Ship Resistance and Propulsion

Prof. Dr. P. Krishnankutty
Ocean Department
Indian Institute of Technology, Madras

Lecture - 15
Resistance of Advanced Marine vehicles - I

Back to the class, we have been discussing about resistance of ships, there is a conventional ships what we can said so far, which generally come under the displacement category. Also, conventional form that is we can say that mainly mono Halwand, we can say that and we are seen that different methods what the procedure adopted. Now, we are moving to the under the category called advanced marine vehicles. You look to resistance of these types of vessels, how they are estimated, what are the different groups, which is studied the resistance primarily using model test for the prediction of these vessels, the resistance of these vessels.

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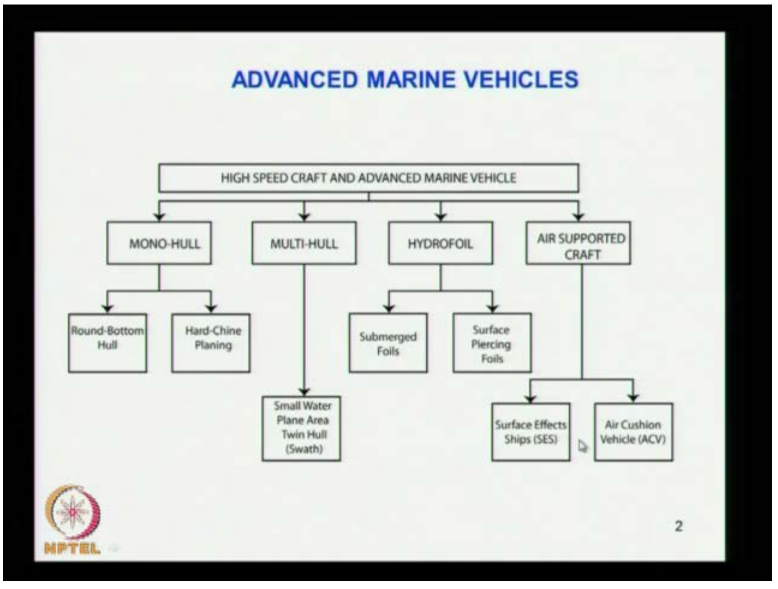

So, you look to the a classification of marine advanced marine vehicles, still you high speed craft and advanced marine vehicles that is what you covered about this topic of the resistance ship resistance. So, under which you have mono term that is a single herb in which you can have a round bottom herb which is a build which is a round builds, it is a semi displacement or semi planning vessel. You can say which is not fully planning, then under the vessel you have the fully planning vessel, this is a planning craft and this is a semi planning vessel.

Then, you have the multiple, you have already discussed about part marines and now we just see multiple here, but an advanced marine vehicle that is which is cancelled. There is a small water plane area tin herbal set, so what you have is the area the two herbs which are displaced and they are connected with deck using starts. That is called a small water plane area it will herbs vessels, then we have the hydroxides hydrofoils that is using the foil beneath and the hall of the vessel, usually small craft. So, there are two types of foils used one is a surface piercing foil and other one is submerged foil.

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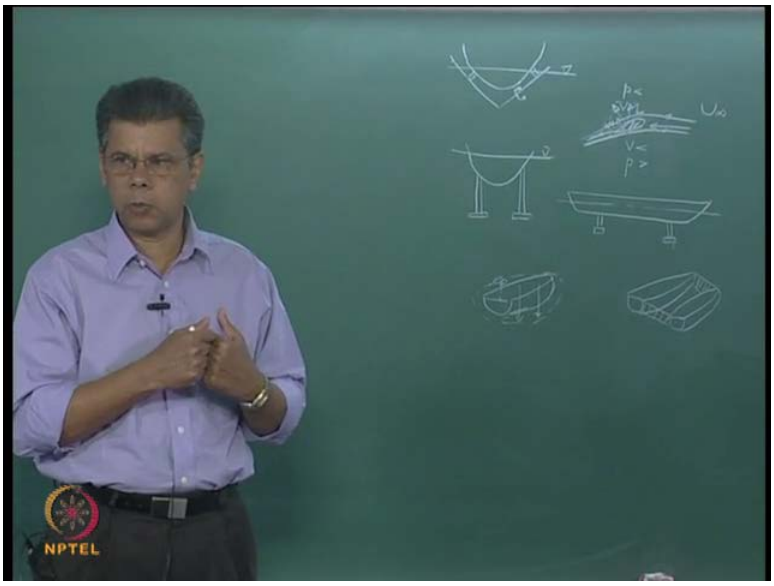

If you consider a vessel of a Cross section view vessel of floating at this line one type of foils is submerged like this which is connected to the vessel. So, this foil has which is surface piercing, so which is this surface is coming out, so this is a vessel which goes like this. We have the foil coming like this, the foil section is in such a way that you will have hydro foil section shape and when you have, maybe I should say then angular attack the flow is in this direction.

So, what you have is, you have the flow lines coming like this, this is section and this is the flow which results in an asymmetry flow, you see the flow velocity at this direction at this position are at the lower side, it is going to be less. So, here the velocity is less and, whereas here due to that you have the higher angular of attack can see there is flow velocity is going to be higher. So, here the velocity will be higher, so when there is a low velocity, this is a velocity compared to you say it is infinity. The velocity here is going to be higher, then the infinity here at the upper side and that lower side is going to be less, then the wave stream velocity.

So, due to the flow velocity reduction here there will be an increase in pressure and here what happens? The pressure will be higher and this is the increase in velocity there will be a reduction in pressure at that surface top surface. So, there is variation of pressure on the either side of the foil due to the velocity change, so due to that there will be resultant pressure which acts may be some in this direction. So, you have high pressure region this is a low pressure region, so you find out integrate the pressure over the surface you get a result in force and that force when you resolve along the flow and normal to the flow. If it is along the flow, you call it a track component, it is a drag component and this is a lift component.

So, that is a principle used here, so here if you take the section what it shows here it is a basically a section taken over the foil. So, due to this effect there will be a hydrodynamic lift which push the vessel up, so it may reach a stage where the whole vessel may come out of water only the foil is beneath that and here this foil is partly above water and partly below water. So, that is why is called a this is called a surface piercing foil, it is a hydro foil craft the basic principles of hydro foil craft is there is foil system which is submerged. It is below the herb partly or fully submerged, so when it moves through water at the higher speed, it generates lift which is sufficient to push the vessel up.

So, vessel is now become a foil bond condition where the hall part is fully out of water and reduces the resistance. Hence, it can achieve higher speed which we discussed in the also discussed when we discuss about the resistance of in general another type of vessel is the same thing what you have is the hydro foil craft. When you have the foils just coming down, then you have foil systems here, so this is the foil is always submerged condition this is a submerged foil system and here. Also, the same you have the foils, which generates or lift and push the vessel up and that is high speed with due to less power.

So, when you consider the vessel itself, you can see that the foils the vessels hydro foils crafts, they generally provide foil systems in the craft and the foil systems in the forward, so this gives you balance in this plane. So, you can adjust the plane the flabs the foil so that the angle of attack can be changed. Based on this, the trigger lift changes and the vessel condition that is whether it is in the foil bound condition or fully in the out of water or whether it is in the submerged condition.

So, all these operating conditions determined by the operation of hydro foils, so that is what the next vessel which we discuss that is the hydro foils. You have the submerged foils you have seen that is which is deeply submerged and the other one is surface piercing. It is a partly out of water that the foil is out of water and partly inside water. So, these are next marine vehicle which fall under this category, then other one is a air supported craft, we have two categories, one is air cuisine vehicle and other one is a surface effect ship.

Air cuisine vehicle you have a it is a typical example is odd craft where you have the vessel and around the vessel, so what you have is you have a consider a vessel like this around which you put squat, so around covering that there will be a squat. Usually, it is not so sharp, it may be round here, so you get the squat a squat is put. So, the squat around that gives a make a chamber air chamber beneath the herb, so then you will have a heavy duty pump heavy duty fans which will be under this the flat surface. So, it generates air pressure, it is put down in the vertical axis, so when it rotates, the fan operates. You can generates a pressure inside the chamber and due to this pressure the vessel is pushed up.

So, that means it is a come out of water and the resistance becomes less when it is air bond and with that you have usually an air propeller, you know not the water propeller here, you have the air propeller with propel the vessel. So, that is the air craft, the air crafts have a squat covering the portion around the herb which gives provide a chamber for the vessel and inside the chamber to inside the chamber. You will use a heavy duty fan in the vertical axis which generates a pressure inside the chamber and due to the air that air pressure the vessel is pushed down. It becomes air bond only the squat is contact with water and this can move at a higher speed with reduced resistance and reduced power.

So, the another advantage of this vessel, it can operate in land also, it is a hydro Dan amphibians character, so it can operate in sea condition and also in a land provided the land is more or less even. Also, when it operates in sea, it will be an effective only when the sea is moderate nor or calm not in the tough sea condition. So, that is a hard craft whereas by when you come next type the surface of its shape you have may be two. It is a cat marine, basically you have a cat marine, and you disconnect it you know you have cat marine, then these n what you see here, these are covered by squat.

This orient also it is covered by squat, so you get chamber formation, the two sides are covered by the hump at the marine at the n's you put squat. So, you get a air chamber again to that air chamber the same principle what you have adopted for the old craft recreation vehicle using the fans. You generate pressure inside the vessel get lifted due to the air pressure and when it is above condition naturally it is going to be a reduced resistance and it can move. So, that is called the surface effect ship surface effect ships are generally twin hold or it is a cat marine type. Here, is air cuisine vehicles under which comes the odd craft is a mono hub with this cat around it, so that is the difference between these two type of vessels.

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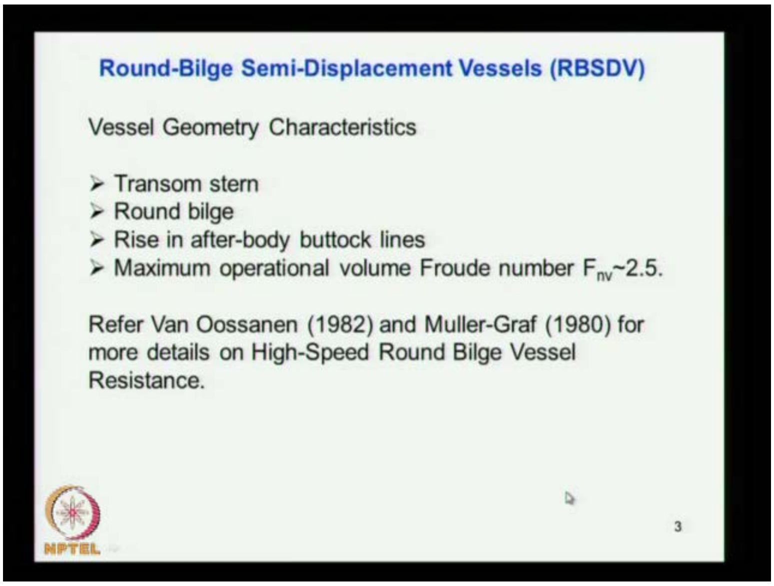

Now, we see a round build semi displacement vessel such that it is a build of the vessel is round shape, you know what it means and it is not fully planning and that is called the semi displacement partly planning and partly displacement mode. So, that is what this vessel means and the vessel geometry characteristics for such type of vessel are these type of vessels will have a transom stern that is I already explained in the previous class what a transom stern is. So, it will have a transom stern I will just that what it means vessel may be something like this.

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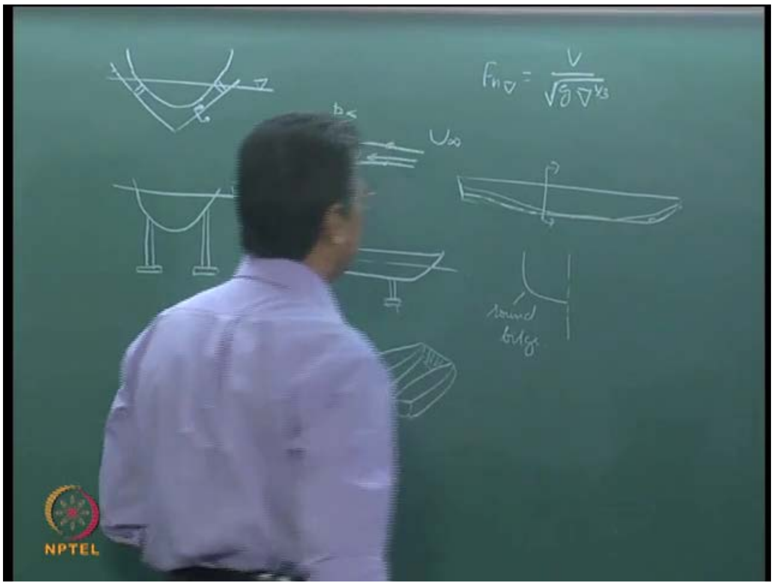

So, that this is a transmission, you can transom it may be vertical or slanting, it is a transmission, then if you look into the section of that that is if you take a section it will be this is a round build shape. So, this is a characteristic of the form of the vessel it is going to be a transition and the build is a round shape then rise in the half body buttock line. So, you have rise in the body, so the shape will be something like this you have this here and it may be like this. So, the buttock line means it is this plane you have a space going the lines parallel lines going like this, so this will have a rise in the half body buttock line.

So, when it comes to the half side, there is a rise in the form that what it means and maximum operational volume fluid number the volume fluid number is if you see that the F n delta is equal to V by square root of g into delta power 1. So, that is what it means, the volume fluid number, so that is value is about approximately 2.5, so that is what it is here.

So, that is general characteristic geometry characteristics of the vessel it is going to be a transom stem vessel round bilge rise in after body buttock lines. That is when you goes to the half set the form is goes up slightly, then the fluid number volume fluid number is given by a approximately this. So, that is relatively high speed, it is a high speed vessel given by 3 and so you can see more information about this vessel from this reference so by Van Hood Oossanen and Muller Graf you can see that you will get more references about that.

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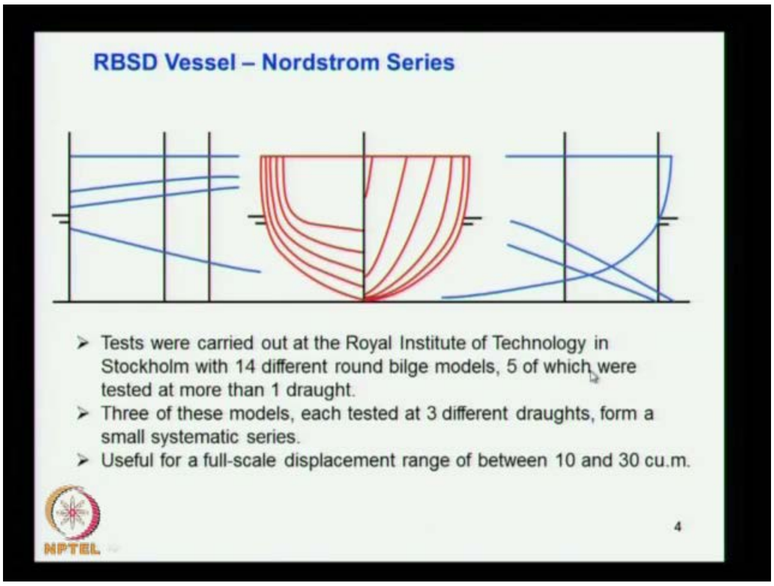

So, we see some of the types of you know vessels coming under this category that is semi displacement type is around build and semi displacement that is what I put RDSB, it means round build semi displacement vessel. So, one of the serious here is not strong serious, so here you can see this the based on the test carried out in royal institute of technology in Stockholm. So, they did with fourteen different round bilge models and five of which tested that more than one draught, so they are for the same vessel. They perform test for more draughts and the results obtained experimentally or tabulated presented and used to fall design.

So, here you can see the form you can see that it is a round bilge bound and you can see here it is a transom. It is in a flat here and some and it is having a buttock race, you can see the shape this is going up in this region to its left and all this is the water plane this plane is what you see is a water plane. So, this is the form of this aegis and see it is the work carried out by the royal institute of technology in Stockholm and there results presented by them based on the results.

So, here what they have done is as I said before, they have for different models, they have considered operating test and form a systematic aegis based on the results the resistance obtained from that they have presented it. It is usually a small vessels, you can see that the volume displacement is approximately 10 to 30 metric cube. So, the considered only a small craft, so this is a round build semi displacement vessel Nordstrom series this is a form of the vessel and this is an explanation about the type of test carried out.

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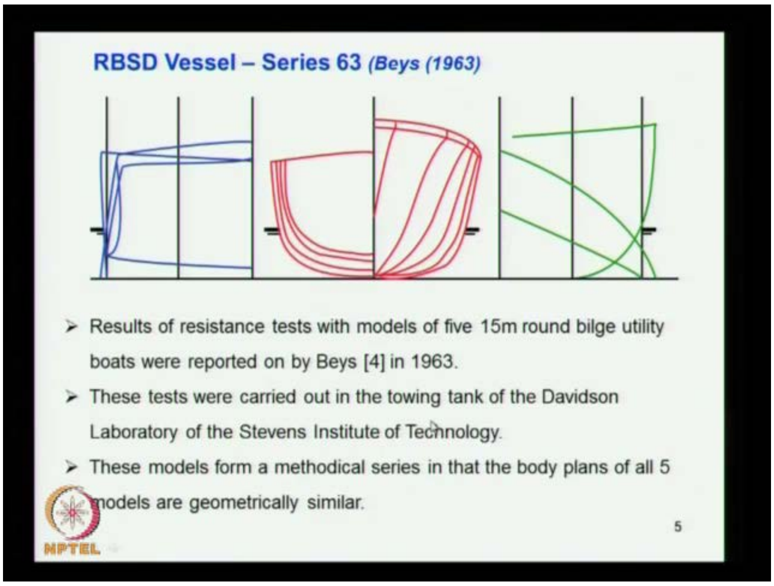

So, we go move to the next one saying again it is a round build semi displacement vessel, it is a series 63 and it got you know in 1963 is the year in which it has been published. Here also, you can see the form the results of the resistance here also you can see there is a round bilge is a transom stem and the water plane that is how is given here half breadth lane. So, the results of the resistance tests with models with five 15 meter long round bilge vessels is bigger one compared to the previous one.

So, that is what the reported on bays, so you have five models 15 meter long these tests were carried out in a Davidson laboratory of the Stevens institute of technology in which you see they have this is a experiments carried out in the towing tank. There the models of a methodical series in that all the five models and geometrically similar models that is what they used.

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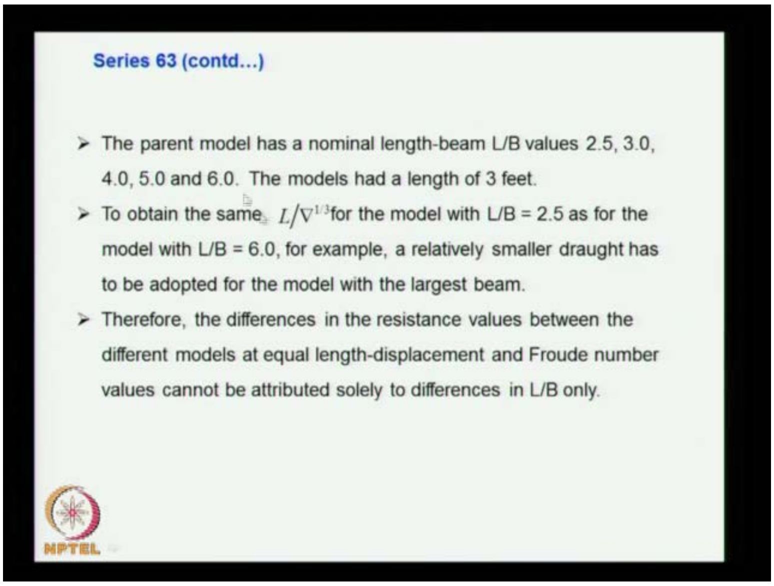

So, here series 63, the parent model has a L by B ranging from 2.5 to 6 that is L by B variation and the models is small you they use a very small model obviously the smaller model occurs the tank carries a speed limitation. Also, the carrier the size limitation the model size is reduced because in one tested the high speed you know that what is based on the fluid condition the models speed comes down with a reference to square root of these scale. The module speed is equal to ship speed divided square root of lam term, so when you make the module size smaller then the speed of the module also reduces.

So, if there is speed limitation, then you may have to go for a smaller module that may be the reason why they have gone for a 3 feet module where this module problem with the small module is a n of some will be high so that is an disadvantage for that. So, to obtain the same length displacement ratio for the module with L by B is equal to 2.5 as for the model. So, what they did is they tried to retain the same l by delta raise to one-third and they have naturally they have to change the values of other parameters and including the drafts of the vessel to match this to get the same displacement.

They manipulate the other dimensions mainly the draft, so for the difference in the resistance value between the different models that equal. So, you are considering equal length displacement ratio that is L by delta power one-third and the Froude number values cannot be attributed only by change in difference in L by B, so what do you do is you change the drafts of the vessel.

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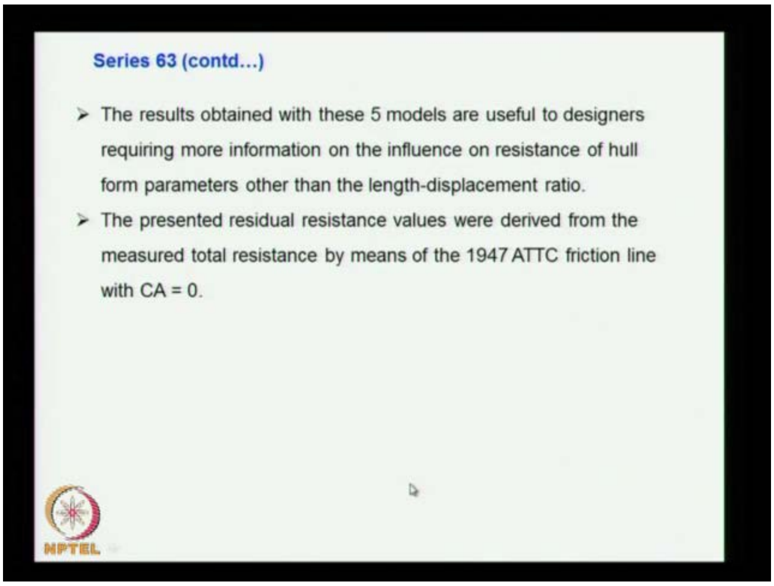

You can see that different drafts are used for to get the same length of displacement ratio. So, there will be an influence on the resistance of the vessel due to this limitation you are trying to adjust the length of this displacement ratio by changing the drafts or other parameters. So, naturally there will be a prediction may be slightly different, so the presented residual resistance values are derived from the measured total resistance by means of so use at ATTC same as American third time conference friction line. So, use the friction resistance from using this formula from the measured total distance of the model you reduce this, then you get the necessary resistance by efficient of the model which is tallied with the that of the procedure resistance co efficient of the ship.

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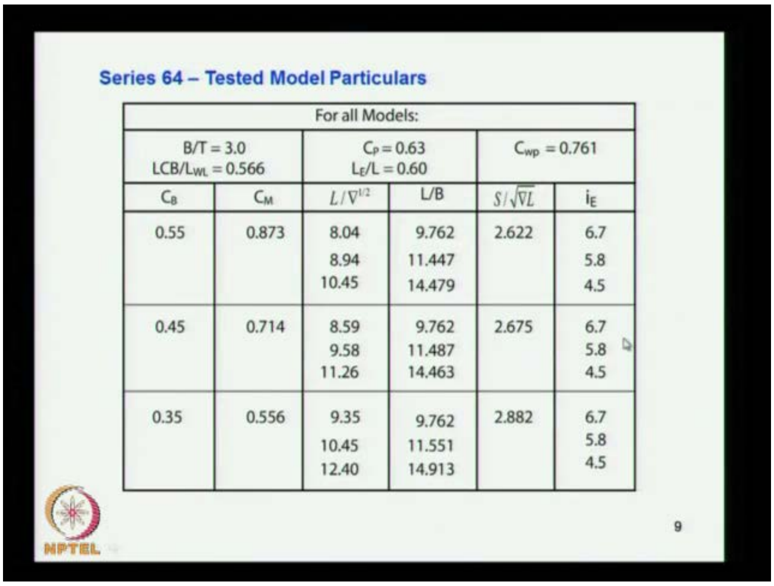

For all Models:					
$B/T = 3.0$ $LCB/L_{WL} = 0.566$		$C_P = 0.63$ $L_E/L = 0.60$		$C_{wp} = 0.761$	
C_B	C_M	$L/\nabla^{1/2}$	L/B	$S/\sqrt{\nabla L}$	i_E
0.55	0.873	8.04 8.94 10.45	9.762 11.447 14.479	2.622	6.7 5.8 4.5
0.45	0.714	8.59 9.58 11.26	9.762 11.487 14.463	2.675	6.7 5.8 4.5
0.35	0.556	9.35 10.45 12.40	9.762 11.551 14.913	2.882	6.7 5.8 4.5

So, that is the model what is used.

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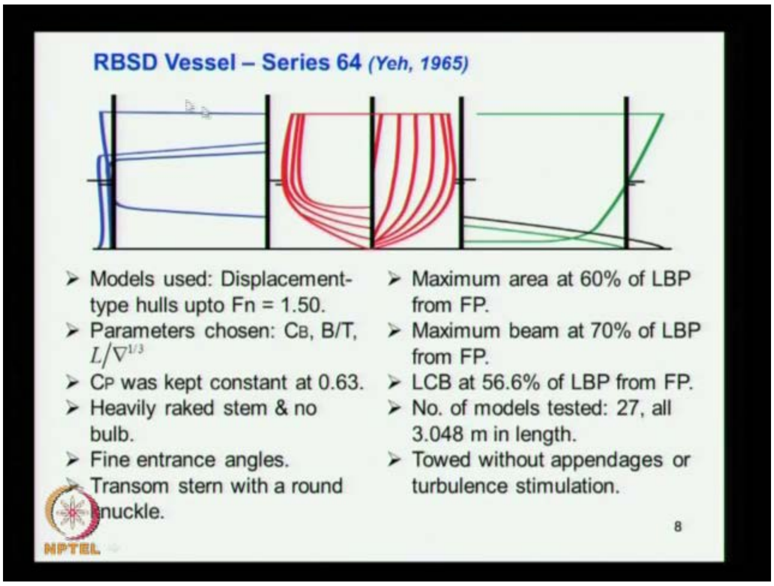

So, next we move to these types it is 64, you can see here it is a reference it is 64 also almost follow. The same you can see there is drat rights angel here, then it is a round bilge then looks like there is a tumble home for the vessel. You can see there is going inward, so this is a shape this is a form of the vessel considered, then it is also having a transom stern here. So, you can see the details here see the water plane is very narrow here that is angle of enter is very small here and also it is having a right stem.

We see that what is the description about the model here, model is displacement type hulls up to fluid number of 1.5. That is what is used is a displacement form and fluid of up to 1.5 is the high speed displacement vessel parameters chosen for the model or block coefficient B by T recruit the ration and length to displacement ratio C. Prismatic coefficient was kept constant at 0.63, so there whenever you do perform model test naturally you try to freeze some of the parameters and wait the other parameters to see the influence of the parameters on the resistance.

So, here C P is kept constant at 0.63, it is a heavy raked stem, you can see that this is a raked this is the inflammation is high. So, it is called the heavily raked stem and no bulb there is no bulb its only a straight stem find in this angle you can see the angle here this is the water this is a after plane. So, the angle is very small is a half angle and atoms is usually kept small for high speed vessels and transom stem with a round knuckle. You can see the transom stem and this is you know round thing maximum area at 60 percent of the LBP usually normal shapes.

You have the maximum area is at the mid ship that is you say its 50 percentage from LBP. This is the depth mid ship, but here if you have the forward side is more fine and the maximum section area is pushed half of the mid ship so that the 10 percent draft. So, you get 60 percent draft of l b after 60 percent from LBP or 10 percent after mid ship is the max position of maximum section area where as the maximum beam occurs at 70.

Further down, maximum breadth is happening even for the down, so that means the after region is more for much when compared to the forward is more. So, that is the shape of the vessel longitudinal position of center points is it is 56.6 percent from LBP that is from the forward side from here it is 56.6. That is it is about 6.6 percent after mid ship.

So, again that shows that the volume concentration is more towards the half of the ship so number of models is 27 all of the same length. That is what they consider towed without appendages or turbulence stimulation, so there is a no appendages like radar or bilge heal or shaft boozing and all that given there. So, it is a barreled resistance which is without appendages and turbulence stimulation. We have already discussed when we discuss about the resistance about the different types of stimulations used for creation of turbulence to match it more with the actual ship because there is Reynolds number variation.

So, that is normally done in model test usually we have seen putting trip wire putting the sand paper or so, these things were normally used which we discussed before so this type of stimulations have been not used in the series 64 model test. So, model particulars what all type of models what is the model particulars used for the model test you can see that models is the they are B by T is equal to 3, the breadth ratio is kept as i. Then, LCB by l W, we have already seen 56.6 that is 0.5 c 6 that is LCB position in relation to length of the load water lane is 56.6 percent half of the forward perpendicular the forward region that is what we have seen.

So, here from here it is a 56.6 percentage of the length of the load water lane prismatic coefficient is 0.63 written as constant, I think its same length of entrance by overall length that is the flow you have seen the maximum section 16 percent. So, this is the ratio of the length entry length or entrance length divided by length, so that length is equal to 0.6 and CWP water plane area coefficient is equal to 0.7. So, these are the parameters of common parameters of the models and also they have varied the model you can see that one set of mode LCB is kept as 0.55 and CM is equal to 0.873 which makes C P is equal to 0.63 C B by 0. So, under this category they have tried three models with length displacement ratio 8.05, 8.94 and 10.45.

So, these are the models they have used and length of breadth of ratio for this models are given. Another vessels here you can see that variations here and here C B s 0.45 and C M 0.714 and here also you can see that C P comes at 0.63, so is another set of vessels here parameters are shown here. This is another set I mean C P C V 0.35 and C M 0.556, so these are the values used on the models are some model particulars.

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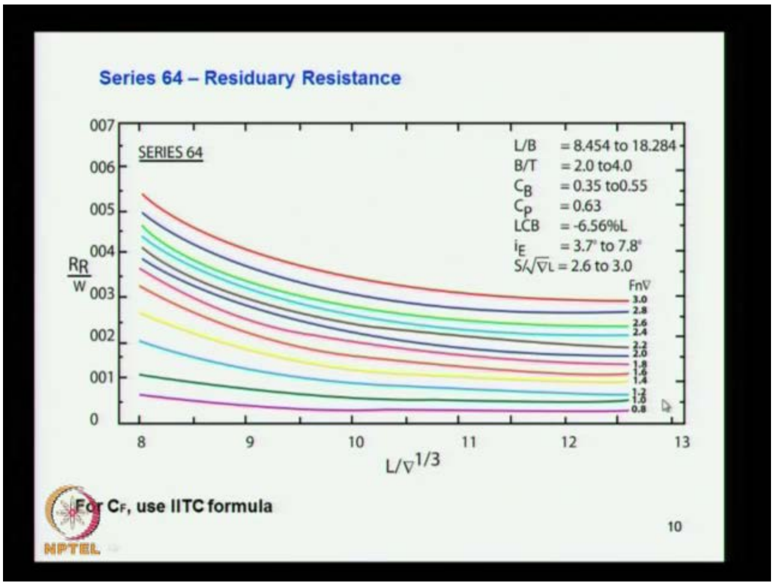

So, based on these analysis that resistance test have been carried out and the results are obtained and the results are put in a non dimensional form residuary resistance component R R by W, W is the weight. So, it is a non dimensional coefficient formed R R by W and you can see this is all point zeros that point is missing here. It is all coefficient given here and the characteristic of the models are shown here what we discussed L by B B by T, C B, C P, LCB and half angle of entrance so all these what we have just seen so these are model particulars. So, what is done is they have plotted these values residuary resistance co efficient against length to displacement ratio.

So, this is the length of displacement ratio and this is a procedure resistance coefficient so then each curve represents for a particular displacement fluid number f and delta. So, you find out for the vessel what is F and delta and then you find out L by delta raise to one-third. So, you just find out the curve and take the value of R R from here so thats how the resistance that has been presented so these series 64.

Now, we have an idea what is the type of form what is the range of vessel want to range of parameters considered and the model test conducted. Finally, what they use this they sort it out the find out find out the residuary resistance and percentage of non dimension form where there have used ITTC formula for the estimation of the frictional resistance coefficient. So, you know the procedure, now once you get the residuary resistance how to proceed to find out the total resistance of the vessel.

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Series 64 Resistance Data (1000 CR) for CB=0.35									
L/V^(1/3)	9.3			10.5			12.4		
B/T	2.0	3.0	4.0	2.0	3.0	4.0	2.0	3.0	4.0
Vk/√(Lf)									
0.2	1.533	1.500	1.403	1.869	1.830	1.718	1.100	1.075	1.003
0.4	0.950	0.929	0.868	0.889	0.869	0.813	0.854	0.835	0.782
0.6	1.477	1.348	1.172	1.053	1.149	1.194	0.936	1.070	0.862
0.8	1.362	1.488	1.310	1.093	1.005	1.135	0.923	1.076	0.932
1.0	1.539	1.617	1.422	1.191	1.083	1.100	0.954	0.954	0.828
1.2	1.633	1.701	1.463	1.227	1.115	1.192	0.913	0.933	0.771
1.4	1.687	1.747	1.509	1.194	1.106	1.167	0.882	0.865	0.709
1.6	1.708	1.732	1.502	1.139	1.067	1.117	0.794	0.778	0.693
1.8	1.690	1.636	1.501	1.076	1.003	1.071	0.720	0.706	0.665
2.0	1.561	1.477	1.462	1.014	0.931	0.990	0.672	0.645	0.660
2.2	1.433	1.332	1.390	0.956	0.850	0.918	0.652	0.639	0.667
2.4	1.300	1.200	1.310	0.872	0.789	0.863	0.619	0.626	0.662
2.6	1.183	1.091	1.216	0.801	0.742	0.825	0.588	0.625	0.643
2.8	1.076	1.014	1.126	0.752	0.710	0.794	0.580	0.632	0.603
3.0	0.998	0.959	1.052	0.700	0.690	0.690	0.777	0.570	0.579
3.2	0.937	0.919	1.000	0.686	0.690	0.765	0.567	0.642	0.576
3.4	0.899	0.901	0.979	0.679	0.700	0.747	0.576	0.646	0.583
3.6	0.870	0.892	0.967	0.686	0.709	0.769	0.580	0.658	0.593
3.8	0.849	0.887	0.962	0.700	0.722	0.774	0.591	0.671	0.601
4.0	0.836	0.885	0.952	0.715	0.736	0.776	0.604	0.678	0.611
4.2	0.833	0.889	0.947	0.728	0.747	0.778	0.615	0.688	0.626
4.4	0.830	0.894	0.939	0.741	0.756	0.777	0.625	0.695	0.632
4.6	0.832	0.898	0.932	0.750	0.766	0.775	0.633	0.704	0.639
4.8	0.836	0.898	0.926	0.759	0.772	0.775	0.643	0.709	0.646
5.0	0.836	0.895	0.918	0.763	0.776	0.772	0.649	0.713	0.651

So, that is the series 64 vessel you can see the data numerical data is also provided here see it is 64 resistance data that is residuary co efficient 1,000 that usually put as into thousand because C R values are small coefficient. Here, this is for C B 0.35, so you can see here what are the things given l by displacement raise to one-third that is the displacement length of displacement ratio 9.2, 10.5, 12.4 B by T 2, 3 to 4. Then, here it is a for this length of displacement ratio and here, so the data obtained from the model test have put in a tabular form.

We have seen the graphical form, so this is V k by square root of l f, so that is what is given here l in feet and feet v in nods, so this is the values so you get the c r from here that is for the case of C B is equal to 0.35. So, if you go to next you can see its for C B is equal to point four five same data for this variation volume displacement all that so you get this formula. Similarly, for 0.55, so we have considered three categories you can see C B is equal to 0.35, 0.45 and 0.55, these are the models.

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Series 64 Resistance Data (1000 CR) for CB=0.55									
L/V^(1/3)	8.6			9.6			11.3		
B/T	2.0	3.0	4.0	2.0	3.0	4.0	2.0	3.0	4.0
Vk/V(Lf)									
0.2	2.888	2.856	2.750	2.504	2.476	2.383	2.065	2.041	1.963
0.400	2.593	2.565	2.473	1.206	1.192	0.923	1.282	1.267	1.218
0.600	2.504	2.478	2.389	1.095	1.082	1.041	1.162	1.149	1.105
0.800	2.612	2.585	2.494	1.450	1.435	0.824	1.203	1.190	1.075
1.000	2.440	2.415	2.330	1.984	1.963	1.357	1.403	1.388	1.157
1.200	2.846	2.817	2.700	2.472	2.446	1.610	1.560	1.253	1.253
1.400	3.163	3.131	3.023	2.734	2.536	2.246	1.552	1.512	1.273
1.600	3.169	3.208	3.052	2.489	2.520	1.000	2.266	1.471	1.245
1.800	2.975	2.993	2.946	2.302	2.335	2.044	1.385	1.356	1.168
2.000	2.711	1.000	2.754	2.797	2.042	1.915	1.278	1.229	1.084
2.200	2.397	2.477	2.580	1.788	1.815	1.685	1.165	1.114	0.981
2.400	2.086	2.206	2.352	1.567	1.609	1.503	1.063	1.019	0.881
2.600	1.856	1.967	2.134	1.390	1.452	1.364	0.970	0.925	0.778
2.800	1.648	1.764	1.928	1.251	1.332	1.263	0.903	0.852	0.706
3.000	1.477	1.595	1.757	1.144	1.247	1.163	0.831	0.801	0.656
3.200	1.347	1.478	1.643	1.067	1.186	1.109	0.818	0.777	0.648
3.400	1.261	1.393	1.561	1.000	1.149	1.062	0.802	0.766	0.657
3.600	1.205	1.329	1.497	0.963	1.133	1.032	0.804	0.774	0.666
3.800	1.170	1.289	1.446	0.932	1.124	1.006	0.820	0.786	0.676
4.000	1.152	52.000	1.400	0.908	1.115	0.990	0.831	0.799	0.689
4.200	1.140	1.257	1.378	0.900	1.121	0.986	0.848	0.808	0.731
4.400	1.152	1.303	1.425	0.904	1.120	0.998	0.863	0.813	0.751
4.600	1.212	1.382	1.491	0.932	1.117	1.012	0.877	0.819	0.764
4.[illegible]00	1.321	1.487	1.576	0.998	1.169	1.049	0.886	0.822	0.779
5.000	1.441	1.592	1.660	1.097	1.222	1.094	0.898	0.825	0.791

So, that is why the data also gives 0.35, 0.45and 0.55, so for these vessels the data is percentage here. So, you can use this charts or this tables to get the residuary resistance coefficient and then you can apply it is the formula and then you can go ahead with the relevance's and all that to get the total resistance of the vessel.

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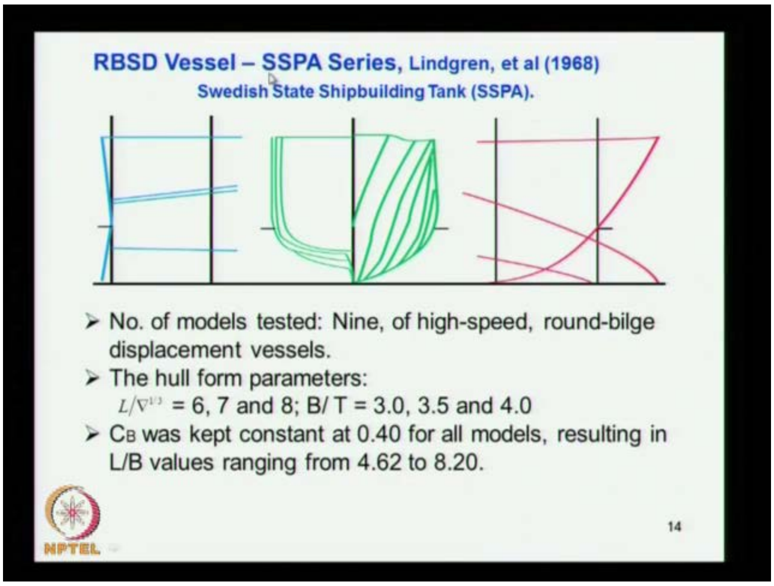

So, that is another that is a series what you have seen series 64, now we consider again round bilge semi displacement vessel Swedish research organization, so that is what is the SSPA stands for. So, they came out with the SSPA series in 1968, now number of models used nine high speed round bilge displacement vessel and hull form parameters you can see the length displacement ratio is 6 and 7 and 8 and B by T 3.5. These are the parameters they use for the model block coefficient kept constant at 0.4 for all the models.

The resulting L by B values ranging from 4.6 to 8.2, so this is the L by B ratio, so these are the vessels parameters you can see that its having a rise form here region you can see the form variation like this. Here, it is more fine, you can see final form here is more full draft region, so that is why usually get the sun all that that is the point sake getting towards this because it is full of here. So, concentration of volume is towards A r distribute it shifts after that is the common phenomena common feature of high speed.

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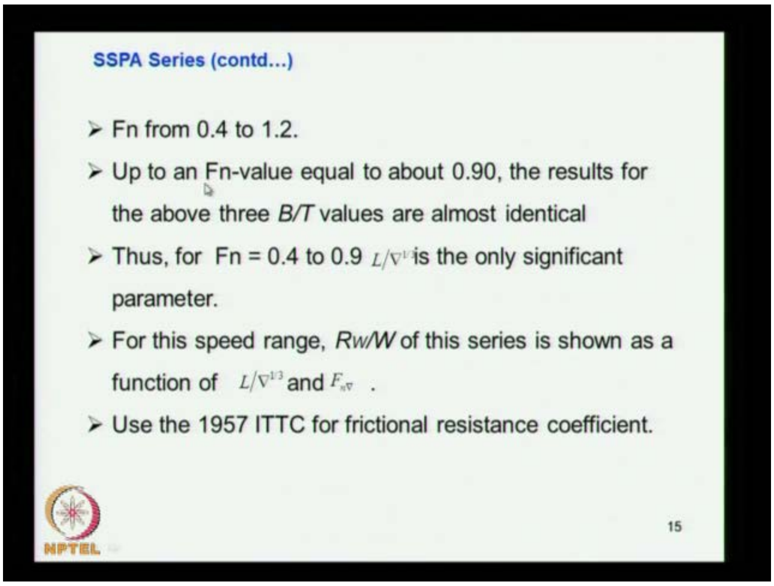

So, here the fluid number varies from point 4 to 1.2 up to a fluid number value of point results for above e B by T values of almost identical. So, that is what this is we have considered B by T value is 3.5 and 4 say is at up to point the Froude number of 0.9 where it is non dimension values remains same for Froude number 0.4 to 59 l by its related displacement this is only significant parameter.

If this range, this is only a significant parameters and you have the resistance wave resistance divided by the weight of the ship it is a non dimensional wave resistance shown. It is a function of l length displacement ratio and volume fluid number ITTC

1957 found is used for the frictional resistance coefficient, so SSPA series, these are the parameters where test have been done and IDDC form rays here.

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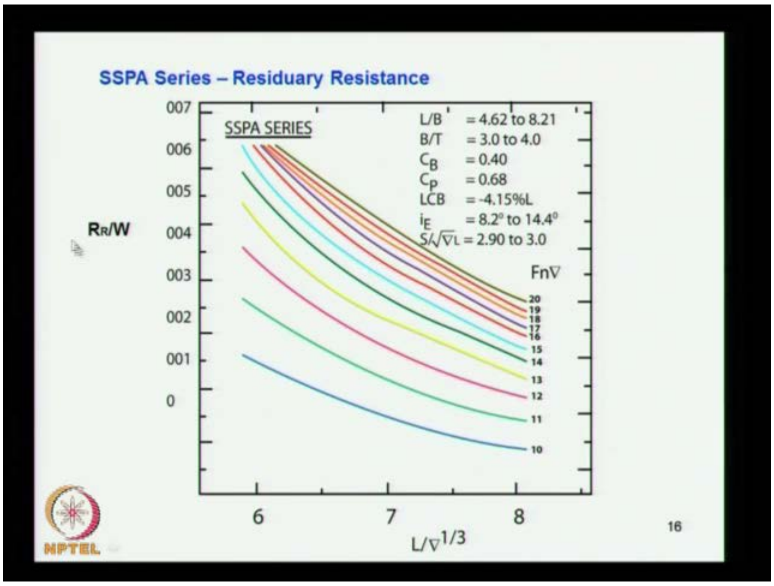

You can see that Its a sphere results presented here resistance non dimensional form divided by resistance by weight of the ship you see these are the 0.007, 0.006 like that, it comes like that. So, against length displacement ratio and as we have seen before its each curve representing particular fluid number that is a volume fluid number and the vessel parameters are shown here L by B what is the range B by T C B, so all given here.

So, use any of these chart and C B is kept constant for 0.4, we have already seen for this as a space radius. So, based on this chart you will be able to identify the vessels if you know the vessel fluid number and the displacement ratio. Then, you can get the curve and then you can get what is the residuary resistance and then use IDDC formula to get the frictional resistance and then find the total resistance by putting relevant for more duck core relation or other components.

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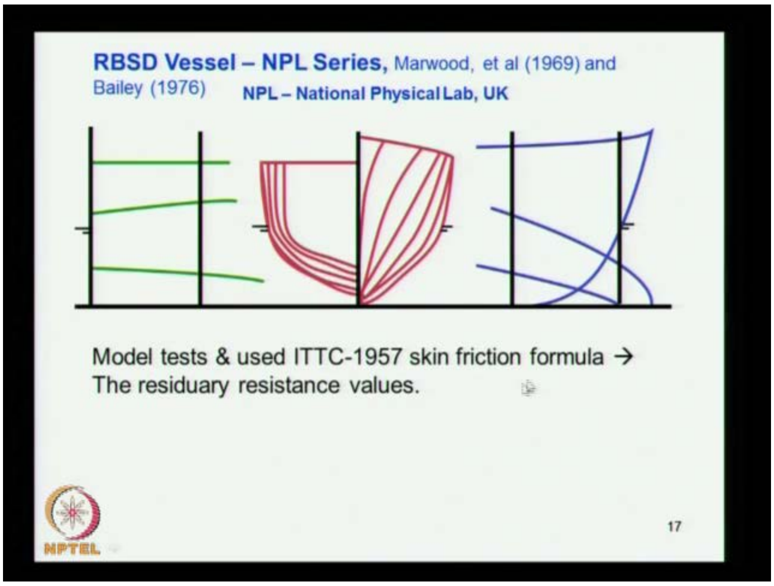

Next series is that is a round build semi displacement vessel is a NPL series, it is a national physical lab which stands for NPL, and it is in UK. So, they have a test specially it is they carried out systematic model test using the high speed this type of vessel and which comes under the NPL series under the results are presented accordingly, so here also ITTC skin formula is used.

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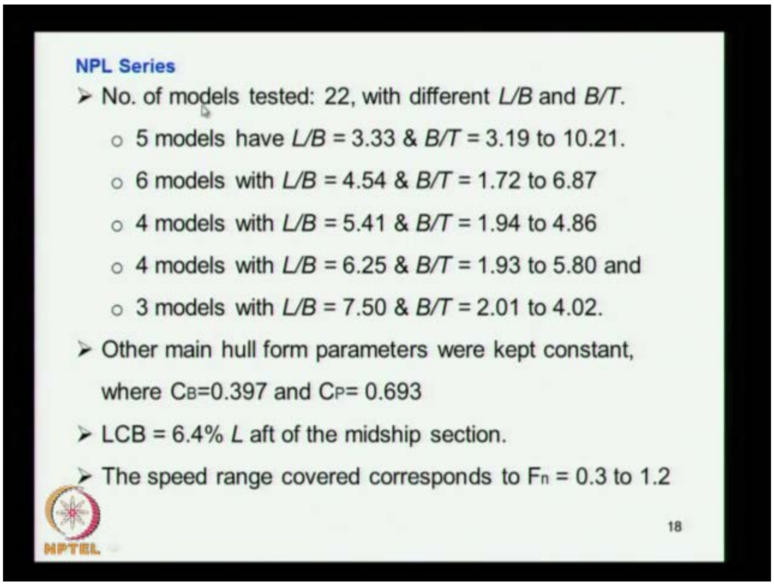

So, here the number of models refers that have 22 models with a different L by B and B by T ratios. So, five models you can see that of the 22 five models with L by B in this range is equal to 3.33 B by T is equal to 3.192 this is the range then six models fall in this range L by B 4.54 B by T in this way 1.72 to 6.87.

Then, this is another four models in this range four here this is the range and another three these are the values given for the models which they have tested in NPL. So, total you have total 22 models, you just count all these you get 22 models so 22 models different categories are shown. So, other main hull form parameters kept constant C B they have kept constant 0.39 and you just look to the C B value is quite small 0.39 seven is a high speed vessel.

So, naturally just we moved fine and you can see the for the case of Bal carious full form ships and all that C B s 0.85, whereas see that here it is a small craft and also with a high speed vessel LCB is quite small and C P value is 0.693. So, LCB as usual it is always after mid ship it is 6.4 percent after mid ship section the speed range covered fluid number 0.3 to 1.2, you can see that this range is the high speed range.

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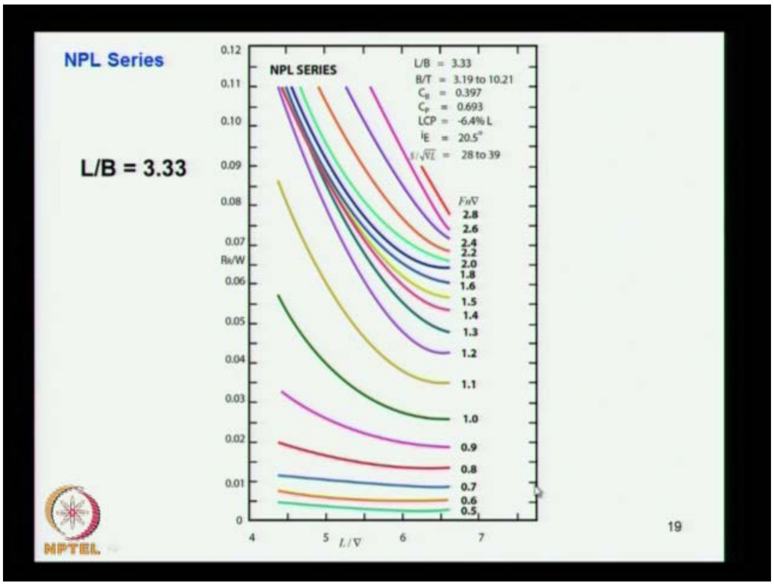

So, that is the high speed resistance so based on the test carried on based on these particular shown for the models, they have systematic did their model test and the resistance or results are presented in a in a systematic way. Here also, they used R R residual resistance by W, so against the displacement delta power 1 missing here. So, it will be delta power 1 length of displacement ratio and it is plotted for different fluid number, only fluid number, so same procedure only this set of curve is for L by B is equal to 3.33 I think we have already seen L by B is equal to 3.33, you can see that.

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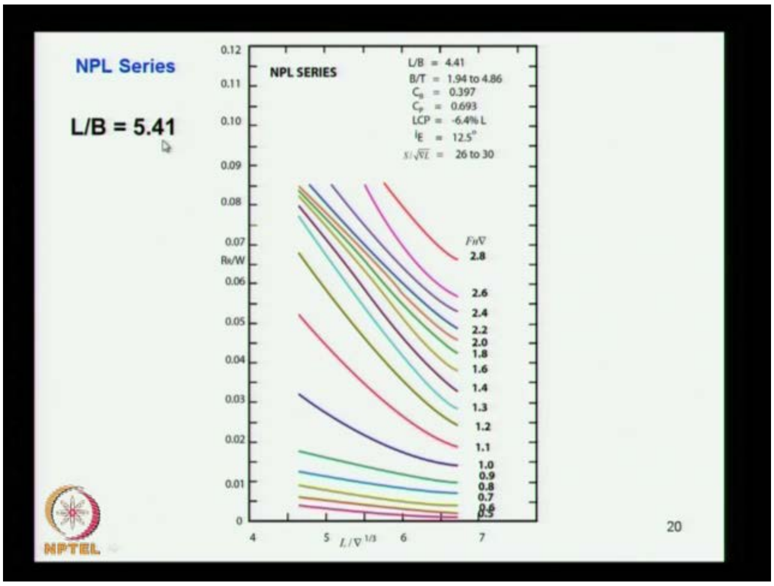

So, next set of curve you have L by B is equal to 5.41, so the same type of data is available you have r that the residual residence coefficient plotted against you get here it put correct length displacement ratio. Here, you have the fluid number and from which you will be able to find out the residual resistance for these L by B ratio.

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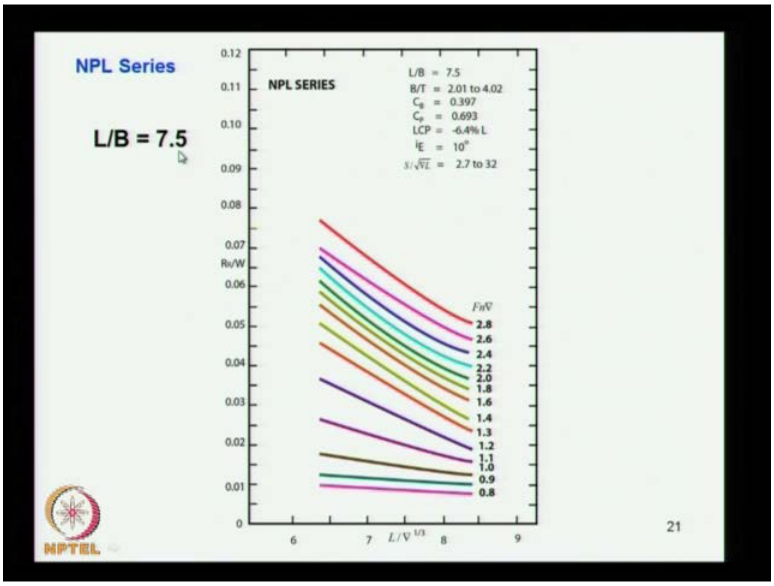

Similarly, you have the same thing L by B is equal to 7.5 here, so you have the values here so what you do is if your vessel is falling in between this. Suppose, you say here its 5.4 and here this is 7.5 suppose a L by B for the vessel which you consider is 6.5 what you do is you find out this value R R from here. That is for 7.5 due to this one you find out for this value then you interpolate the values, then you get the value for the 6.5.

So, that is what you have to do when you consider a vessel which called not exactly as the same value of the LBP may be something in between provided other parameters or the characteristics matching with the experimental data. So, you can use these charts even for these values intermediate values where you have to perform a interpolation even for fluid number also if you say its 2.7, you do not have a curve 2.7.

So, what you do is take the value for two point eight take the value for 2.6 for the same length displacement ratio that is you find out a particular suppose length displacement is 8. So, you just come here you read the value for R R and same thing then you come here you for the 2.8. So, in between you interpolate, so you have to do one or two or more interpolation to get the correct value for the residuary resistance coefficient in this charts, so that is how this charts are used.

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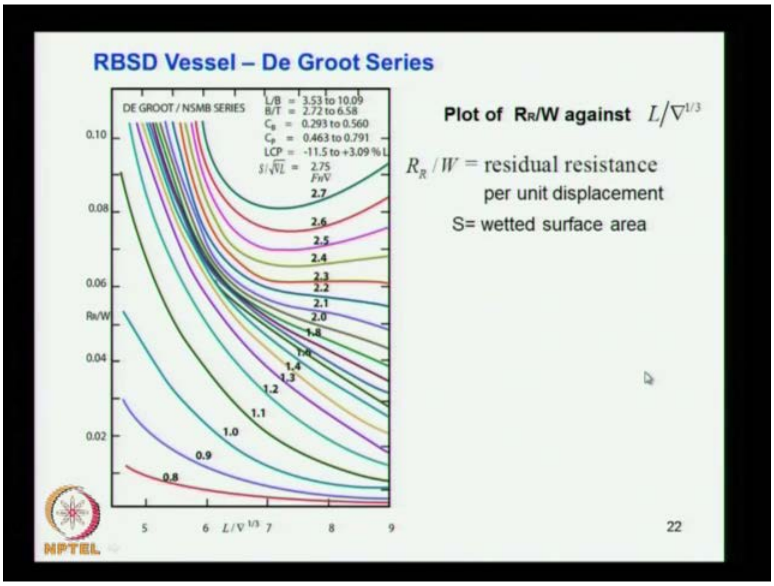

So, the next one is again all these vessels come under the round bilge semi displacement round bilge semi displacement is a displacement means it is high speed, but not fully plane, so that is the difference. So, here you have to here this is a ring road series, it is also we can say that presence that R R W that is the residuary resistance coefficient against length displacement ratio for different volume number so the parameters L by B what is used.

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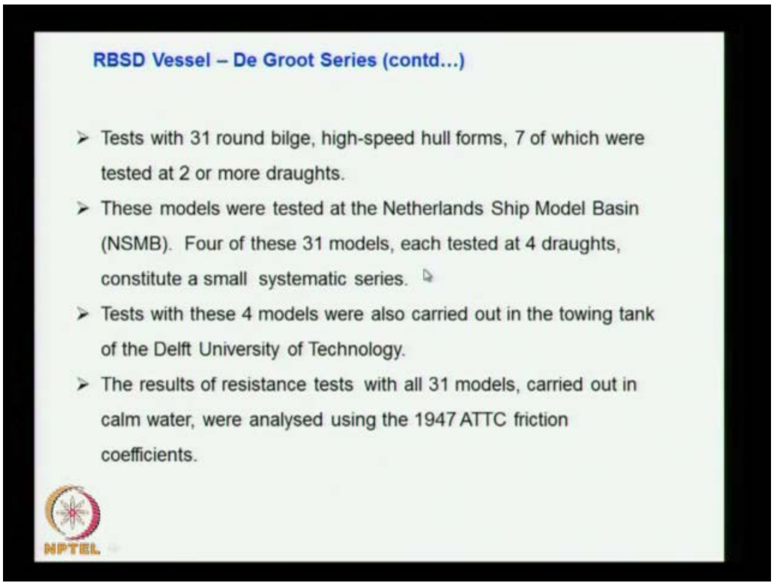

The test with 31 round bilge high speed hull forms then seven of, which were tested at two or more draughts, so the same vessel did performed for different draughts for the model test, so these models were tested at the NSMB ship model basin is the very good hypodermic test what did they have then it is done there four of these of the 21 models. So, different they have done it for different draughts consider a small systematic series, so you they made under series based on the four, this results then test with another four models are carried out in the towing tank of the Delft university.

It again in another lengths, then the results for all the 31 models carried out and they few sight ATTC fiction coefficient formula. So, that is what under based on this results they have floated the curves here, so the curves you can see L by B for these resistance range from 3.53 to10 more than B by T ratio given. So, you look for the vessel which you consider whether it is following the same series that is the form is following it and also the parameters match it if that is the case you can use these charts.

Now, you have a set charts set of data for the round bilge semi displacement vessels, so the round bilge semi displacement vessel we have seen many charts. So, we know the applicable to the range of these charts or these data and when you design a high speed semi displacement vessel. You can go through these charts and find out which chart is appropriate for the vessel which you consider by looking it to a form coefficients length or other dimensions and dimension ratios.

So, you have to look to that then you choose which is more appropriate, then you can use the data here, so because you do not know the initial the inches face of the design what is going to be the power resistance and all that. So, this gives an indication you can have the form also you will get an idea what is going to be the form of the vessel and also you will get information about the resistance from these data shield.

So, with these, we are conclude this section of which about the round bilge semi displacement vessel. May be in the next class we will look into the other types of the crafts the resistance estimation, how it perform and like the planning crafts and other things we have seen multi cuisine vehicles and sub surface of the ships and all that. So, we will continue next class with the other topic.

Thank you.