MARINE ENGINEERING

By

Prof. Abdus Samad

IIT Madras

Lecture4

Second law of thermodynamics

Hello and good morning. Today's topic is Second Law of Thermodynamics, Carnot Cycle, Heat Pump, Refrigeration Cycle, Reversible to Reversible Cycle. Anyway, these are the recap of basic thermodynamics which is required for this course. So, I will be going through the topics quickly. And the topics I have selected from PKNR, Basic and Applied Thermodynamics, Tata McGraw-Hill book.

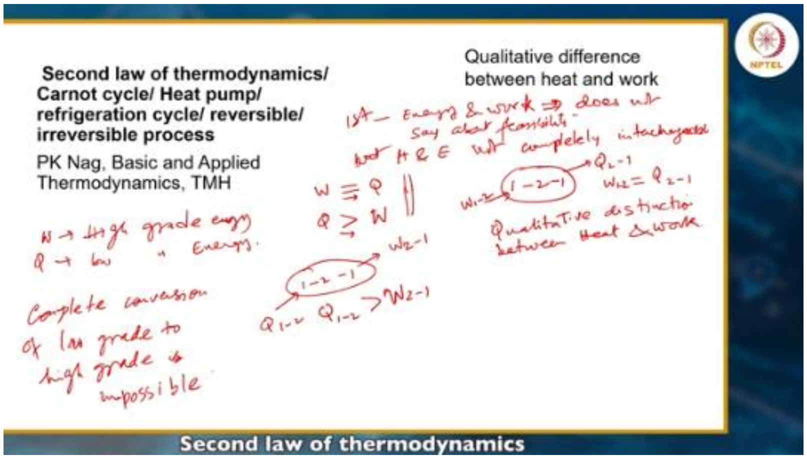
So qualitative difference between heat and work. Fossil law says certain energy balance will hold when the system undergoes thermodynamic process. But it does not give indication of the change of state or process is feasible or not. it says energy and work can be convertible but does not say the feasible or not does not say does not say about feasibility heat and energy are not completely interchangeable heat or energy not completely interchangeable actually in first law

but heated energy not interchangeable, not completely interchangeable. when work is converted into heat, so work is converted into heat, W is work, Q is heat, then 100% conversion possible. When heat is converted into work in close process, so 100% conversion are possible. Q arrow shows direction.

this is work is converted 100%, but heat is not converted. if you see one thing like heat all the form final form all the form of energy whatever is there so whenever you convert you do anything so final form will be heat actually so whenever work is being converted into heat so some work uh there will be no loss actually finally everything will be heat but whenever heat is converted to work so some heat you cannot use actually okay that's why heat will be higher work will be lower but when work is going to heat so everything is heat finally okay so Let us say one process 1, 2, 1. Process 1, 2, 2 again going back to 1 and giving work 1, 2, heat 2, 2, 1. W1, 2, 2, 2 equals Q2, 2, 1.

But in other case if you consider 1, 2, 1 same. Q1 to 2, W2 to 1, W2 to 1 cycle process is happening. in that case Q1 to 2 more than W2 to 1. this figure says qualitative distinction between heat and warm. Qualitative distinction

between heat and work work is said to be high-grade energy work high-grade energy Q low-grade energy low-grade The complete conversion of low grade to high grade is impossible. So, complete of low grade to high grade is impossible, is impossible. Now we will go to cyclic heat engine. A heat engine cycle is a thermodynamic cycle in which there is a net heat transfer to the system and a net work transfer from the system.



The system which executes a heat engine is called heat cycle. Heat engine cycle is called heat engine. A heat engine cycle is thermodynamic cycle in which there is net heat transfer. Now first we draw one figure. Q is coming and Q2 is going out system.

Figure says that heat engine cycle heat engine cycle performed by a closed system undergoing from successive energy interaction with the surrounding interaction with the surroundings so cycle heat engine we draw one another figure this is turbine turbine is there so turbine will be giving work output turbine work wt and this turbine is getting work from boiler you have one boiler okay from boiler you are getting turbine get energy and after turbine there will be one condenser so condenser actually it will be releasing heat turbine work, work output and from condenser there will be one pump. from pump to again boiler, so certain steam you take, so steam will go to turbine, turbine will be extracting certain power, so the turbine will get power, then after that the steam will go to condenser, so when it is going to condenser, steam will get liquid water again, so that water will be pumped to boiler again, boiler will be giving lots of heat, so boiler will get furnace heat or I can say furnace heat.

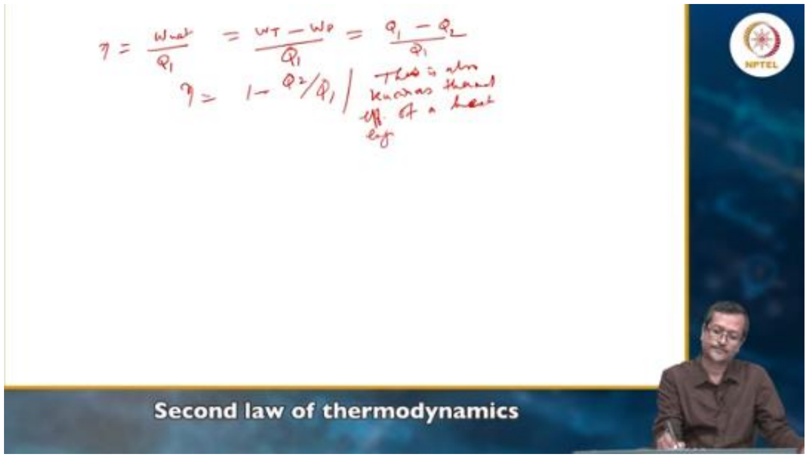
furnishments, lots of heat will be generated and that heat will go to boiler. this whole cycle will continue your steam power plant or your steam engine, wherein steam engines are there, later we will discuss in details. this whole cycle will be there, turbine, condenser, pump, boiler, then water will be circulating continuously. that water will not go outside of this whole cycle, but heat and energy will go in and out. heat engine cycle performed by steady flow system interacting with surrounding.

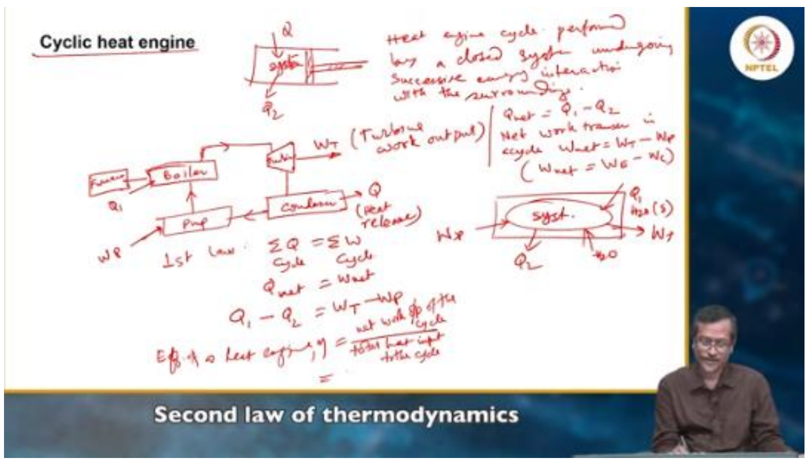
this is a cyclic heat exchanger. the net heat transfer in cycle either of the heat engine Q net. q1 minus q2 so q1 is here q1 it is you are giving q1 minus q2 so this is net heat input so net work transfer net work transfer in a cycle W net equals W t minus W pump. pump will be requiring power W pump to run pump you need extra work input or I can write W net equals W e minus W c compression you can say W e means expansion W c means compression is also.

first loss is summation of Q equals summation of W cycle. Q net equals W net, net input heat input equals net W watt output. Q1 minus Q2 equals W turbine minus W pump. Now if I draw whole thing in one simple cycle like this I have the system.

what is coming? H2O liquid coming then Q1 H2O gas. turbine work going out, H2O coming in, then pump work going in, turbine is going out and Q2 is going out, Q1 is going in, Q2 going out. Q1 minus Q2 equals Wt minus Wp turbine power minus pump power. now cyclic heat engine with energy interaction represents in a block diagram.

if efficiency of a heat engine of a heat engine eta equals network output network output of the cycle by total heat input, heat input to the cycle equals W net divided by Q1. So, eta equals W net by Q1 equals Wt minus Wp divided by Q1 equals Q2 minus Q3. q1 minus q2 divided by q1 so eta equals 1 minus q2 divided by q1 so this is also known as thermal efficiency of a heat engine so this is is also known as thermal efficiency of a heat engine energy reservoir a thermal energy a thermal energy reservoir t e r thermal energy reservoir hot from which heat q is transferred to the system operating in heat engine cycle called source okay so reservoir is called source so i will have one





t e r h or source okay it is coming to one system uh so system will have like turbine output pump input pump walk input a turbine walk output and one reservoir the source uh sink okay t e r This is low temperature L, this is high temperature H. And this is Q1 coming and Q2 coming here. Now, T, E, R, L or Q rejected to sink.