MARINE ENGINEERING

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Lecture43

Marine Fuel & Properties

So, marine engine needs fuel. So, fuel marine or bunker fuel. So, sometimes they will be using the term bunker fuel. It will be like HFO, heavy fuel oil. This term you should be familiar with, heavy fuel oil and distillate or marine gas oil, MGO.

Blend of HFO and MGO are referred as a marine diesel oil, MDO or intermediate fuel oil. Blend with low proportion of HFO. The International Maritime Organization they will be deciding this quality. Specifies the requirement of petroleum based fuel and they have standard like petroleum products and fuel class F. So it will be matching with MARPOL instruction also. Residual fuel of six type depending on their kind of viscosity.

So lower viscosity means higher quality fuel and very thick fluid. Higher viscosity means very thick fluid. This quality will be lower. So, thinner fluid will have better quality. Distilled fuel and less viscous residual fuel oil are divided into four classes that vary with trace of quantitative residual fuel.

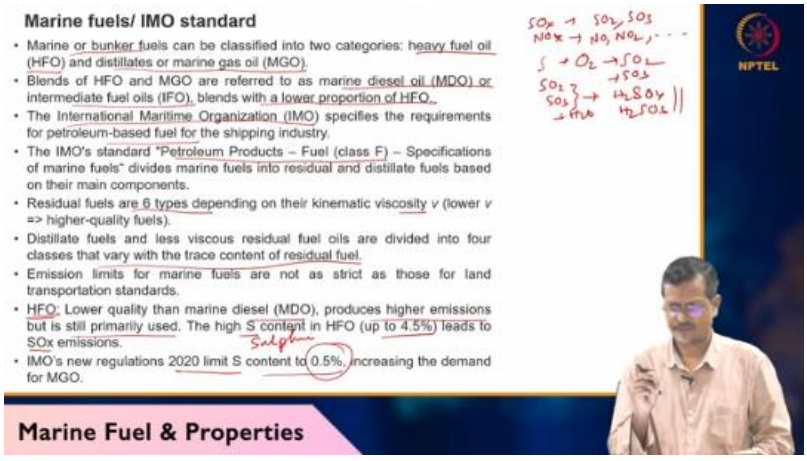
Emission limit of marine fuel are not as strict as those on surface vehicles. HFO or heavy fuel oil, lower quality than marine diesel oil. Marine diesel will be thinner little bit. Produces higher emission but still primarily used. High S means sulfur.

In HFO up to 4.5% it is dangerous. It is creating SOX. Normally we write SOX, NOX. So we do not write all these oxides. SO2, SO3.

NOX will have 5 oxides because 5 valencies are there, right? NO, NO2. So, instead of writing all the 5, we write NOx, SOx. So, many people write NOx, SOx. The pronunciation is like this.

IMO's new regulation 2020 limits sulfur content to 0.5%. Because sulfur is dangerous, I already told you. Sulfur will be reacting with oxygen. It will create S plus O2. SO2, SO3 also.

I'm not balancing left and right side. So SO2, SO3, it will be producing H2SO4, H2SO3 plus H2O. so acid finally it will be producing so acid will be reacting with your metal so that will be dangerous and it will be dangerous for environment and it will be dangerous for the human being also whoever nearby because this acid as you should not go to your lungs okay so they limited uh this sulfur content 0.5 percent very low amount of allowed but more than that one they will not allow okay so every time we are talking about thick fluid thin fluid viscosity so let's guess let's get the definition so first You learn Reynolds number. Reynolds number is rho U L, rho density and mu viscosity and L is the length, U is the velocity.



okay so if density changing or velocity changing or viscosity changing Reynolds number will be changing okay and Reynolds number also has a limit like laminar flow turbulent flow laminar flow means more viscous flow turbulent flow means it will create more turbulence okay so viscosity is a measure of fluid resistance to deformation at given rate so fluid is there if it is resisting flow itself so that is more viscous It quantifies the internal friction between adjacent layers. So if you have short chain hydrocarbon or long chain hydrocarbon, short chain hydrocarbon like CH4 or other, especially hydrocarbon application. for your fuel or lubricating oil, short chain hydrocarbon will have less viscosity. Okay.

Sometimes it is gaseous form also. But if you have say propane, butane, pentane, hexane, those gradually you will go towards liquid formation. And if you go to let's say C18, H20,

some that range. So that will be more viscous, more thicker. Actually particle, the chain is so long, it will not try to evaporate also.

It will have a more boiling point will be higher and because of long chain it will be acting as a lubricating oil so lubricating oil will have long chain hydrocarbon very thick fluid will have long chain hydrocarbon thinner fluid will have short chain hydrocarbon lubricating oil if it is getting broken in engine like say if you have bike at your home or car after some time like say 2 months 3 months or 6 months it change lubricating oil what happens at high temperature lubricating oil bonds will be getting broken when it is getting broken some carbon particle will be producing carbon particle will be producing and it will be making thicker lubricating oil so thicker fluid will not work for your lubrication okay for your oil for engine oil for your fuel oil So, thicker fluid will be having difficulty of injecting into the cylinder. So, thinner fluid is better.

The viscosity of a liquid corresponds to the informal concept of thickness. So, this thickness is higher means high viscosity. A fluid that has zero viscosity or non-viscous is called ideal or inviscid fluid. Non-strumper inertia force by viscous force. You should remember this term.

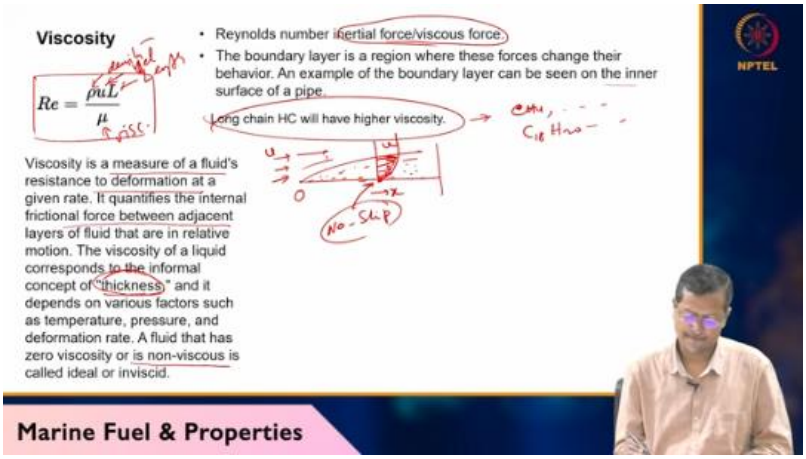
The boundary layer is a region where these forces change their behavior. An example of the boundary layer can be seen from the inner surface of pipe. So boundary layer, many times we will discuss in our discussion of engine and systems. So boundary layer means like you have flat plate and fluid is moving like this. Then it will create one layer here.

And particle will be moving And if I draw velocity profile 0 L or I can see this one X and particle velocity profile will be like this. So, velocity near wall will be 0 because near wall air particle or water particle or liquid particle will not be able to move slide over the system. This is called 0 no slip condition. No slip.

No slip means particles are not sliding over the surface. When some particles are touching the surface, those will have zero velocity. But you go away from the surface, so velocity will be increasing, velocity increasing, velocity increasing. So, that profile will be like this. After certain time, velocity will be like if it is u, it will be also u velocity.

this way you get velocity profile so this is called boundary layer where the velocity is changing this is zero to certain value u so that changing area called boundary layer area okay and many piping calculation and engine calculation also sometime we use this boundary layer for theory okay marine diesel oil so marine fuel ranges viscosity from 1

CST to 700 so unit also you should remember CST means this is kinematic viscosity unit okay another viscosity will be CP dynamic viscosity okay centipoise and you should remember to write like small c capital P okay here also CST written like this small c capital S small t many time I have seen student will be writing capital C small p or some other way or both capital both small. So, all are wrong. you have to write small c centi small c as per notation and p scientist name it will be capital P. So, stroke CST centi stroke actually.



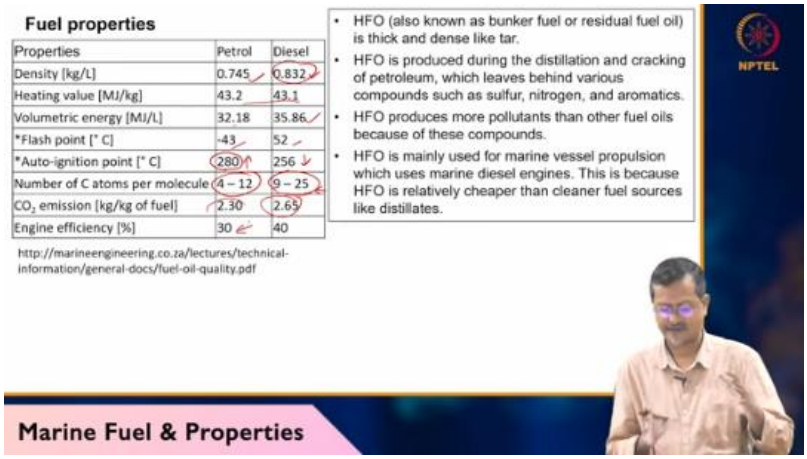
stroke the S should be capital scientist name. C small ST S will be capital then T is small that is fine. higher viscosity grades are preheated during the use okay so high viscosity fluid is there then you heat it reduce viscosity then you use okay and whenever you are getting this marine diesel oil or hfo so you have to check if it may whenever getting hfo or marine fuel so Catalytic cracking method will be giving or vis-breaking method will be giving that fuel. And IMO regulation, it will be defining your marine fuel property or that viscosity limit or emission limit.

And it will be giving information with the regulation of International Convention for the Prevention of Pollution, MARPOL. okay so the full form also you should remember in exam suddenly i can give then you should not say sorry it is not there in your notes so i have given so that i can give in exam also okay so fuel property like very common fuel i have taken petrol and diesel you can see this density 0.745 and diesel 0.83 so diesel density is higher than petrol okay heating value both are almost same volumetric energy 32 35 diesel is a little bit higher flash point you see flash point difference petrol very thinner fluid so flash point minus 43 d but diesel 52 in degrees a degree centigrade auto ignition point here another thing auto using petrol although thinner fluid but auto ignition is higher than diesel okay diesel is 256 but petrol is 280. Okay. Auto ignition means you increase temperature when 280 degree temperature will be reaching it will be burning quickly.

Okay. But diesel in diesel case 256 degree is auto ignition temperature. Number of carbon atom per molecule. So diesel 9 to 25. You can see diesel is higher.

this is thicker fluid if you go to a petrol pump you see the digger is thicker fluid petrol is thinner fluid actually petrol if you put in normal vessel after certain time you see the petrol is not there because it will be evaporating quickly because short chain hydrocarbon is there okay so it will be evaporating quickly viscosity lower evaporating quickly done but diesel is much thicker okay it is having long chain hydrocarbon 9 to 25 so chain will be longest Carbon dioxide emission 2.3 and 2.65. Efficiency diesel engine 40%, petrol engine 30%. So, these are relative thing, but approximately data they have given. So, many data we give approximately, like efficiency you cannot measure, like you cannot say exactly 30.

It will be approximately 30, because it will be depending on many factors. Inlet temperature, fuel property, whether water content is there, engine cooling properly done or not. So, all these factors will be included when you are calculating efficiency. For our approximate calculation, we may not consider everything, but detailed design when people are doing in mechanical and other department, they will be considering all the small factors also. After that, they will get exact efficiency values.



So HFO also known as bunker fuel. Combustion, so CI engine, so combustion in SI engine, CI engine will be different. So in CI engine first thing, first thing. So combustion will be having ignition delay premix. So in combustion phase, ignition delay is like this.

Time interval between the initiation of the spark or other ignition source and the start of combustion in the fuel mixture. So the time delay is called ignition delay. Okay. So, in many cases, pre-mixing is required. For example, carburetor will have lots of pre-mixing.

Pre-mixing is rapid combustion phase. This fuel accumulated in the cylinder ignites high heat release. So, CI engine, fuel injected, already air is there. So, it will be pre-mixed. Then, burning will start.

Mixing, control combustion phase. Burning rate is controlled. Heat release is decreased. Late combustion phase. Lowest heat release rate.

Only a small amount of fuel is available for burning. Okay, so combustion process is complete when you are getting only carbon dioxide and water. But if you are getting more carbon monoxide, then it is not complete combustion because oxygen shortage is there. Okay, in reality exhaust gas will contain NOx. Why NOx will be there?

Nitrogen you have and oxygen you have, high temperature, high pressure is there. So some nitrogen will be converted into nitrogen oxides. Okay. So some unburnt hydrocarbon may be there if engine design is not proper. Carbon monoxide may be created.

Soot may be created. Soot means actually unburnt or ashes or some heavy metal particle. Those are soots or maybe carbon particle. Carbon dioxide is not a pollutant. Carbon dioxide is a greenhouse gas.

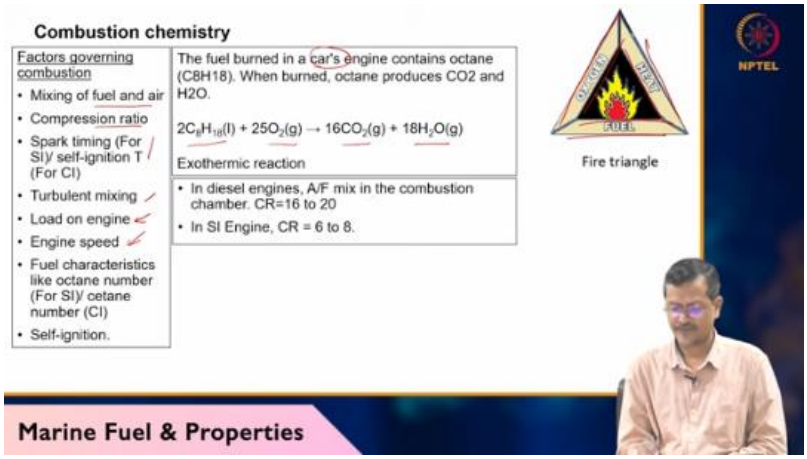
So whenever we are designing any engine, so we assume carbon dioxide is not a pollutant. it is there already in the atmosphere we are exhaling every time so it is not a pollutant gas but it is giving greenhouse effect so whenever you are considering engine or chemical reaction in the engine so we assume that carbon dioxide is not harmful produce carbon dioxide not carbon monoxide if you are producing carbon monoxide that is harmful so Whenever you are running an engine or you are designing an engine or buying an engine, you have to see it is producing carbon dioxide only, not carbon monoxide. So combustion chemistry, when you are burning fuel, you need three things actually. You see right side picture, oxygen is required, heat is required and fuel is required.

So three things must be there. If you break one, you say heat is not there or oxygen is not there or fuel is not there, then it will not burn. So three things must be there to get your combustion done. Okay, so mixing of air fuel is required. Compression ratio must be proper.

These are affecting the combustion. Spark timing, proper timing also will be required. Like say system is compressed but spark is not happening. So things will not work. Okay, those are also important.

Turbulent mixing, how much mixing done properly. So that is also important. Load on engine, if it is too much loaded, like say bikes or scooters are designed for two persons but four students are riding, then things will not work. So then combustion will be affected. Engine speed also will be affecting your combustion system.

Fuel characteristics, self-ignition, so all these things will be affecting your combustion. so one example of reaction i have shown here the fuel burning in a car engine okay the simple fuel i have taken c8 h18 and oxygen it will be producing carbon dioxide and water this purely ideal case uh because it is not producing carbon dioxide or socks or knocks i'm not showing there and this is an exothermic reaction when in combustion chamber all reaction will be exothermic so it will get you'll get lots of heat actually In diesel engine, air fuel mixture is a combustion chamber. In diesel engine, air fuel will be mixing in the combustion chamber.



Compression ratio will be 16 to 20. But petrol engine or SI engine, it will be 6 to 8, very low compression ratio. thank you very much for today's lecture. Next day, we will be starting new topic. Thank you.