mean whichever way you call (Refer Slide Time: 11:08).

Unfortunately what happen, now you measure that you see this is a interesting part that you just measure that, but what would happen? In some ships you will find that, this plot does not show like that, it shows something like this (Refer Slide Time: 11:26), suddenly goes here goes like that and at this point suddenly it goes here I I will explain to that one but, so you get the points like that in some ships at this point suddenly it jumps to this point, then it comes here, here, here, here, here if you come this way or rather no no sorry come this way (Refer Slide Time: 11:52), this is more logical. And if you go this way, you end up getting this way I will explain to that in a minute.

What it means? See here, see this is very interesting and you must you must pay attention to, this hysteresis loop type. What is happening some ships, suppose you measure it, it turns out there is a hysteresis loop, what it means that? I gave a rudder here, this angle I was getting the same direction, the direction I give rudder I am turning in that direction; but, some then I keep on lowering the rudder I bring it to 0, yet the ship is turning in the same direction. See, what is this point would imply? What it would imply is that, I have brought my rudder to 0 from this side from negative side; I see this ship from here, I brought the rudder to 0, it is still turning this way, because that is there is a rate of turn.

Then, I lower rudder, rudder is on the other side it is still turning in the same direction, but there is a point suddenly you will find out that beyond that, if the rudder is slightly improved increased, then suddenly it will swing to the other side. And then, it will have a rate of turn in the that means, at this point also is turning here; but, suddenly when you give more it will begin to turn the correct side, swing it suddenly it will swing to the other side, this is the nature. See, what I am saying of course, you say why should it happen, no the point is that you have no control you are doing a test and when you are doing a test, you are actually measuring as the ship behaves and this is how you find out.

Supposing, you find out some ship behaving that way, what does it mean? In this place, you really have no control, because I give a rudder here 0, yet it is turning and you know it is turning from the same direction, because you are giving at that side; then, I give a negative rudder means let us say, I give a minus 1 degree it is still turning in the opposite side; but then, when I give minus 2 degree its then begin to turn on the correct side and suddenly swings fast. So, it means in this region that is rudder angle this to this (Refer Slide Time: 14:09), I have no control, this is a indication of if it's happens, this extent is an indication of lack of straight line stability.

See, what is happening is, that rudder is giving extra force you know if I use equation of motion I had equation of motion m all that equation this side was 0. But, now I am going to have this side rudder forces Y R well rudder forces let us say. What it means is that?

See, that had the rudder not been there, I have no control ability, because rudder is there, so there because there is an unstable force, there is a force which is trying to go in the opposite side; but, if I give rudder beyond this this threshold limit, then rudder force is enough large enough to absorb that unstable hull forces. Obviously, if this is larger if this hysteresis is larger, it would imply larger in stability.

Now, this part is very very similar in fact, what would happen is that, actually if I were to look at that that the way the picture is, this is my stable ship and this slope this slope is d r by d delta or you can say or rather no no you can say d delta by d psi dot, so this is positive one side you know the side is supposed to be; but, the one that is behaving that way one can show that, it has got actually d delta by d psi dot opposite, it will be this one. And I will explain to, see sometime there was a difficulty understanding very nice analogy very nice analogy within initially unstable ship with the negative g m ship.

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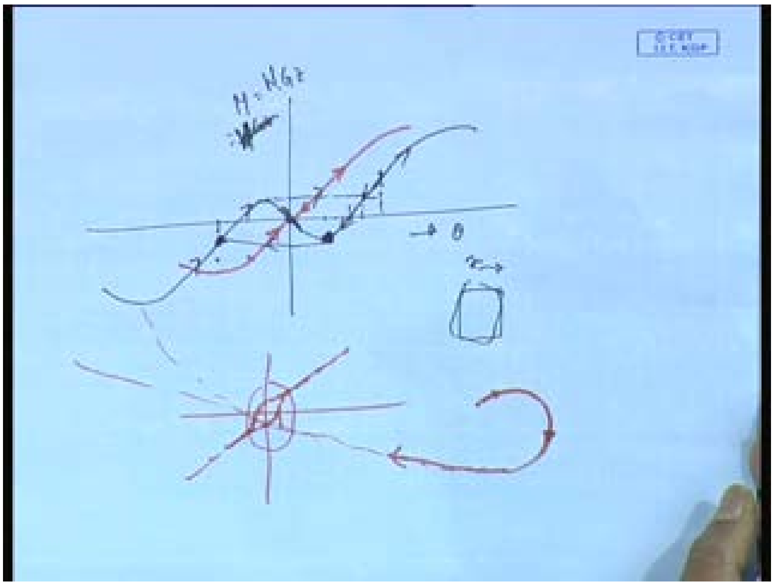

What happens to a negative g m ship, there is an angle of loll, how does the g m look like? you see here, I have got here heeling moment let us say, which is (( )) say you know delta G z let me call it that way with with this may be the weight or W into G z call it W G z otherwise. Now, this is a ship is an angle of loll you agree what happen, I have a heeling moment here, it has got this (Refer Slide Time: 16:47) I lower the heeling moment it has got this, I lower the heeling moment it has got this; but then, I am giving a negative heeling moment remember, it keeps coming the the the angle become on the other side it comes out to this point right, even if I give a negative heeling moment.

Then if I give beyond that some value, suddenly what will happen this this will shift here and then, it will a (( )) this angle means the vessel you see, this vessel I am giving a heeling moment then I it is on this side, I eventually lower it down give this, it is still on this side this point (Refer Slide Time: 17:29); then, when I give little more suddenly it will swing to this point suddenly it will swing to this side. So that means, it will behave that way and if I go that way also, it will behave that way, so that means it is going to behave heeling moment verses this thing in this way.

So, you see it is exactly same as the fact that my slope of this curve which is my met centric height being negative. If the met centric height was positive I would have had got a graph which will have been simply like this (Refer Slide Time: 18:01), it would have gone this way and come back this way, can you see this comparison of them. So, what it means is that, when you determine when you find out this will never look so nicely **(( )).**

Now, if you do actually a actual experiment the plots will look something like that and it has been seen, you will find plots which will look something like some kind of loop like that you know it will not be so nice and what we have presented, but it will look something in actual this thing it will look something like, if you actually take a measurement, but moment you have a hysteresis loop. Moment you have a loop that implies immediately that, you are not having a control of the turn with rudder in that loop, because here it shows even if I have my rudder 0 I am still turning and this happens on one side. The side you are turning as I said, you are turning some port you are turning port at 15 degree rudder bring it to 0, if you bring it to 0 you expect that eventually see bring it to 0 eventually at some point it will go on a straight line; but, it does not go on a straight line, you still go on a circle large circle.

You see understand this know, the ship is here you are turning, so 15 degree you are turning at this rate, at this point of time I have brought my rudder to 0. What do you (( )), it will keep turning for a while or eventually it will become a straight line, because my rudder is 0. But, if the ship was unstable and in some ship say it say, reality it is still keep turning slowly; and this is a very realistic scenario, which also means that is one thing.

Second thing is in control, see this is turning this side, but not only that, it is a 0 rudder, even if I give rudder to be say plus 1 up to this point, that is up to this point (Refer Slide Time: 20:00), let us say this is 2 degree. So, I give rudder 1 degree on the other side, yet it is turning on the same side.

And in fact, I without naming I can tell that we have experienced of for this in real objects for example, the certain under water vehicle that you know real life problems we are looking at, they are it will behaving that side that way. It is actually have and and that trajectory is an indication that, the inherent body has a negative sea. Negative sea meaning, remember what we have talk talk talked about that, you know all this N r by this Y r minus m it is actually becoming less than this thing (Refer Slide Time: 20:41). So, therefore, we have to make design changes you have to make sure that, there are proper changes, so that it does not behave that way, because you really cannot control.

Now for a ship, what is happening? So, this is a this is a test which will tell you about the indication of you know like instability; but, now for a ship there are ships, which has got this instability may be within 2 degree 3 degree. See, this is this this extent is the extent of instability, larger the sea larger will be this loop.

But suppose it is within plus minus 1 degree sometime you may not worry, because you can always absorb them by action of rudder, you can always control it you know by using rudder or the only problem is that, if I want to go on a straight line I had to continuously (( )) by acting rudder. So, as I was saying we will find out later on that, if you have instability or seas very small, you actually have very quick responsiveness you give a rudder it will zooms pass and have a very tight circle.

So, if I want a tight circle I have to have a sea small, sometime it become negative we can leave it that, you can leave it that because you can always design a rudder as long as it is within a small distance plus minus 1 degree you can correct it by rudder action right. So, this is what is called the direct you know like spiral manoeuver. What here we did you know is that you wanted to give a rudder and find out the yaw rate.

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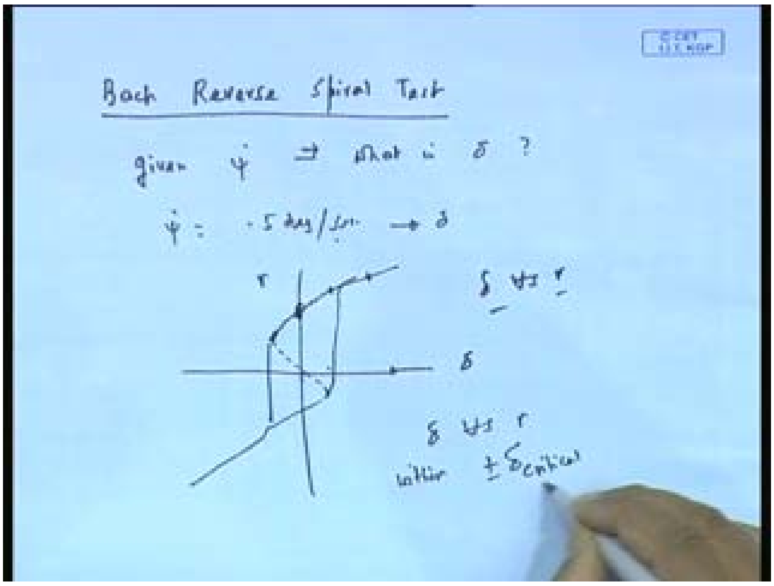

Now, in what I was telling the next one that is, this back reverse spiral where you do the same thing. Let me remove this pages (No audio from 22:32 to 22:41). Here, what you do actually is the same thing as the spiral test, but what you want to do is that, you want to find out for a given (No audio from 22:51 to 22:58), this what you do, essentially what you do is start. Let us say, you try to give a certain delta to find you you want to start with say psi dot equal to something like say some rate of turn let us say 0.5 degree per second or something, find out this is achieve for what delta?

You keep trying and find out at which delta I am getting this, then lower that to 0.4 find out for which delta I get this, so it is a opposite thing. See in this case, you find out x verses y here, y verses x you may say, so what would happen? This measurement you will find out, again same thing rudder angle here, this is rudder angle and this is here r. So, you will find that, unstable ship will come like that.

For this I have a rudder angle this (Refer Slide Time: 23:44), for this I have rudder angle you will find out that for 0 also, there is a rudder 0 also there is rudder angle here, it it behaves that way and suddenly it will jump here and then, become going like that; and if you go that side it will go like that suddenly it will jump and go like that; and this spiral the path taken is this same thing in fact, the the loop that you are finding out essentially the same thing.

The what its means you know there, if if it is unstable you expect delta verses r unique relation for given delta there should be given r it should go through 0 delta 0 r should be 0, that is what should be a stable ship. But, unfortunately, there are ships, if this kind of loop happens that, delta verses r within a certain limit of plus minus say delta critical say delta verses r within does not follow a proper relation, no unique relation. Therefore, we will tell that the vessel within delta plus minus delta critical is uncontrollable.

Say plus minus 2 degree (( )) uncontrollable, if you give 1 degree you do not know which side it will turn. If you give plus 1 degree you can turn this or the other way around, that is what it means. If it happens, so this is the test and people can find out from this test diagnostic, what is the instability, so this is one test.

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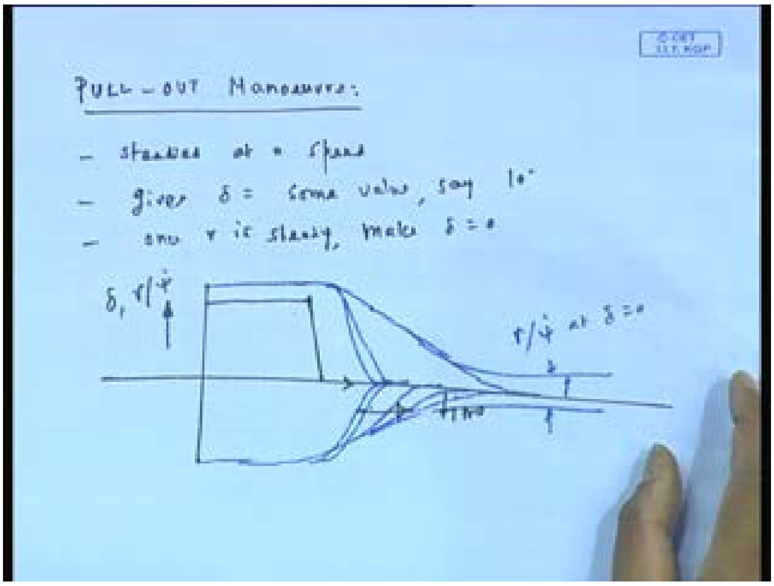

Now, I let me talk about quickly pull out test, this is of course another test, even simpler which will give you (( )) what you do is very simple. This is actually straight like this you begin basically the ship is steadied (No audio from 25:38 to 26:09), that is all. All that you do, if you look at that you are giving a rudder angle basically a turning steadily at some 10 degree, 15 degree which is large enough, where it will turn then, just bring it back to 0. So, what would happen? This is your time and you are measuring here rudder angle is held delta and r or psi dot, r is same is as psi dot right, rudder angle is held fixed then rudder is simply brought back to 0, this rudder.

Now, what is happen what do you expect to psi? It is having a fixed of course, I have already assumed that, it has turned from before I include, so say it has reached to some kind of this thing constant then, you expect it to eventually become 0; and you will do that in both sides, this side also you will do eventually it should become 0. But, what would this the the the simple test you know there is very simple test. All you do is that, you simply you know like give a rudder 15 degree or so, a sufficiently large rudder then bring it back to 0.

What would happen is that, some vessel you will find out that this does not come to 0, but it becomes like that and this side if you do it will become like that, there is a gap in fact, this gap this delta gap is exactly this delta gap; It will it can be found out this delta gap that we found out here this this gap (Refer Slide Time: 27:50), will turn out to be this.

What it means see here, I brought the rudder down to 0, but I am sorry this gap is the r dot gap not not delta, because here of course, delta has been brought to 0; it is this gap r dot gap (Refer Slide Time: 28:06), that is even if my delta is 0 my so much r dot is there, that is this (Refer Slide Time: 28:13), that is the value of r, not r dot, r or psi dot, this is actually r psi dot at delta equal to 0. You see, if this happens obviously, it basically means that, the vessel is unstable.

And you know you can do all these thing even numerical simulation, you can also do in fact we keep doing it I will say that later classes to diagnose that you will find out that, if you are taken the equation of motion where sea was negative and if you were to do a simulation of this type, trajectory simulation you will find a graph like that. If sea is very very positive it will be 0, if it make it larger positive it will become like that, if you make it even larger it will become like that the faster it will come back.

Now, more sea stable faster it will come to 0; it is say, sea was minus something it will become off then, if your sea was 0 it will be just gradually coming very slowly. If is sea is say positive small positive it will become like that, make the sea larger positive it will look out like that; So, this is another test very simple test that is done. And you know these test are very common in in in there are real objects there are actually ships design, which does have instability. There are practical objects even a submarine in a surface condition quite often become unstable.

For example, there is an object I do not want give the detail, but if you bring the rudder to 0, it will still keep turning, but at a larger areas in the same direction, so you have no control on that. So, when you do this test you of course, come to know the vessel we were as it actually happens lack of stability or not. And once once more I am saying, you can do this test at a model scale, you can also do this test or you can simulate numerically using those coefficients.

You can also simulate this trajectories you know numerically simulate in computer to determine this and in fact, it is nice to play around. Then, you change n v and all you will find out exactly how much I should change it to make it how much stable to get a course. Then of course, you have to ask that a question to do that I need so much n v to make it stable, what is the design change I should make to get that n v? As I said yesterday, we put a (( )) n v has become less negative or what do I what should I do and these are these are (( )) problems.

Reverse problem will also occur that I will tell you this reverse problem just before I go is that there was a case of this certain shipping corporation ships, which were suppose to go on a canal in Japans for a long distance, this ships were very sluggish. So, stable that if you give rudder it does not turn. So, when there is a canal back you know going like that it is not able to turn, because it takes much larger radius of turn, it is all most like a dogmatic you know like a like a mule or something, it does not want to turn.

So, then you have to have a design changes to make it more maneuverable it was so stable, because what happen, typically larger ships you see like tanker and all you make it reasonably stable, because they are designed to go straight in some course; and even open ocean also if they turn very small turn, when they come to port you actually have (( )) assisting it from all sides. It is it is essentially the smaller petrol vessel, naval vessels, you know coast guard vessels, these are the one that you want high (( )) we will come to the the other one.

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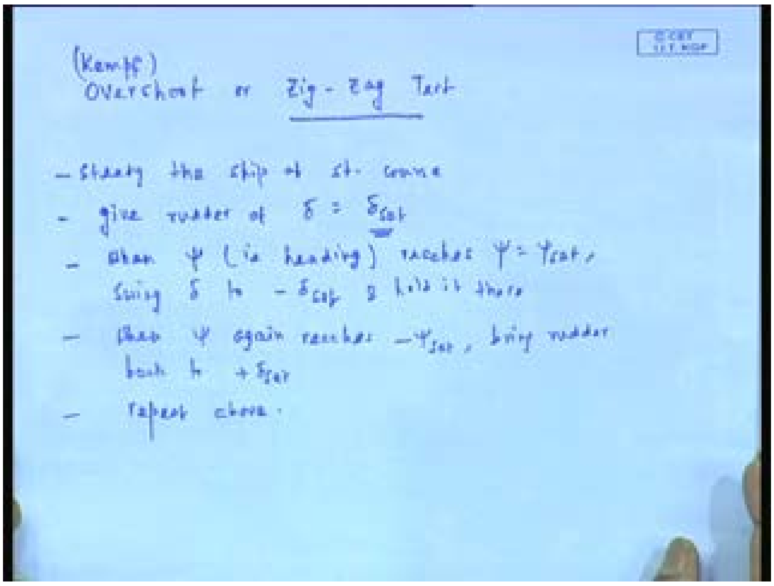

Now, call zig-zag test overshoot of zig-zag test, this is another interesting test. Let me put that from here I like to these numbers. Actually, they call this we call it sometime Kempt, basically you know the the test have been kind of named with the in the name of the person who was kind of you know like suggested that, so that is why some people will call you Kempt overshoot test; but, we call a zig-zag test, the name is very common-obvious you know from the name.

This is a test you know it gets carried down for land vehicles like scooters, cars etcetera you have to just see how you can go zig-zag, how fast you can go. So, here what we do is like this, once again this this steady. Now here, see this is a this is important that we will do slowly give rudder let me first write down this way, you give a rudder to certain value delta set, which you have set the ship begins to turn, all right (No audio from 34:10 to 34:35).

As the heading begins to turn, there is a set value you I will you will understand that, when we actually plot this diagram much better. When it reaches a particular set value just at that time, bring it bring the rudder back to minus delta set just reverse it and hold it there (No audio from 34:57 to 35:28). See, basically you are swinging actually this this is in writing is always difficult to understand, when I actually plot the diagram you will probably find out much easily. Now, let me plot this diagram here let us probably use color some, it will be easier then.

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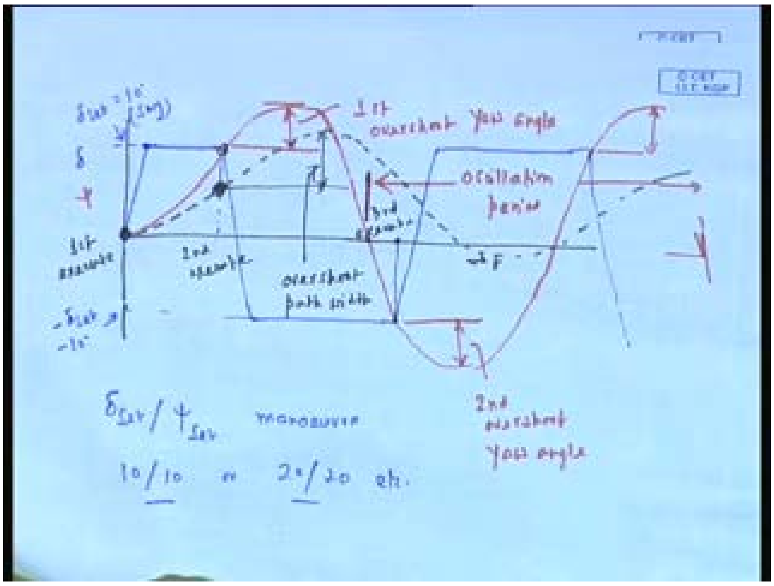

This is time with time imagine see here, rudder is your bringing at to delta some delta set value, actually typically typically this is called as delta set psi set manoeuver; and these are typically 10 10 or 20 20 etcetera in fact, these two are the most common test, 10 10 we call 10 10 zigzag or 20 20 zigzag which means my delta set is 10, psi set is 10 or 20 20 we do not normally have 10 20. So, but I the reason I mention is, because I wanted to have a general description.

So, what happen you hold the rudder here, the blue line is rudder. So, this is my delta set value say 10 degree hold it here, what happen to my heading? The ships heading is begin to change, it was 0, this is psi it begin to change, now at some point it reaches its value. Moment it reaches its value moment is a reach this value, bring this back to minus, minus 20 degree, this is delta set; so, this is minus you hold it here, what would happen to this all all you are doing is basically what you are measuring is exactly you are measuring its position, its heading angle etcetera. You also measure y, the position how much it is shifted, so this will heading will go like that; and it will come back eventually here.

Moment it has reached this minus delta set, swing it back opposite side and again hold it here, so this is going to go like that, and again go here again shift it back; So, this is again like that, this is now what you are measuring? Remember, what you are measuring, you are always measuring the heading you are plotting this in order to plot that, what I need time verses this is time time verses the way I have swing the rudder; and heading angle also y, y is the you know if you call this x distances the ship will behave like that you know I will show that in next page.

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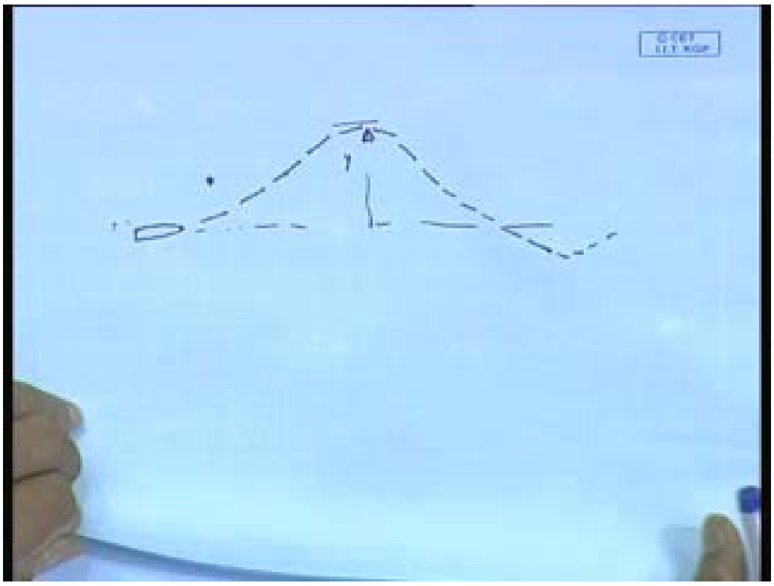


It will be something like that today the ship here, if I draw a straight line, so then you have give a rudder, so it is going to turn eventually here, it turns here the heading has turn here remember this, this is a path straight line path; then at this point, I give the rudder, but it will it is still going to turn for some more time here; then, it is going to come back here. But remember here, this distance is y distance it may not come other side, but this heading angle would have reached minus 10 degree when again you turn it, so it will again overshoot and go.

So, this y there is path width is also what you measure and that may be plotted here, the path width will plot here as something like say, it not it not necessary come back exactly here, it may comes something like that because after all, it is a heading on you have changes. Remember, the the vessel may not have come back on the other side, just the heading has changed remember that.

So, you plot this and the measure now, the measures are like this that let me tell you this, most important measure is overshoot measure, this side, this first overshoot (Refer Slide Time: 40:08). What is the overshoot? Remember that, when the heading was 10 degree I reverse the rudder, but the ship kept going to the same direction turning in the same direction for some more time, so it overshot.

Let us say, it went up to 18 degree before it begin to reverse; that means although when it was a 10 degree I change my rudder, unlike a car it did not change the direction on the spot it went on the same direction for a while and then, changed. How much it went more is what is called overshoot that is first overshot.

Similarly here, this is my second overshoot (Refer Slide Time: 41:04). You can say, its first overshoot yaw angle of course, if you keep going like that you have third over shoot yaw angle and all that. Normally for so successively that, basically why it is important because, you know after second, third, fourth, fifth, sixth becomes all most the same one, because they reaches steady state type.

First one is always less, because of the transient you know it is just going on a straight line you are going. So, first one is usually less, second one is more than that, third, fourth, fifth one becomes similar; and most ships will not go beyond second one. I will tell you later on the rules and regulations given by I m u that a ship must satisfy, which would be stipulating for first time second only that is it must be so and so for you to certify.

So you see here, this is one measure then other things let us look at the time. So, execute wise basically this point first point t wise I will say, this time for first execute of rudder, because there is a time, where you have first execute. Why first execute? This is a time first time you are given a rudder angle, you are executing the rudder bring it to this then at this point I swung it back; So, it is my second execute then, at this point my third execute right.

This distance that one more thing I should tell about this overshoot. Now you see, there is another thing called path width overshoot, the overshoot of y, this is given by this distance that is first path width over in fact, only this one is important let me write it down. Why this much, remember at the time see it was already here, see at that time I reverse my rudder it was already here it was already shifted to this much.

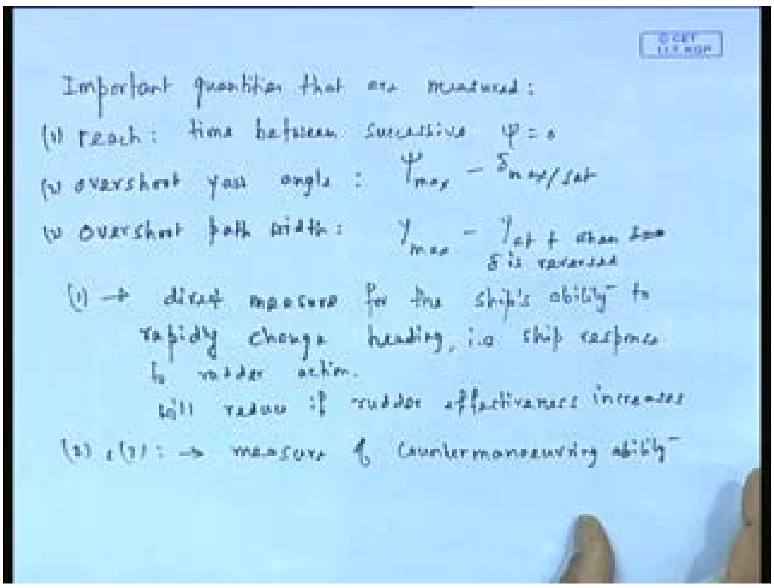
Now, I reverse the rudder and I expect the ship to go another side, but it has not gone to the other side, it has still kept going in the same side for a while and overshot this by this much amount. So, you see it has still kept going on the same direction and overshot see, my it has gone see this at this point at this point I have reversed the rudder I want the ship to come back; but from here, it has still gone further this much and then, begin to turn back. How much further it has gone, that is my overshoot. So, this is my path overshoot then comes this time period, period of oscillation.

Normally, the period of oscillation would be 0 to 0 this say this 0, let me put the red line, to where again it actually here where again it comes down this much that, that is you know like a sine curve that comes from here to where it has come, this would be a period of oscillation, up to where this graph has come down here.

The important point is of course, one important point is reach, reach is basically this is important, how do I write this reach means yaw 0 to the time where that is time time to reach basically you can say this is reach (Refer Slide Time: 45:50). Of course, it is you can say time reach time, what it means is? See, once again you must understand heading must 0 again it the heading become 0 after so much time, the time that is taken as reach time to reach; and the distance if you measure all x axis will be distance to reach, these are the thing therefore, you measure one execute reach etcetera.

Now, how are they related, let us see how they are related to the maneuvering. So, let me write it down here, because what happen I will just write it down little bit and then we will go.

(Refer Slide Time: 46:41)

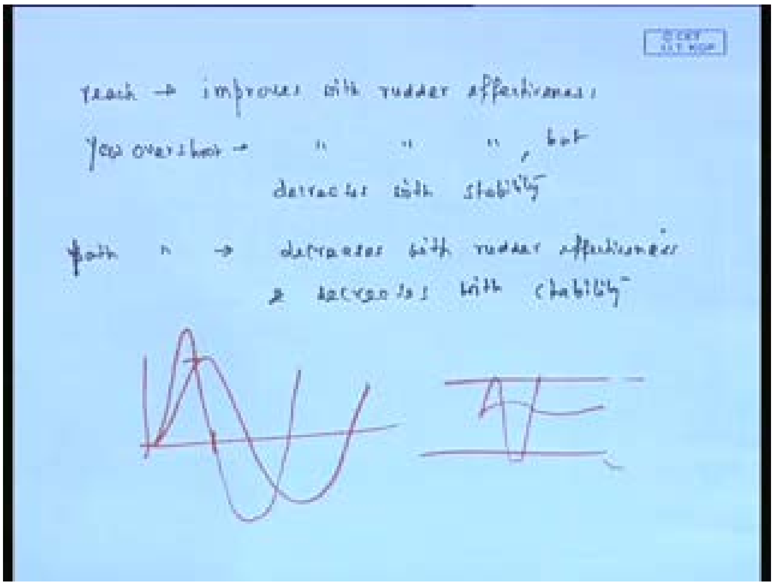


So, the important quantities that you measure (No audio from 46:43 to 47:05). In fact, reach can be called, this is first reach (Refer Slide Time: 47:09), then next to next 0 is second reach etcetera which is also like oscillation period. (No audio from 47:13 to 47:28) Other two are important are these overshoot, (No audio from 47:32 to 47:47) max or set, which is of course same thing. (No audio from 47:52 to 48:30)

When delta is basically what I mean it is the time y max minus the time the y as a time, when delta was reversed. See, this is the time when the rudder has been reversed, the execute time, so y maximum y minus the y at the time delta is reversed, that is an overshoot. See, now the question is like this, if I call this 1, 2, 3 I will tell you it is a direct measure (No audio from 49:12 to 49:55) I will just mention this. (No audio from 49:58 to 50:20)

Basically reach line, this reach line, this time or the oscillation period directly tells me how effective the ship is how fast it is turning, because its time will reduce what you know, if it is turn faster that means, the rudder is bigger or the ship is quickly responded to rudder; obviously you will reach this much faster, because it is turning very quickly you know moment you turn, it the the ship turns. So, reach basically will be a measure of how fast it turns, how fast it responds. Similarly now, the 2 and 3 measure of counter manoeuvaring abilities. What is known as counter manoeuvering abilities? Let me write down this part again.

(Refer Slide Time: 51:34)



Reach improves (No audio from 51:38 to 51:51) as I mentioned here, here this is important, but there is a but there, decreases with (No audio from 52:13 to 52:53) I will tell you what the this point. See here, what we wrote see this is what we we we need to see now, reach of course will improve with rudder effectiveness; bigger rudder it will be much faster. Yaw overshoot is important, it will increase with rudder effectiveness that means that means, this will go shoot further. What would happen? If you make rudder bigger this full thing gets squeezed. So, this graph this graph will become squeezed pushing that means, you are reaching faster, but you are also over shooting more remember that, you are also over shooting more.

And of course, the other thing that we said what is this it will decrease with stability. If you now make it very highly stable, rudder may be effective see the two things having, rudder responsiveness is one thing how fast it respond to rudder that depends on also that is the effectiveness of rudder, how much rudder is acting; but, if the ship is for example, very sluggish very stable. So, you make a bigger rudder also it will not overshoot much.

So, see the stability over list stable will try to reduce this, so basically overshoot will decrease the stability, so it will come down, if you make it stable. Now obviously, you do not want a ship, which is very stable and therefore, in order to turn I want a very big rudder right, so you obviously want a balance. So, the point therefore is that see, that this two are reverse (( )) may be the same thing will happen the part width. If you make it very stable ship, it will respond very slowly to rudder take longer time and have a lower overshoot, lower overshoot means in a canal and all lower overshoot, but respond much much slowly.

On the other hand, if you want to make it very you know like very what I should say less stable it will quickly turn, but as in turn it overshoots more. So, it might hit the (( )) for example, if I have a canal here, so if you make it where is the the ship can actually overshoot and hit, but if you make it very small then, it may not able to turn negotiate here.

These are the reason why in the next later we I will tell you that i m o has given stipulation that a ship must possess certain overshoot, but not more than this. Overshoot has to be limited because, you cannot allow the overshoot to be high; because, overshoot high implies lack of safety, it may hit on the side; that, two ships are going you want to turn you just overshoot and hit. So, overshoot is actually opposite of safety you know more overshoot means less safe, but on the other that is what is the i m o will tell from safety, it is just like for safety as a make it very high g m, but we will like to also make sure that, the ship is able to respond.

So, designer will try to make sure that, it has got good responsiveness just like we will try to make sure that, met centric height is not so high, so that the it becomes very stiff ship; but rules will tell me that this is, so there is again an opposing factor, safety and control ability. Basically, control ability safety (( )) and maneuverability, highly maneuverable means it tries to overshoot.

So, you make the ship unstable towards unstable less stable very just marginally stable, it will very quickly respond, but becomes unstable overshoots more. So, this are kind of measure you know like, so we in in ship building are always; obviously, confronted with such kind of duel requirement you know one gives you more, the other gives you less and you have to make sure, there is a balance there. So, when you are designing you have to make sure that, this is within the limit. So, with that I am ending today, tomorrow we will pick up the turn the other very important manoeuver call the turning circle manoeuver, so with that.