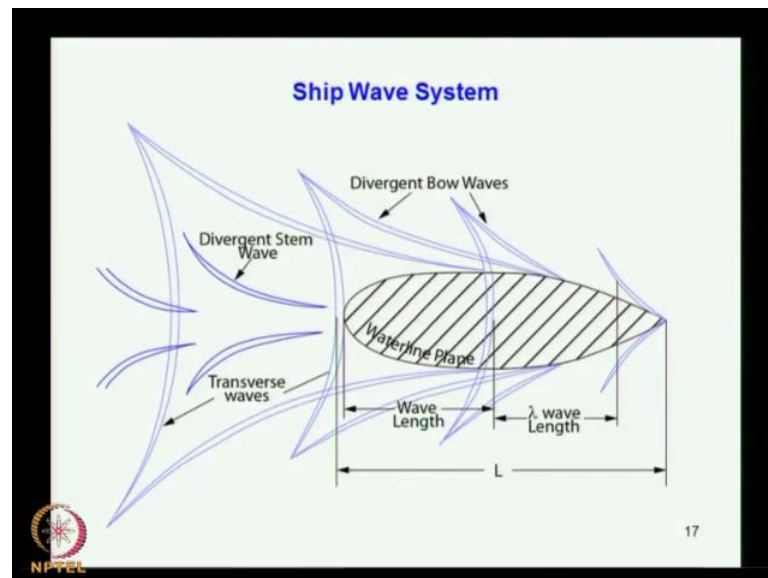


Ship Resistance and Propulsion
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Lecture - 3
Ship Types and Powering Aspects

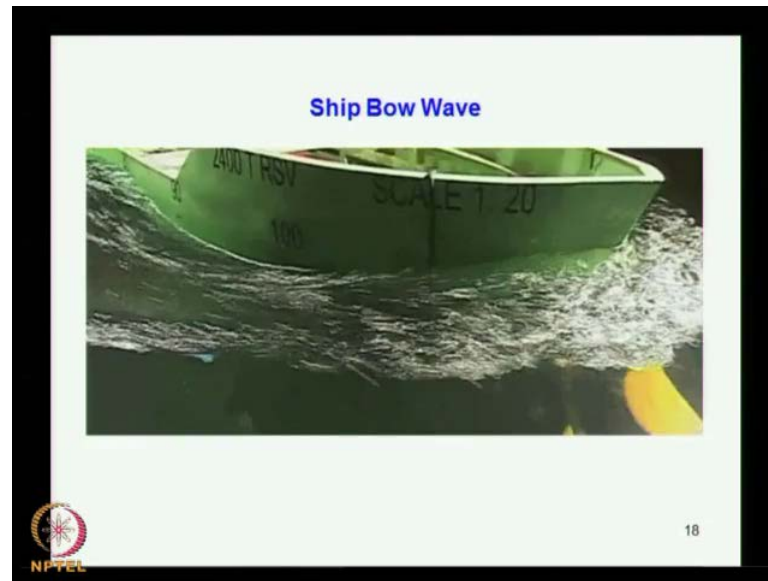
Good morning to you, and just looking back to the previous class some portions, we have been discussing about boundary layer and we discussed about laminar boundary layer, turbulent boundary layer and Reynolds number normally associated with this type of boundary layers, which we discussed. And this figure which we have seen in the last class, which it shows the boundary layer, where it is laminar in the forward side and it mix up transition then to the turbulent boundary layer and the boundary layer increases its thickness towards the aft. And we also seen in previous class that the boundary layer separates towards the aft and subsequent affects also we discussed on the previous classes.

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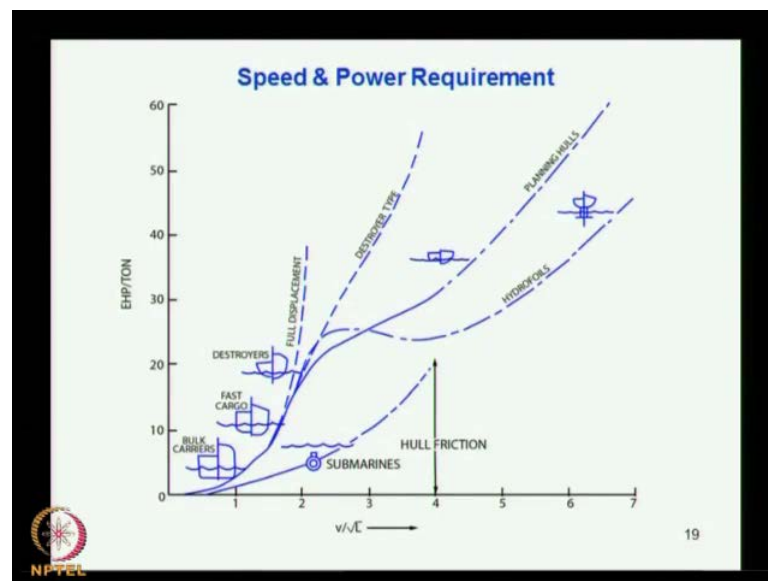


So, then we have we shown that wave systems generated by ships to the slides last in the last class.

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Then coming to the speed and power requirement depending on that when the vessel is water bound, the resistance is more. If we can partly bring it out of water then, the water bound area will become less and thus resistance will be reduced. So, which implies that vessel can attain a higher speed with the same power. So, there are vessels which use this advantage to put it above the water and then attain high speed. So, here this is a comparative study this diagram here shows the comparative study between various types of vessel.

You can see bulk carrier here, which is coming at the bottom, then fast cargo vessel destroyers. Most of these vessels come under the displacement. You can see that this is coming at the displacement; you see the displacement type of vessel resistance going up. You can see that effective horse power per ton requirement is plotted here and against the speed basically on here. So, when the speed goes beyond a limit for a displacement vessel, the power requirement shoots up drastically asymptotically and it becomes difficult for a displacement vessel to achieve high speed.

So, if you look the other type of vessel there is a destroyer type which is finer in ship again also comes under the displacement type whereas, these two vessels sit on the deep displacement. This is not so deep displacement then you consider small this called planing craft. Planing craft is one which having a hydro dynamic effect maybe I should give you picture of that in other class. We discuss with resistance of advanced vehicles we see that. And here the power requirement you can see that particular EHP per ton if it is a 40 you take or you just take 30.

So, a deep displacement will result can take only a speed of v by root 1 of 2 whereas, destroyers highly fire. And if you look the planing craft for the same power at it is much high speed and thing is much better for the case of hydro foil crafts, you can see this hydro foil craft. Hydro foil craft that means it has good foil beneath the vessel, which when moves forward through water it generates a lift and this lift pushes the vessel up. So, the resistance comes down drastically and due to that it can attain high speed with the same power.

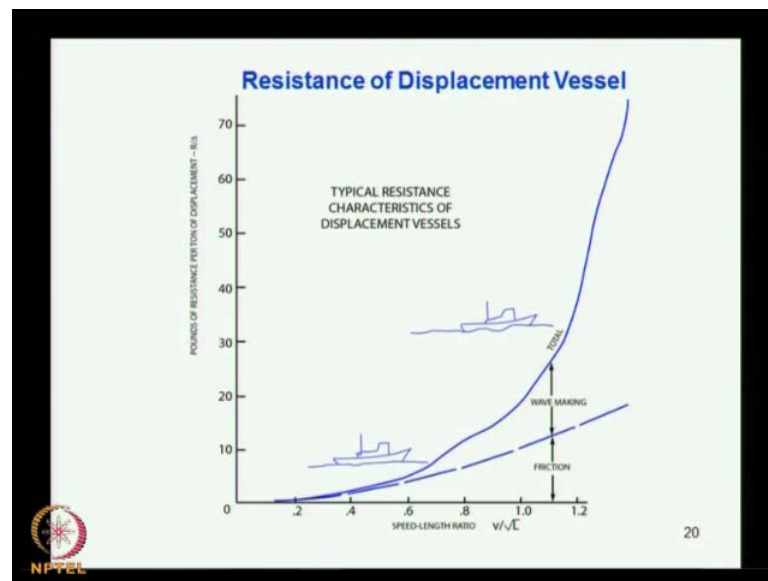
So, there are two types of hydro foils one is Surface piercing and other one is some foil type. So, at high speed you have at the vessel attains operating situation, which you call it is a foil bound condition. Only the foil is beneath the water and the whole hull is lifted above the water. And thus bringing down the resistance and hence enabling it to have high speed for the power. So, you can see the difference power, if you consider here you see the displacement towards vessel. What is the speed achieved for the same power than for the destroyer type then, you have for the planing hull and then the hydro foils.

So, there is an innovation and technology still getting advanced, there are more type of vessels coming up acutation vehicles, surface affects shapes. So, there are different types of methods a technology advancements using which, the resistance of the vessel can be

brought down and it can achieve a high speed or less power. And there is a new generation there is a lot of demand for passenger ferries. Passenger vessels will see may be in the subsequent slide.

Passenger ferries and passenger ship the difference is the passenger ships go at relatively low speed usually cruises and all that go at about 25 naught speed bit results whereas, a passenger ferries smaller vessels compared to the passenger cruisers. And it is for basically meant for commuting people that is particular after the formation of European Union. People in one country of the union can work in another country. So, they can stay in one country may be say in UK and may be they want to work in France, if it is possible if they can commute the distance within 2 to 3 hours. So, naturally the demand for fast passenger ferries got importance and people are looking into the achievement of higher speed to ((Refer Time: 06:58)) to the need of this people. So, that is a place, where you have to look into reduce resistance and higher speed options.

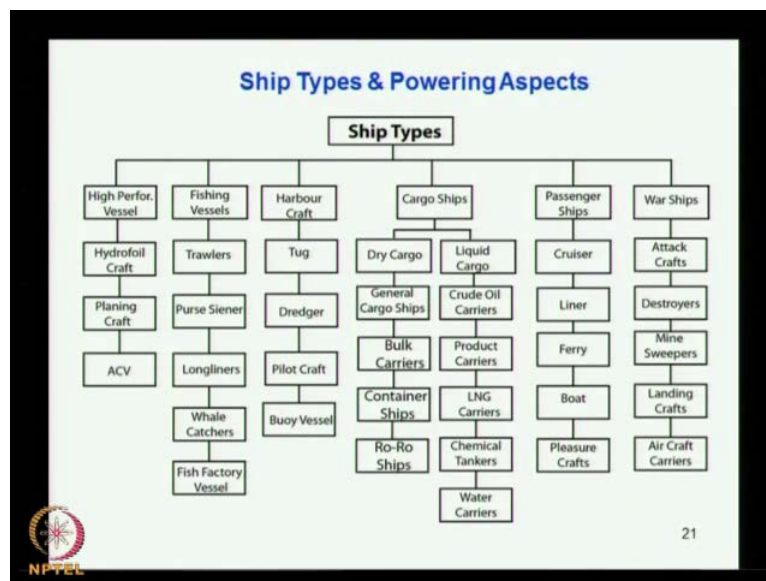
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Here it shows the sub merge submarines and submersibles and you can see that here the growth is relatively less compared to other types because it is submerged and there is no wave making. And hence even at a higher speed it does not shoot as it does for its surface ship. This is the comparison for displacement vessel you can say for the displacement vessel and this is resistance and resistance against the speed here, speed length ratio. You just give the integration how the friction compound?

The major two components which we discuss as part of a resistance or friction and wave making and here you can see that how this components matters in the case of depending on speed. You can see that speed when there is a speed length ratio 0.4 the wave making affect is insignificant and when it grows, the speed picks up you can see that the wave making is picking up. And at some stage you see that it is crossing or exceeding the frictional component. So, this gives an indication that how this speed influencing the resistance and which component dominates at higher speed.

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So, look to the ship powering aspect where this shows the classification of ship types, different types of ships. How do you view from the perspective in the powering, how do you identify this. So, first we have a look say the types of ships here it is a high performance vessels, we have already mentioned hydro foil craft, planing craft ACV air cushion vehicle and one more may be SCS surface affection. So, here the hydro foil craft moves at a high speed usually small craft and due to the hydro dynamic affect, there will hydro dynamic lift, which it pushes it up partly above water.

And meant coming to the displacement condition so which reduces resistance and enable the resist. So, here what you have to do is you have to find out what is the actual displacement of the vessel in a displacement condition. And what is underwater portion or submerged portion when it is in the planing condition, so which enable you to find out the resistance of the vessel. When plain that is again planing craft sorry this one I

have explained this planing craft. And when it comes to hydro foil again you have a displacement mode because initially it is a fully water bound.

So, it has to attain the speed to get a threshold so that the velocity of flow to the underwater foil is sufficient to generate the lift and push the vessel up. So, in that power also should be estimated that is what the power required at the transition region that is shifting it from displacement to foil bound plantation. So, that again that means resistance need to be estimated for different operating conditions to find out the power requirement then, to select the engine and then to decide the propulsion system for that.

Air cushion vehicles are again another concept ACV generally the typical thing is hover crafts, they generate a cushion whereas, and escort round the vessel generates a cushion by fans. So, because of the under air pressure the hull lifts up and the hull goes to where it been contact with not in contact with water. What is escort in contact water to make the chamber raino and a air chamber and this been the case that is the hull is gone up then, the resistance comes down because now it is an air resistance primarily and reduces resistance source as a higher speed.

So, this type of vessel usually used because it is above water use air propellers not water propellers hover crafts. So, that is the air cushion vehicle and one more surface affects ship which is usually catamarans type where you find shape. And end of the catamarans open a catamarans ranging gives covered the skirt and they forms a chamber and air pressure in side is created using fans. And then it performs morals similar to air cushion vehicles. Then the other type of fishing vessels, there are lots of types of fishing vessels many vessels come under the class of fishing vessels.

Some of the primary type of trawlers, which use for trawling operation, this type of trawlers they have a net attached to it and they vessel moves with the net open across schoolar fish, which has been previously identified. And schoolar fish moves with some speed because the whole mass of fish moves with a particular speed and usually it may be 2 to 4 naught speed for the fish schools. So, what you do is the fishing vessel net has to operate at its higher speed, so that it over come the speed of the fish.

And also if the speed is more than the fish speed, the fish once it caught inside the net will not escape. So, that is how it is done and trawlers that mean it has to go from the fishing ground, I mean for the harbor fishing harbor it to the fishing ground. So, that

should be a free running condition that is a vessel a fishing vessel operates from a fishing harbor. And it goes to the fishing ground mean few nautical miles away tens or may be even hundred nautical miles away.

So, that region it will be a transit region will be a free running condition. So, once it is in the fishing ground then the speed of the vessel should be reduced so that it encircle the fish school and catch the fish using the net. So, while doing so there are two aspects one is a resistance offered by the fishing vessel and other one is the resistance offered by the net with the fish inside. So, it is a different operating condition.

So, whenever you do resistance estimation for fishing trawlers or the power requirement power estimation for fishing trawlers or it has to be done for the two cases that is, in the free running condition and also in the trawling condition. And also when is the return trip now it is loaded more, so that means the displacement is more and you have to look into that aspect also. So, you like to have the hot fish as soon as possible back to the shore.

So, that you the fish can be kept as fresh as possible and then it can be taken for processing and marketing. So, that is a trawler so trawler when you do the resistances calculation, you have to have considered the free running speed condition and also the trawling condition. When it comes to the next type called purse seiner, purse seiners it is basically making of purse. You identify a large school of fish usually it is a small fishes like the Saddains or Macorites and all that, you identify it may run into may be kilometers size or such a massive school of fish.

So, these vessel purse seiners usually have a net, which will encircle the whole school of fish. And that is a small boat is used to launch it from the mother ship and it takes one end of the net and encircle the and bring it back to the mother ship then there is a ((Refer Time: 15:29)) which will be tied up so it is brought down closer-closer and purse is formed. The whole fish is now trapped inside the purse then they make it small and then it is usually pumped, it is using on into the fish hold and then process.

So, that is someone so here the power requirement comes only when the vessel is in free running condition. The power requirement during the fishing operation is not high. Long line is again a long lining, this line of net you must have noticed somewhere line is a like a wall of net, which is laid across stream. When the fish try to cross the net it will get

entangled by its grill sand that is all then the net is removed and fish is taken on both the vessel and subsequent processing or cleaning washing storing and all that.

So, long line is also primary consideration or from power estimation it is from the free running condition. The whale catches that catching of whale is banned now and Japanese are their favorite whale. So, whale catching is allowed to only for research activities now. If you want to do some researches, but I understand that Japanese do lot of catching, they brand it as for researches. So, naturally they are consuming it so here these whale catchers whale is consumed or may be huge revenue.

So, you do not go for multiple catch, you just catch hold one whale at a time. So, handling it is also difficult this type of vessel so usually the fishing vessel fish is caught and it is loaded on that, but whale is unable to you cannot load it on that. So, this under there is a bottom of the vessel, it has a provision to open the bottom opens, the whale is brought in, close the bottom and that is how it says. So, that is a whale catcher, whale catcher again you have to look into the powering aspect when it is in the free running condition.

Then the fish factory vessel, fish factory is the one where the fish is caught you can do catch, catching a fish and also it can be a part of a fleet of fishing vessels. So, you have many fishing vessels operating in the same region or may be in different region. The fish is brought to this factory vessel, factory vessel have all plans the plans for processing, canning and everything may be their storage and everything. So, it does the central processing way of the cord fish. So, here the power requirement becomes a free running condition and also the power required for the plant machinery and all that.

So, you have to look into that power requirement, it may be a auxiliary machinery devoted for the plant or maybe it is a power take off from the main engine, depending on the type of processing capacity or processing and the width. So, this is a power requirement for a fishing vessel then, comes the harbor craft. Harbor crafts tug is the major one; there you can see that tug harbor tugs, tugs are different type ocean going tugs, harbor tugs and all that.

Harbor tugs confining primarily to harbor region assisting big vessels to move from berth or getting to berth and all that. And the ocean going tugs; it has to go at a free running condition. So, it is a harbor tug the power requirement may be mainly when it is the

todopole condition or may be in the black pole condition. So, that is the requirement for harbor tug and power propulsion system also it differs for harbor tug where, the controllability is more important and free running is less important for harbor tug.

Dredgers mostly the harbors water ways need dredging operation, dredgers just do that there are different types of dredges. Power requirement free running is normally less dredgers; usually do not go for a long free run situation main operates dredging. And the power requirement would be decided based on the dredge machinery for requirement and also hefty pumps on both the dredges, which pump out the sludge dredge from the watery bed.

Then you have the pilot craft, pilot crafts are made for piloting vessels from out of harbor, when the ship comes to out of harbor and save, a vessel will go with a pilot to guide the vessel to the port. So, that is the purpose of pilot vessel and pilot vessel will normally go by the free running condition. Buoy vessel is buoy vessel mainly used to fold as a buoy is a laying buoy.

And you know buoys are used in harbor region for the identifying water ways that is a navigational channel to identify because that is a place with a deepest region where mainly the big ships. When they come in you should have a clear idea through which it has to may now. Then coming to cargo ships, cargo ships we can widely classify into dry cargo and liquid cargo ships. So, they under the dry cargo it is a general cargo ship, general cargo ship can carry any type of cargo that is what it means.

It can carry liquid cargo, it can carry dry cargo, it can carry grains or water. Only thing in all the cases it will be unitized that is if you want to carry grain, you have to grains in sacks or bags and if you want to carry liquid it will be in barrels. So, that means you can carry everything and also lot hefty machineries steel plates sections and everything or being carried using dry cargo lot of things are required. If you need this you have a ship yard, you most them into ship yards lay input steel and machinery from abroad.

So, these things the machinery carried using a general cargo vessel. So, general cargo vessel is which normally operates conventional vessels, all these vessels which we discuss here. Most of the vessels they have a different majorly four operating conditions are considered, that is you cannot consider the fully loaded departure condition, fully

loaded rival condition then, by last departure and by last rival condition, these are the four conditions.

So, fully loaded departure condition is the one with the maximum displacement. So, when department stores are fulfilled water fresh water everything is full. When it reaches the other port may be 80 percent 90 percent of the stores are consumed. So, that is why that means hundreds of tons of fuel it has been consumed. So, the displacement is different when it coming to the blast condition, it is lightly loaded because no cargo unloaded the cargo into on the return trip, the displacement may be 35 percent 40 percent of the maximum displacement.

So, the when it comes to the power estimation, you do the power estimation for the maximum displacement and at the service speed. So, that is what is done for the joule curve. So, same thing bulk carriers, bulk carriers are the type of ships which carries dry cargo in bulk, bulk means we say this a lose form. So, it carriers are gel say green carriers in lose one of sacks nothing required just pour it into the ship hold and carry it.

And also there are different types of bulk carriers' ore carrier, Sulphur carrier then any dry cement carrier. So, all these are come under dry cargo carrier in bulk, which are classified as bulk carrier. There are sub classifications of bulk carriers; we are not going to details as it is not required here. Container ships is the relatively a new generation ship compared to other types of ships. You can know container is session, which has got the old for faster and fastest transport as it spends less time in port because a containers loading and unloading is rather easy compared to other type of cargos.

So, this versus the fastest is important. So, the speed of the vessel is also much fair compared to other types of ships whereas, general cargo and bulk carriers, the speed may be around 14-15 naught, container ships comes about 25 naught. So, container ships hence become much fine in form compared to bulk carriers and other general cargo ship. Ro-ro ships are roll on roll of ships that is the cargo is roll on and roll of there is no plain that is for transport of car, vehicles, locomotives and all that this type of vessels are used.

So, here the if you look to the picture in the space recommend is much more compared to the weight then, actually the free port of the vessel that is above of the portion is much rear. So, the wind resistance will be more for this type of vessels, the same thing for container ships also. Nearly 50 percent of the container ships, nearly fifty percent of the

container are loaded above the deck. So, above deck you must have seen picture or actual container ships, their exposure to wind is much.

And hence the wind resistance will be much more for container ships and the same thing apply for ro-ro ships, the same thing may apply for passenger ship too. Then other classes are liquid cargo liquid cargo onto which we can say crude oil carriers, crude oil carriers usually very full form walker fish and about 0.8 0.85 or even more. The biggest ship ever built is a crude oil carrier and I think the displacement is 550,000 non displacements that did is 550.000 tons.

So, you can just imagine its size is around 450 I think long and 70 meters of more wide and all that you can just see that that is a floating island and moving island. So, such a massive ship so when you have similar made the power came in for that ship, it will be enormous if you look at displacement and all that. So, then the product here is product carrier is petroleum product carriers that is, which carries diesel petrol after from the refinery.

Crude oil go to the refinery and product comes from the refinery which is been transported. LNG carrier liquefied natural gas so gas is easy to carry in liquefied form otherwise the space recommend is sides. So, you compress the gas or may be bring down the temperature of the gas which imports, so that gas get liquefied or use both co partially compress and partially reduce the temperature. So, it is showed in a normally severe temperature and carrying this type of products is a risky business.

So, because a slight change in temperature can make fumes and it can lead to explosion, high pressure them inside the container and also this being under low temperature. The material, which you choose should be able to perform satisfactorily under this temperature. If you normally ship is built using mild steel, if you use mild steel normal ship building called this ship steel for LNG containers. Then naturally LNG is kept at very low temperature, the mild steel which is ductile when it is a low temperature that means, if you dip into liquid nitrogen the steel will break like glass.

So, it becomes so brittle. So, such type of material cannot be used for this container. So, special type of material so LNG ship building is a very highly skilled and specialized job and very few conditions they hold go for LNG vessel construction. Then chemical tankers again is a liquid carry liquid chemicals may be a Benzene carrier, phosphoric

acid carrier or Sulphuric acid carrier or any chemical liquids, which are been carried in the liquid form it is called.

It comes under chemical tankers, water carriers which carries drinking water normally because mainly in the Persian Gulf region some countries in the shortage of drinking water and it is transferable from one place. Water they send from water is transferred from Iraq to may be places like in UAE and all those regions. So, water transport, water carriers are used again comes under the liquid cargo vessel or tankers.

So, in all these spaces we have to see, all these dictet carriers are usually at low speed may be 15-16 naught and their resistance for these vessels depending on the fullness, most of the vessels are these dictet carriers are full form. So, the resistance will be more from the frictional side and form resistance will be more because for the full of form. We have already discussed that form resistance, what is the component. And we make it resistance if it operates at high speed, it will begin very fine and that is why I know the speed of that such type of vessels is not put at high, it is at low speed.

If you remember the previous slide where we have said that, the resistance shoots up with the increase in speed for displacement vessel then, avoids that part of the speed. Passenger ships another category are there is a cruiser ship, cruiser ship is a pressure craft, it is a pressure vessel, it is not a craft. You must have seen tunnels birth and other types of passenger ships very luxurious ships, which can have may be a five star hotel facility inside, lot of facilities shopping facilities, swimming pool and everything.

So, this is for pleasure activity people go around the globe and spend months together in the ship for enjoyment. So, this usual speed is 25 naught in that range and it is a big ship. And the power estimation and power requirement resistance estimation depends on the displacement type of vessel where, you have to consult the frictional distance. Then the way making come on, this are the major components and accordingly you decide about the power requirement for the main each.

Then passenger line is, we have already discussed the cruiser when it coming to the cruiser you knows that it is operating across the globe. And one of the aspects, which we discussed in the previous class, is that the severe affects on the system. So, when you design a cruiser you have to consider different locations of the ocean through which, the ship is put to operation. You have to understand what is the motion characteristics, what

will be the added resistance coming to the vessel and which will go as an input into the total resistance estimation and subsequent choice of the main each.

So, when it comes to liner we put a line, which is often says a cargo liner or passenger liner it is a liner, when you say it is a liner it is going to operate between specified ports. If the vessel is going to operate from a Chennai to Singapore and this meant to operate only in that region, you call it is a liner. So, that means the sea changes for that region only it will be known and you have to make the assessment for the motion characteristics in that region.

So, that is usually the liners, some they say call passenger liners or a it is a passenger ship operating in between specified in a specified route, the specified between specified ports. Passenger ferries I have already explained ferries that it is for short trip, it is not for long trip may be 2-3 hours, 4 hours trip and usually used for commuting. Some fast ferries are there and slow ferries are also there, if it is in a harbor ferry just go, transporting people from one place to other from island to other, and this is not far off.

So, then it is a low speed if it is the case, which I said before like an European union or US you have this type fast ferries. I think we do not we have a fast ferries in India offering, there is no necessity as of now. And may be if you go for a union of what I said SAARC, South Asian region countries then, may be things may come and people in Calcutta or may be somewhere can go Bangladesh or Burma or somewhere. And then passenger boat again is usually small craft or just a commuting passenger boat.

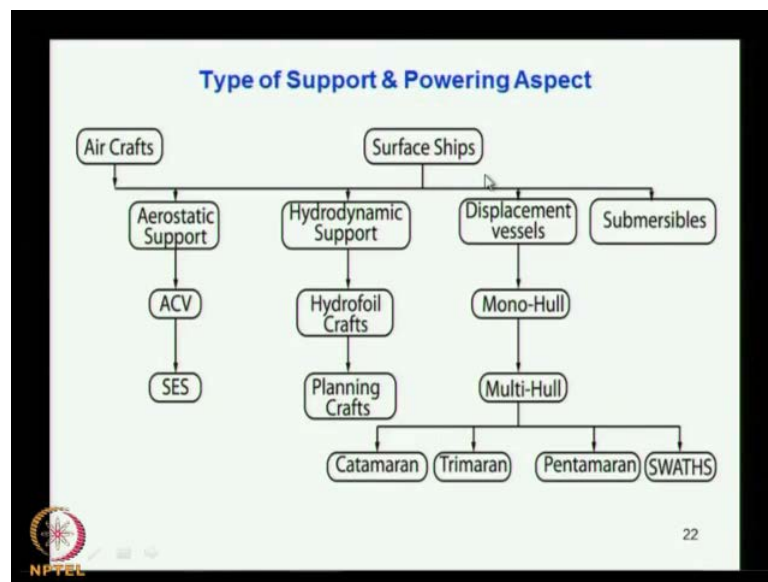
So, in all this cases resistance matters whenever it is almost same as displacement vessel. When it comes to far fast ferries then, you have to consider the high speed. There is speeder the vessel comes about 65 is 17 naught now a days or they fast ferries. You just imagine it is enormous speed 17 naught means it comes to a boat nearly a 130 kilometers per hour and through water is very-very high, not like through land. Then pleasure craft, there are different types of pleasure craft.

So, all these either resistance estimation depends on the type of operation type of vessel and speed of the vessel all matters in the estimation. When the speed is high you make because the way make resistance become higher. And you have to take at the way making is brought down by fine tuning the form of the vessel. War ships, another

category. There are different type of war ships attack crafts, destroyers, mine sweepers, landing craft aircrafts, various and many more.

So, depending on the operation of these types of vessels again, you have to look into that is I am not going to write each category wise, so this is that. So, you have to look into the type of vessel its operation, type of operation, what are the its going to have the single mode of operation or like tugs, it will have rerunning, light fishing and also doing condition. So, you have to look into the different operating conditions of the vessel. And based on each operating condition, you have to make power estimation and go for the highest power; we get depending on the type of stage of operation of the vessel.

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So, naturally there is no limit for achievement, limit means our wish or should say may be more greet to have more speed, higher the speed is our wish. So, when US invaded Iraq, they preferred our vessel with 100 naught speed for transport of military items to Iraq. So, 100 naught speed it is as of now it is achievable, but the trend shows that it can be achieved. Now you have to find out ways of achieving the speed like the air craft, the Concorde aircraft, supersonic passenger craft, air airplane which is been grounded for other reason though it is.

So, you go for higher speed either this evaluates our craft or whether this for ships or even for surface vehicles and all that, you prefer at a high speed. So, here as I discussed before the surface ships, surface ships that means the ships which operate at the free

surface vessels, where the way making is also important. So, how to depending on the support, there is a aerostatic support. If you look it here air cushion vehicle, which I have already explained.

First thing is I do not have the picture here, may be next class I will show the picture. In these two types because of the creation of air cushion, the vehicle get pushed up contact with what water become less and the speed become high. So, you have to look at the resistance estimation of these vessels, when it is in air bound condition at air resistance become more means also important for that where air resistance is a very major quantity in case of conventional ships.

Another one is hydro dynamic support where you say hydro dynamic support under, which come the hydro foil crafts or planing crafts. I have already discussed what these are, I will show some pictures later and just to give an idea what are these type of vessels look like. Then these placement vessels under which, again you have mono hull that is a single hull. Most of the ships which we discussed are single hull that is cargo vessels, passenger ships and most of the things we discussed are single hull, but there are multiple hull vessels.

Even passenger vessels and even some research vessels and all that. Catamaran having 2 hulls, if you have 3 hulls that is a main hull, two out triggers called trimaran then, same thing if you have a main hull. And I think of four out triggers call it is that is 4 plus 1, 5 is called a penta hull pentamaran and then you have the swath, that is the swath is the small water plain area between hull ships. So, these are the other types of ship, which use for reducing the resistance and also increasing the performance of the vessel like that depending on the type of its use.