



MECHANICAL ENGINEERING SCIENCE (UE25ME141A/B)

Dr. Mantesh B Khot

Department of Mechanical Engineering

First Law of Thermodynamics - Limitations

The First Law of Thermodynamics is another form of the Law of Conservation of Energy. It merely states that when a process takes place, energy can neither be created nor destroyed.

However, from many observations of common experiences, it is observed that

1. Processes follow a definite direction.
2. Heat and work are qualitatively different.

These are not addressed by the I Law of Thermodynamics and thus are referred to as 'Limitations of the I Law of Thermodynamics'.

I - Processes Follow A Definite Direction

- ✓ Heat flows from a hot body to a cold body on its own but never vice-versa.
- ✓ Consider a vehicle moving up hill at the expense of fuel burnt. If we reverse this process i.e., make it move down hill, it is not possible to get the fuel back.
- ✓ Water flows from a higher to lower level and not vice-versa.

I - Processes Follow A Definite Direction

- ✓ Electric current flows from higher to lower potential and not vice-versa.
- ✓ A magnetic pole would move from higher to lower potential and not vice-versa.

Even if these were to happen, it would still satisfy the 1st Law of Thermodynamics.

II - Heat and Work are Qualitatively Different

Heat and Work are qualitatively different. Heat is referred to as a qualitatively lower form of energy while work is qualitatively higher.

All work can be dissipated as heat while all heat cannot be converted to work by any device working in a thermodynamic cycle.

Even if this were to happen, it would still satisfy the 1st Law of Thermodynamics.

Heat Reservoir: is a body of infinite heat capacity, whose temperature is not affected by any heat transfer.

It can also be defined as a body of infinite heat capacity, which can absorb or supply heat without any change in its temperature.

Heat Source : is a heat reservoir which can supply heat without any change in its temperature.

Heat Sink : is a heat reservoir which can absorb heat without any change in temperature.

Important Definitions - Source



The Sun

Important Definitions - Source



Furnace

Important Definitions - Sink



The Atmosphere

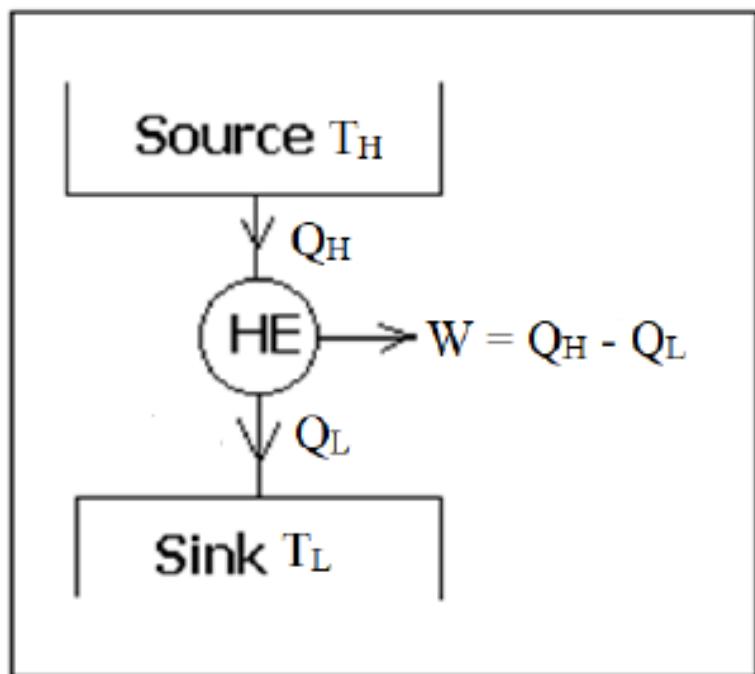
Important Definitions - Sink



The Ocean

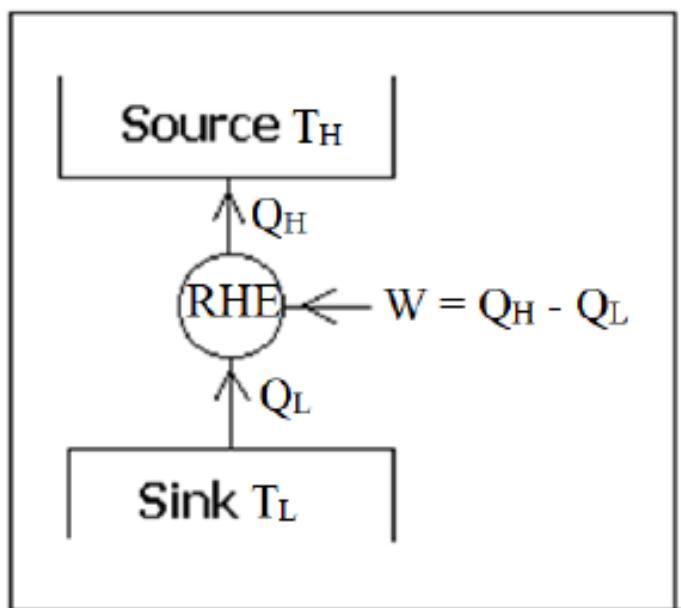
Important Definitions – Heat Engine

Heat Engine : is a device that works in a thermodynamic cycle and produces net positive work while absorbing heat from a source and dissipating heat to a sink.



Important Definitions – Reversed Heat Engine

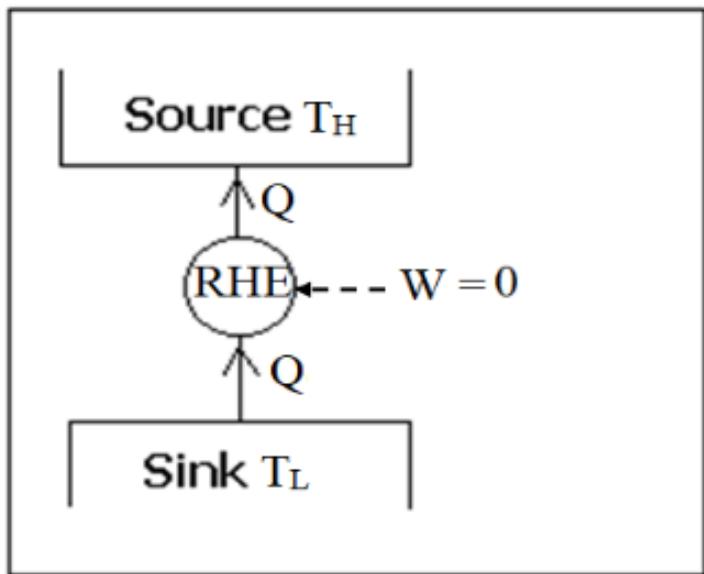
Reversed Heat Engine: is a device that operates in a thermodynamic cycle and transfers heat from a low temperature body (sink) to a high temperature body (source) with the aid of external work.



Statement of Second Law of Thermodynamics

Clausius Statement

It is impossible to construct a device that operates in a thermodynamic cycle and transfers heat from a cold body to a hot body without the input of external energy.



Statement of Second Law of Thermodynamics

Kelvin–Planck Statement

The Kelvin–Plank statement of the second law of thermodynamics refers to a thermal reservoir.

“It is impossible to construct a heat engine that operates in a cycle and produces no other effect than the absorption of heat from a single thermal reservoir and the performance of an equivalent amount of work”

- In Figure 1, it is shown that there are two reservoirs from which heat is interacted to do a work W_{net} .
- Heat, Q_H is taken from higher temperature reservoir and work is done and rest amount of heat is rejected to lower temperature reservoir.
- Thus, the total conversion of heat to work is impossible; there will always be rejection of some part of the heat supplied by the heat engine.

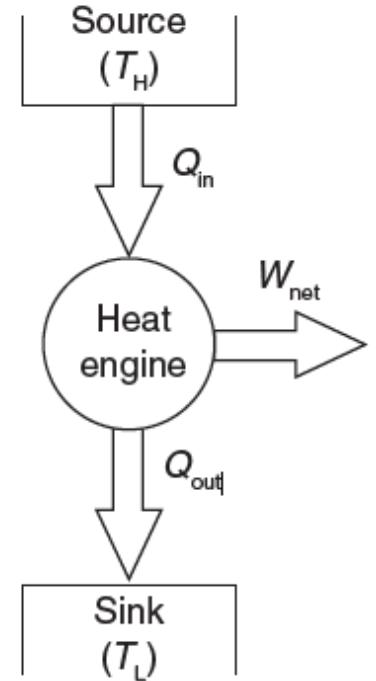


Figure 1 a Heat Engine

THANK YOU



Dr. Mantesh B Khot

Department of Mechanical Engineering

mahanteshbk@pes.edu

+91 87 2202 4584