MARINE ENGINEERING

By

Prof. Abdus Samad

IIT Madras

Lecture68

Power transmission system, shafting, bearing, gear, lubrication, Electric propulsion

good morning everybody today's class basically power transmission systems shafting bearing gear lubrication so i will take two and a half hours about lectures on these topics because when you are producing power in the engine so engine power must be transmitted to the propeller because propeller is the main uh main uh turbo machine which will be giving thrust to your ship so the ship will be moving forward backward sideways so that you can manipulate so you need one engine then unit connecting shop a cylindrical rod you can see this picture this is engine that colored one engine okay inline engine inline engines several engines several cylinders are there in a reciprocating ic engine or maybe you can have your steam turbine you can have gas turbine system you can have any other many other type of engines are there you can have any type of engine the rotary motion or torque torque means power actually power equals torque in omega omega means shaft rp not rpm you can say sharp speed in radian per second and torque means newton for newton meter okay power in watt So, if you are transferring torque, that means you are transferring power and the power will be depending on amount of rotation. So, if you have fixed amount of rotation, so torque and rotation speed multiplied will be, if you multiply it will be power.

now it is going through shaft you can see shaft is not one continuous shaft it is having lots of boxes over it okay so we'll discuss what are these things and how uh why we should place all these things and how this torque will be transmitted to propeller so propeller also again can be fixed propeller controllable pitch propeller fixed propeller or controllable control well pitch propeller and there will be one another system called rudder okay rudder will be controlled using your wheel okay you have seen already in the previous lectures so in this lecture i am not discussing the rudder and wheel that mechanism that i'll be discussing the mechanism from engine to propeller how this power is getting transmitted and what are the different equipment needed how to design it or how to size it and different option possible options also i'll discuss so another option will be there for power

transmission you convert that mechanical power into electricity that electricity further you transmit through where and again there will be one generator one term motor so motor will be running your propeller now power transmission system will have main components shaft bearing gear coupling and propeller okay and propeller transfer thrust to the ship so if I draw one ship hull like this okay so propeller will be here and it is going to engine and propeller when it is transforming when it is rotating actually it is pumping fluid okay

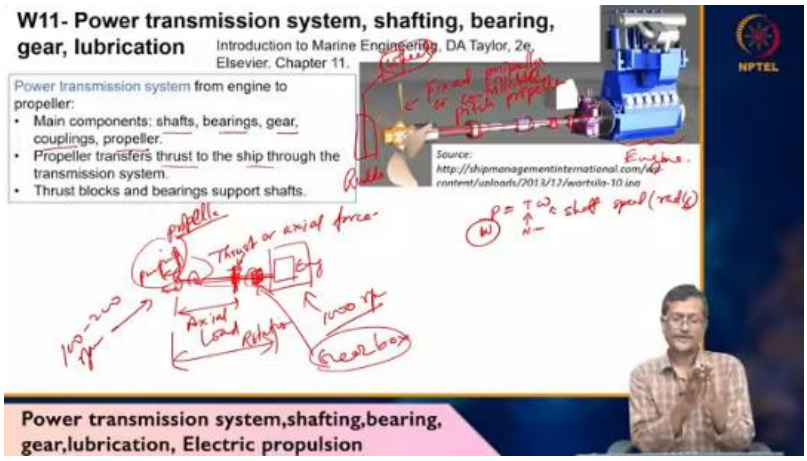
It is pumping fluid or transferring fluid. So fluid is giving reaction force. You can remember Newton's third law of reaction. So it is giving same reaction force to propeller. Propeller is connected to one shaft.

So shaft is pushed. So shaft is getting pushed. That's why shaft is connected to your ship and ship also getting pushed. So propeller is a one type of pump. Propeller

because you can remember the lectures on pumps where i said like pump means you are giving electrical energy or mechanical energy to fluid and fluid is getting energy so here also you are getting energy from your main engine or electrical engine and you are delivering fluid that fluid is giving reactive force to your propeller and that reactive force actually going through your shaft and to your ship and ship is moving so one thrust block now what happens this whole the actual load or thrust load you are getting from propeller that should not get transferred to your engine because engine is designed for certain specific properties designed to produce power not to take any other extra load and already it is busy with producing power and if you are giving extra thrust load also then it will not work properly so what you have to do you have to isolate that thrust and engine shaft so you cut the shaft here okay then you put on thrust block later we'll discuss what is this thrust block so thrust block will take all the axial force okay thrust or axial force so thrust block will take axial force and whenever engine is transferring torque, torque means rotational motion rotational motion is transferring to the propeller so it will be transferring only torque rotational motion not it will not take any axial load so axial load will be there from here to here but torque or rotational motion will be transferred from here to here rotational motion now another issue is coming uh rotational engine speed can be maybe 500 600 1000 2000 3000 okay large speed also possible but normally propeller speed will be 100 200 rpm okay so propeller speed will be 100 200 rpm within this range and engine speed can be more than one thousand two thousand three thousand rpm

that means rpm is different engine is speed high but your popular speed lower that means you have to reduce the speed so to reduce the speed actually you must have another

mechanism called gearbox gearbox mechanism so gearbox mechanism actually will be reducing your speed of the shaft or propeller shaft or engine shaft okay so first you get power from engine then what you do you will have speed reducer gear Then from gear, again another shaft will go to thrust block, where you will be transferring thrust to your ship, not transferring that thrust or axial load to your engine. So, right side, you will not have any axial load. Left side, you will have axial load. Let us say, from thrust block to your propeller, shaft will get compressed or it will get axial force.



That axial force will get transferred to your ship. okay so now you have engine you have gearbox you have thrust bearing thrust traction uh thrust block i said right uh thrust block here we can say thrust bearing also okay now engine is here propeller is here now issue is that whether this sharp very heavy shaft will be hanging From engine? No. So, there will be certain holding device or some mechanism will be there inside the shaft will be passing and shaft will be rotating.

Okay, this is called bearing. So, bearing must be there. So, bearing in different places, bearing must be there. Here one bearing, here one bearing. So, different bearings will be there.

okay so many types of bearings will be there storn tube bearing normal radial bearing actual bearing thias bearing we'll discuss later what are the different types of bearings and what type of bearing is used for your specific marine application you have many type of gears arrangement and what type of gear can be used for a marine application now engine speeding height you are reducing then you need gear mechanism then after that thrust block you put then after that you put not after that in between several bearings will be there so that that whole load will be hold by the bearing again bearing will not allow the shaft to motion laterally or vertically it will be giving only it will be allowing only rotary motion

shaft will be giving some time some axial motion allowance for axial motion also so if you are not giving axial motion allowance for example thrust block then your actual bearing radial bearing will have difficulty or it will fail so radial bearing will be holding your load plus some lateral axial moment of the shaft while thrust block it will be allowing only axial load radial load load will not take so what the different bearings i will discuss later next is that when you are putting bearing you need sealing element sealing and lubrication Although lubrication we have discussed during IC engine discussion, so again we need to discuss here because in IC engine high temperature lubrication was working to reduce friction inside engine where piston was moving up and down and you reduce friction.

But here when shaft is moving inside bearing, so surface and bearing surface is rubbing continuously. And if it is rubbing, then heat generation will be there and system can fail. Then what you do? you increase uh you give some lubricating oil and make smooth surfaces so that friction will work system will be running smoothly now you can see this one sharp transmission system so here engine here is your engine actually this one your engine main engine okay so from engine you have one thrust shaft this is thrust shaft okay thrust So, thrust shaft is taking all the stress load and here one journal bearing system is there independent main block.

So, it is allowing power transmission, but it is not taking thrust load journal so yeah different types of bearings are there one journal bearing radial bearing so we'll discuss later what are the different types of bearing okay and intermediate shafts engine shaft then thrust shaft then intermediate shaft in there will be two three intermediate shafts also because you cannot a very long shaft you cannot take only one shaft and you cannot transfer whole power from propeller to engine or engine to propeller So, you have to break it because there will be several issues. Alignment issues are there. There will be vibration issues are there.

So, just to prevent all these things, you need several shafts and you can connect it one by one and you can transfer power. Now, you can see this tunnel bearing. It is supporting shaft from above and below so that the shaft will, because of its own load, it should not get bent. okay so what happens let's say you have a straight shaft and if your bearing placement is not okay let's say this bearing is here another bearing become like this okay so your bearing is pulling your shaft downward but another bearing is on right position what will happen because of this misaligned bearing your shaft will get extra force or shaft will give extra force to bearing so bearing will break or shaft will not hold that force what will happen shaft will be transferring that load to another bearing so another bearing will also fail it will

give vibration wear tear and many issues will be there so all every time you have to check alignment properly if you are not checking alignment not fixing system properly if one bearing is pulling down one bearing is pulling up or

just opposite happening or combination of something happening then vibration will be there wear tear will be there and system can fail so alignment of shaft is very important part of your marine any machinery system including marine so here you can see engine to propeller this is your propeller you can see here propeller here okay so propeller And here one seal section is there called stun tube seal. This is called stun tube. Stun tube. Okay.

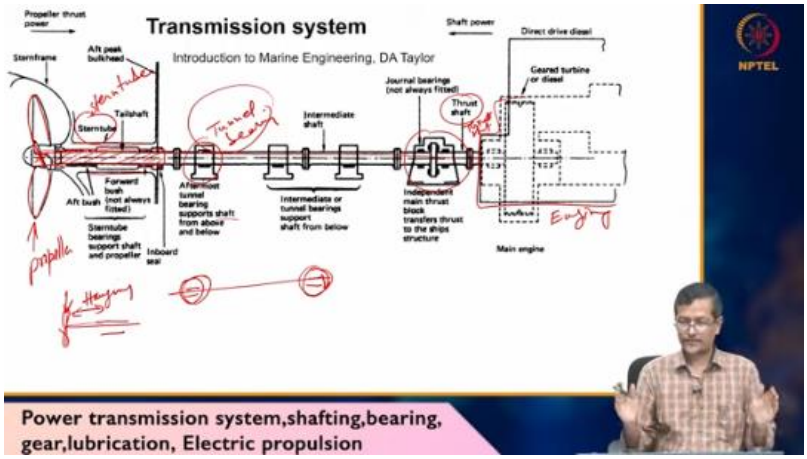
So, a stun tube is like this. One tube. Inside one tail shaft is coming. Tail shaft is connected to your propeller. So, this is actually tail shaft.

Propeller is connected to tail shaft. So, I am making hash line. This is tail shaft. Okay. So, when tail shaft is connecting to propeller, that means tail shaft is hanging.

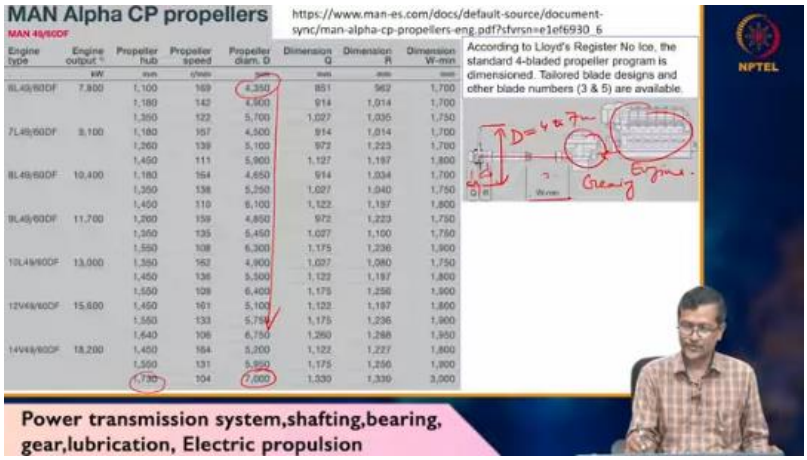
Propeller is heavy weight. It is hanging from here. okay when that means it is getting bending load i can assume like this this is my load propeller propeller means downward load and this is my bearing that means this portion is getting my simply support uh hanging okay when it is hanging it will try to bend bend means you will have extra load on your bearing so whatever bearing you have here extra load okay so how to hold this one then you will have long bearing though the starting basically longer bearing section and longer bearing section means here one bearing will be there here one bearing will be there two thing next thing is the bearing must be lubricated lubricated means inside some lubricated fluid is there that fluid should not go into your sea water seawater it should not go why because marpol is there marine regulation body so they will say hey your lubricating oil going to ocean this is this is harmful so you cannot do that so you have sealing must be proper you must have bearing then lubricating oil whatever you are putting is it biodegradable non-biodegradable if it is water-based lubricant or biodegradable lubricant that's fine if it is

purely hydrocarbon or which is harmful to environment then there will be issue so that also you have to consider for example in ceiling section bearing selection section you have to consider so stem tube seal actually is a longer section if a bearing you will have seal if you have lubricating oil okay then you will have propeller so propeller is hanging so it is creating some hanging system now when you're transferring power from an engine to shaft you have thrust block you have tunnel bearing intermediate shaft thrust shaft you have gearing mechanism you have stun tube you have propeller now we'll see one by one all

these things okay in these few lectures Now, one example I have copied from this MAN alpha CP propeller. So, you can see how big the system can be. If you see one propeller hub size 1.7 meter or height will be less than 2 meter, 1.7, 1.8 meter.

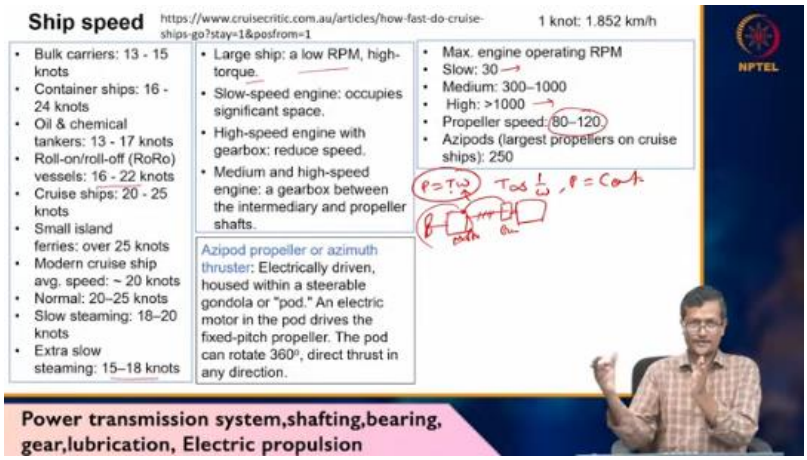


So, but propeller size you can see propeller diameter 7 meter. okay so big propeller is possible so four meter to seven meter for they have designed so there will be many types of propellers small shape big shape large shape small so based on that propeller size will be decided okay so in this case your propeller size like they have four meter to seven meter and and right side this picture shows the dimension you can see propeller diameter diameter is this one okay this is your d meet d equals four to seven meter actually and q value is given q value is like one meter about r value also given more than one meter okay and this w w is given one point seven two meter around so from engine this is engine gearing mechanism uh gearing okay engine to gears yes basically reducing or manipulating speed from there the sharp transmitting power to your propeller okay so so big the system now ship speed so many types of ships are there they will have different types of speed so just i have copied several ship speed just roughly remember this to get idea what should be the average or about speed approximate speed for example row a vessel 16 to 20 no 22 knots speed will be there and extra slow will be like 15 to 18 knots will be there so several vehicle will have several types of speeds



so large shift low rpm and high torque so p equals t omega same power if i have high rpm so torque must be reduced right so just inverse relationship or t 1 by omega if p equals constant okay so torque increasing omega will be reducing so this opposite relationship is there slow speed engine occupies significant space high speed engine with gearbox you are reducing speed Another type of propeller is that called azipod propeller. Azipod propeller is like this. I have one ship. So, propeller will be hanging here and one motor.

So, your engine producing power that then it is going to generator. So, generator producing electricity, the electricity will be running your motor. So, in that case you do not need that long shaft. okay so many cases if you need multiple propellers so then in that case you can use azipod or small thruster also can be designed like motor and one propeller small propeller big propeller you can connect and maximum engine operating rp speed for slow engine 30 rpm and maximum 1000 rpm can go propeller speed 180 to 120 so like 100 to 100 around rpm speed will be there for propeller but engine speed you can see 300 to 1000 normally so that means you have to use some speed reducer but if you have electrical powered propeller so in that case you are have you have engine generator produce electricity connect electricity to motor motor will be running directly to a propeller

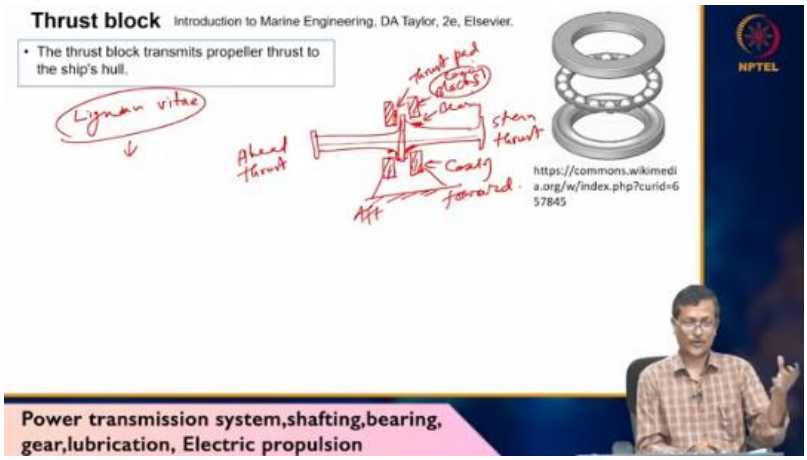


So, I already told there will be one thrust block. Because thrust block will be taking axial force from your propeller shaft or tail shaft. Then it will be transmitting that force to your ship. So, ship will be moving. Now, thrust block transmits propeller thrust to the ship's hull.

So, thrust block is like this. I have one block. uh like this okay then my shaft is connected here not like this parallel shaft and their axis almost axis will be same and there will be axis also here okay then you have block like this okay this block will have thrust pad and there will be bearing okay and this is a head thrust this is stern thrust okay so bottom side also you'll have bearing like this so axial and axial as well radial motion should not be there that's why so whenever now we can see this one if shaft is rotating like this and it will not have motion of axial that means these blocks blocks will be holding that force okay then that will be transferring to your hull okay

left forward and this is called casing casing blocks okay now different bearing materials can be used for axial thrust bearing or radial bearing so one type of bearing called ligni weighty lignum Actually, this is wood. This wood is very hard, hardest wood in the world. And this is available in Caribbean and northern Caribbean areas. Coast of South America, that area, this wood is available.

Normally, this will be used for sleeve bearing. So, for thrust bearing, normally it does not get used because thrust force is much higher. But for radial and strand tube bearing, it is used because it is self-lubricating and inside water, like so when you are putting this one in water and something going into water from this one, this is already wood, biodegradable. So, it is not having any problem with environmental concern. So, many people still use lignobiety for their strand tube bearing.



So, this is good for radial type bearing or sweep bearing, but it may not be good for your thrust type of bearing thrust type of load.