MARINE ENGINEERING

By

Prof. Abdus Samad

IIT Madras

Lecture69

Stern Tube Bearings and Misalignment

So, I said stentive. Stentive means I have one cylindrical cylinder and my tail shaft is passing through this and my propeller is here. So, propeller hub. Sometime they say boss. This is propeller blade and this is your tail shaft.

tail shaft now this stern tube will have sealing arrangement here seal actually it will allow rotational motion but it will not allow liquid or gas to pass inside or outside so this is seal this is called forward seal this aft seal okay now inside there will lubricant ok now seal and lubricant will not work you must have bearing also ok so because sealing lubrication purpose is to save your bearing so the bearing can resist and load and the system can run longer time stunted bearing supports the tail shaft and the propellers weight act as a gland to prevent seawater from entering the machinery space so seawater if is entering into machinery space that means this corrosive fluid is going into your machinery area it will be much more complex if water is going there so because there will be lots of oil and lubricating oil and other things so you cannot put seawater there so the seals will be preventing this one material like lignum vitae are lubricated by sea water while modern design employ oil lubrication with a white metal line stentive bearing so lots of material science research is going on to replace this lignum lignum vitae or other type of material so for example white metal is being used these days oil lubricated white metal bearing normally this alloy of white metal this one is alloy of antimony tin lead and cadmium bismuth

and zinc okay so using this one they make white metal so bearing normally it will be cast iron based metal bearing metal normally cast iron based will be there while lining inside lining will be white metal so cast iron will be protected by your white metal so this is sliding bearing or journal bearing you can see this one shaft can be going inside and outside one just you can fix now this bearing this sliding bearing like one there is no rolling element

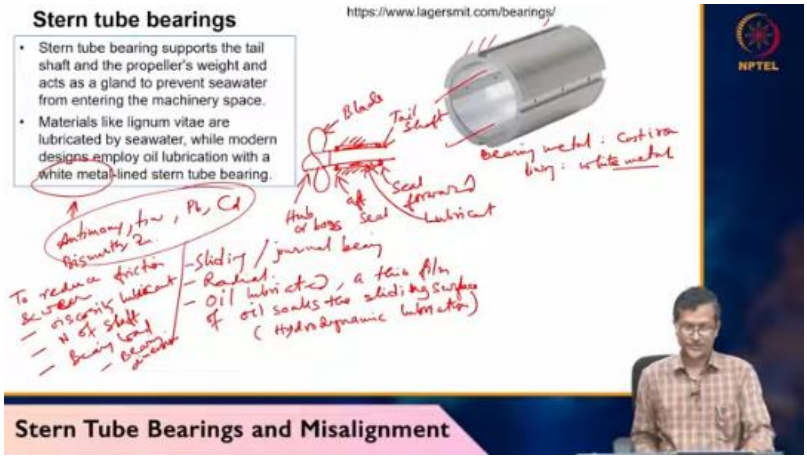
lowering ball bearing or roller the shaft will be sliding inside okay so this is called sliding bearing carries radial load so this is sliding bearing or sleeve bearing or journal bearing this is called journal bearing or muff bearing and it is carrying radial load There is no actual thrust load taking capability here. Only radial load it will take because your propeller will be hanging.

Okay. Because hanging and water, seawater will try to enter into your machinery area. So that thing, it will prevent that water injection into your machinery area or oil going out to your water and propeller load or sharp load will be hold by this bearing. So normally it will be oil lubricated. Oil lubricated

a thin film bearing will be created film of oil soaks the sliding surface okay so thin film will be reducing friction so friction reducing means life will be longer at higher shaft speed a thin film oil is created so this principle is called hydrodynamic lubrication. Hydrodynamic lubrication to reduce friction and wear to reduce friction and wear Viscosity of lubricant will be important. Viscosity of lubricant is very important.

Lubricant shaft speed, bearing load and bearing dimension. bearing diameter smaller diameter cannot carry very high load but larger diameter can carry very high load so to have a good lubrication and to reduce friction where viscosity should be higher and sharp speed should be lower higher speed means higher surface friction means higher temperature generation so lower surface speed better But in certain cases, your speed is the main parameter. So, you cannot control. So, in that case, you can control other parameters, viscosity and hydrodynamic lubrication or material or other parameters.

Bearing load, how much load it is carrying and bearing dimension. This is the main factor. So, stunt tube seal. A stunt tube is a welded ship's hull. So, shaft propels the propeller.



The shaft propels the propeller and transmits its thrust to the hull. Journal bearing supports the shaft propeller. So, here journal bearing you are giving. You see right side picture, top left corner. You have journal bearing or stentive bearing.

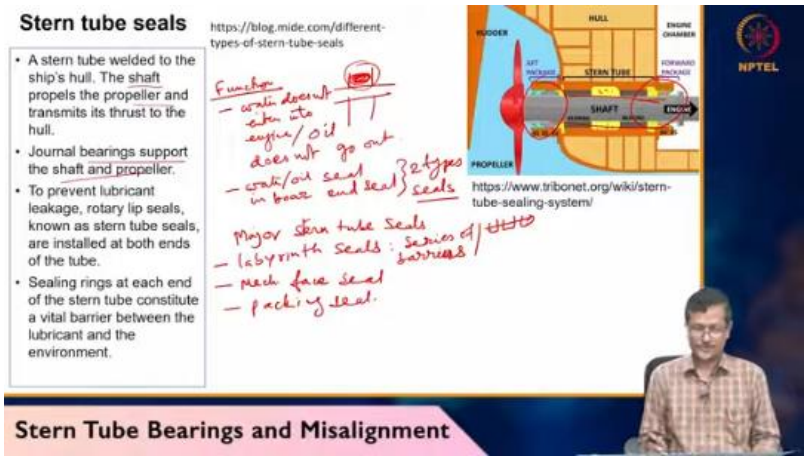
So, to prevent lubricant leakage, rotate lip seal. Lip seal means like one face is here, another face is here. So, you can put certain amount of seal. okay so that fluid will not be leaking so that's called lip seal it can be used sealing rings at each end of the stun tube constitute a vital barrier between lubricant so there will be a sealing there will be another sealing so both end will be sealed and inside there will be lubricant it will be saving your system so stun tube seal function function it will be ensuring water, oil, water does not enter into engine area and oil does not go out.

Oil does not go out. So, oil lubricated stone tube has two types of seals, water oil seal, water oil seal and another is inboard end, inboard end seal. So, water oil seal is nearby water. So, water should not enter. Another end of the seal you have inboard end seal.

So, two types of seal. Two types is used. A few major stunt tube seals are labyrinth seal, mechanical face seal, major stunt tube seals. Stunt tube, sills, labyrinth sills, sills, series of barriers

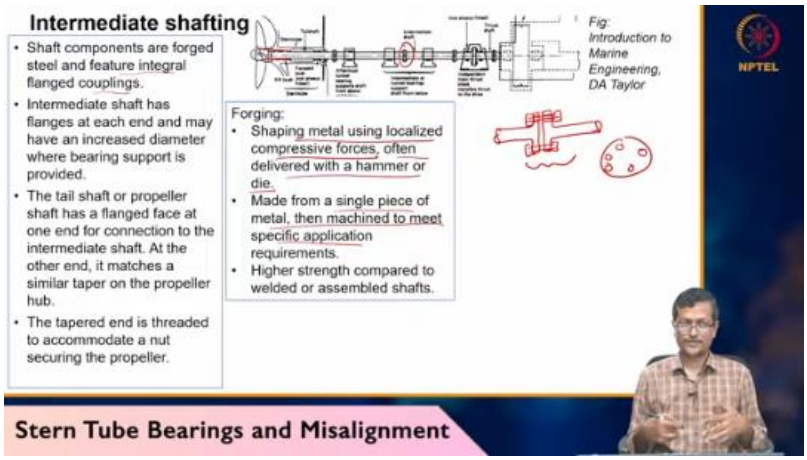
series of barriers means like one seal is here another seal is here also here so pressure changes from one seal to another seal so that way they prevent leakage mechanical face seal and packing seal So mechanical face means two surfaces there, one surface, another surface. In between you put some seal so that fluid will not be leaking through this. This is called face seal. Another is packing seal.

Packing seal means like one rotor is there and you put lots of rope or cotton rope with grease coated and that will be creating a long seal. That is a mechanical packing seal. that also will be preventing your leakage in many engines it is it is very used to very uh common to use in normal application this packing seal because any people will take one cotton rope and put some grease and use it okay intermediate like shuffling in general shuffling you say sharp components are forged steel feature integral flange coupling so flange coupling will be there these are flange coupling flange coupling like This is one shaft and this is one end. Another shaft will have like this.



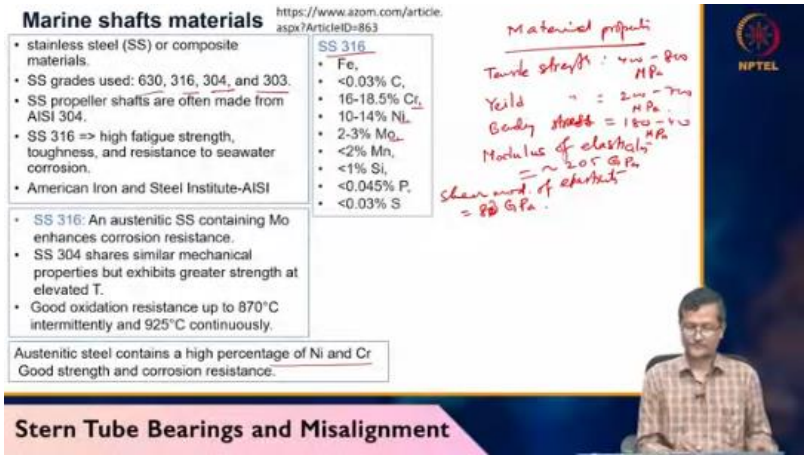
So, now you put two holes, put nut bolt here. Here also to put nut bolt and in circular pattern if I draw this one, it will be looking like this. Several nut bolts will be there. okay you connect to one shaft is here one flange is here another shaft is here flange is there put two air front by front make a hole here hole here like this and not here and put nut nut and bolt one bolt is there and not to put here okay then whenever this shaft is rotating this all shaft also will be rotating because this is many type many nut bolt will be connected maybe five six okay so normally this is very common connecting mechanism this will be giving some flexibility also for the shaft to move little bit movement lateral or axial motion is misalignment is there this will can hold it the taper end is threaded accommodate nut okay tapering means this propeller end is called tapering so tapering like you put propeller put on big nut

okay it's a pilgrimage pilgrim nut so that way you fix your propeller and so propeller is connected to a tail shaft then there will be intermediate shaft two three intermediate shafts will be there there will be thrust shaft then engine shaft okay so now uh propeller shafts are made of for using forging method so what is forging the shaping metal using localized compressive force often delivered with a hammer and die made from single piece of metal then machine to meet specific application requirement higher strength compared to welded or assembled shaft so these are having having higher strength that's why people are producing using forging method marine shaft material so marine shaft must be very strong it is obvious but all type of metal you cannot use because marine water is very much corrosive so corrosive environment you cannot use mild steel so you have to go for SS So, stainless steel also several grades are there. For example, one grade is SS316. So, iron, chromium, nickel, molybdenum, silicon, many components mixed with the iron and it is made SS316.



So, there are other type also the 630, 316, 304, 303. So, SS30 and austenitic stainless steel containing molybdenum to enhance corrosion resistance. SS304 shares similar mechanical properties but exhibits greater strength at elevated temperature. Good oxidation resistance at 870 degree centigrade. Austenitic steel contains a high percentage of nickel and chromium, good strength and for corrosion resistance.

So, normally this material property will be like this. Material property. Tensile strength, tensile 400 to 800 MPa, megapascal yield, yield strength 200 to 700 MPa within this range thus I am writing bending stress bending stress stress 180 to 400 MPa modulus of elasticity of elasticity 205 gpa about shear modulus of elasticity of elasticity 83 gpa gigapascal okay



propeller mounting when propeller is fixed from the shaft so there will be certain mechanism for mounting so propeller is attached to the tail shaft a taper and key or keyless system can be used so keyed system is there key system is large knob is secured onto the end of the tail shaft with a cone bolted over it to ensure the smooth water flow from the propeller so water should not get resisted so it should not get distracted too much the

propeller should pump properly keyless system axial and circumferential groups are machined into propeller bore allowing high pressure oil to be injected between the tail shaft and propeller another option is a pilgrim nut so at the end you put on big nut and that will be holding the propeller it will provide a frictional grip between the propeller and shaft it is screwed onto the tail shaft with a steel ring receiving thrust from hydraulically pressurized rubber tire this thrust force forces the propeller into tapered tail shaft allowing engine torque transmission without loading the key. So, classification of shift propulsion system already we discussed, but again you see this enable propulsion system. On the geared system, engine speed is very high.

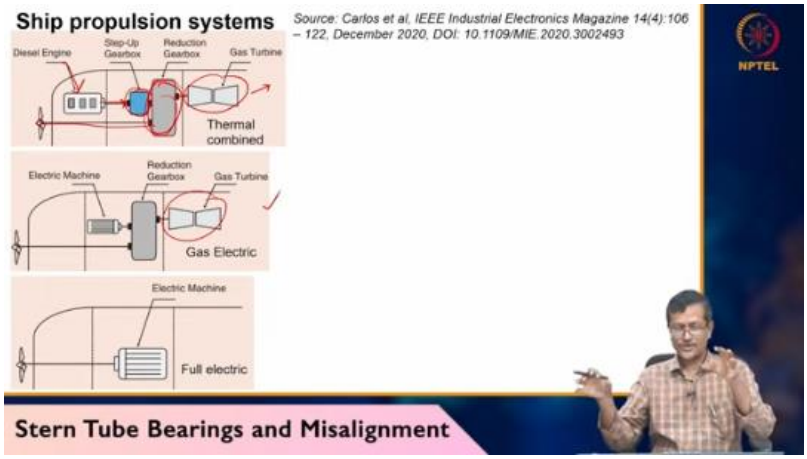
So, you need to gear to reduce the speed. If engine speed lower, then gearless system also possible. Very high, for example, gas turbine engine, diesel engine, those will have higher RPM, engine shaft RPM. So, in that case, you have to reduce the speed using gear. so combined gas and diesel power cycle uh diesel electric gas those will have higher speed so you need geared mechanism and the galley system can be possible low speed diesel engine is there directly you can connect engine shaft to your propeller shaft or fully electrical so electrical system is there if using one variable frequency drive you can control electrical frequency

that frequency will reduce your motor speed that motor speed will be reducing further your propeller speed so that way you can use geared system or gearless system so here you can see some mechanical direct system or electrical system here in this picture you can see gas turbine system so gas turbine system is speed normally it will be higher so higher gas turbine system you must go through one gear reducing system then you connect to propeller okay and if you have multiple engines supplying power to your propeller so then you have diesel engine maybe so diesel engine speed normally lower so diesel engine speed will be increased then it will be connected to your main gear system and you can transfer the power to your propeller next picture you can see Gastronomy system is there. Electrical system is there. So both speed may be higher.

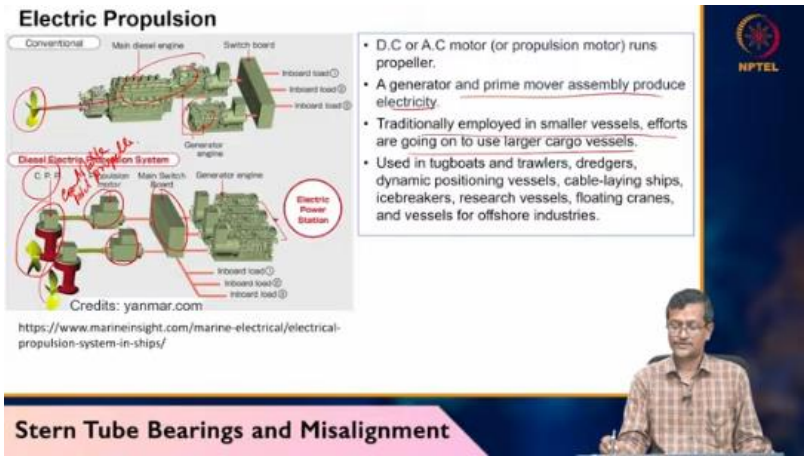
So in that case reduce gear reducer. Then you transfer the power to a propeller. But in many cases like powered propeller only electrical system is giving power. For example battery operated system is coming these days. uh so in that case or engine is producing power that power completely you produce electricity then electricity give to motor so in that case motor can be running directly to your propeller so there is also one mechanism so the different mechanism will be there one is basically i am discussing mechanical system to

produce power and mechanically it will be transferred to your propeller another way is that you can use electrical system or multiple power source

diesel engine gas engine a gas turbine engine together connect all together in a common gear system then you send to propeller or take main engine power produce electricity then motor will be running your propeller so that way your ship can be propelled so here some picture i have taken from marine insight that website so you can see here also like engines are here marine diesel engine is here some generator engine so generator you can produce electricity then same power your transformative propeller in another case main switchboard is here proportional module is here ported propeller okay controllable pitch propeller cpp means controllable pitch propeller controllable pitch Okay, CPP. So, you can control pitch of the propeller so that your speed can be changed. Your amount of thrust you are giving to your ship can be changed.



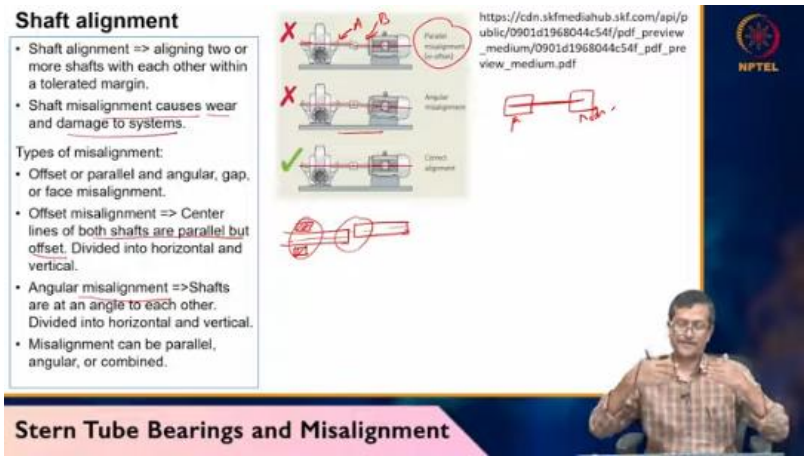
Maneuvering will be easier. So, DC or AC motor or propulsion system motor runs propeller. A generator and prime mover assembly produce electricity. Traditionally employed in smaller vessel, efforts are going to use larger cargo vessel. used in tugboats and trawlers dredges dynamic positioning vessel cable line shapes icebreakers many applications are there so i already told the shaft alignment is a big issue here one example is given you can see this picture if shaft is aligned properly



your motor or engine your propeller is here and completely aligned there is no misalignment lateral or angular then things are smooth there is no vibration will be less machine wear and tear will be less and system will be running smoothly for longer period but if you have lateral alignment for example your shaft A and shaft B are not in axis okay one shaft is here another shaft is here it's not in axis okay so in that case it is rotating but it it will also be rotating but there will be some vibration because of this misalignment another option another is that instead of completely straight line it may be creating some angle so if it is creating angle again it is rotating but it will try to rotate there will be some problem it will give extra load to your bearing okay or it will fail because of the vibration will be coming because of the angular thing or actual misalignment also possible for example two shafts are here you are targeting to keep almost zero gap but because of misalignment you are giving longer gap or very smaller gap or forcing each other so that also will be a problem so maybe your misalignment will be combination of all these or misalignment can be only one okay so sharp alignment alignment to aligning two or more sharp with each other within a tolerance margin sharp misalignment causes wear and damage to the system so types of misalignment offset offset means center line both of short or parallel okay so first one parallel or offset misalignment second angular misalignment this one and another can be like axial misalignment like distance this element can be parallel angular or combined okay now if let's say I have one shaft here and another shaft is here both are not in axis their axis are not matching so what will happen let's say I have one bearing here right and I have another bearing because bearing I said properly but one shaft because of certain reason it got misaligned so this

when one shaft is rotating another side will also rotate on the same axis so it will happen extra load will be coming on the bearing and vibration will start so when vibration starts so vibration will be again it will be multiplying so finally whole system will be filled so

before starting your machine first you have to check your critical speed your alignment properly then you can run your system okay sharp misalignment So it is a major contributor to rotating machinery failure. And misalignment increases failure. instrument increases failure increase failure friction you can say friction so energy consumption will be increasing so energy consumption increasing this heat generation will be higher second system can fail so premature bearing seal failure and seal failure excessive seal lubrication leakage lubrication in seal leakage because seal will be wearing out quickly



failure of coupling and bolt any joint connection coupling they will fail increasing vibration noise Okay, this sort of problem can be coming if system is misaligned and not handled properly. Thank you very much for today lecture. Tomorrow we will start new topic. Thank you.