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SELF STUDY MODULE

Power systems in practice and their impacts

Objective

Quality of energy

Power generation cycles

What happens to Q_C, the heat discarded at the cold side of the cycle?

What is global warming? What is climate change? How much of this is due to our power conversion systems? What can we do to change this?

Vocabulary

Heat: Energy in transit due to a temperature difference. Heat is transferred to bring objects to a thermal equilibrium.

Work: Energy in transit due to motion, due to a pressure difference. Mechanical equilibrium is reached through work.

Global warming: Fill in your perspective of global warming here.

Climate change: Fill in your perspective of climate change here.

Balance equations

The general mass conservation law $\frac{dm}{dt} = \sum_{in} m_i - \sum_{out} m_j$

The general conservation of energy or the first law of thermodynamics

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$$\frac{dU}{dt} = \sum_{in} m_i h_i - \sum_{out} m_j h_j + \dot{Q} + \dot{W}_S - P\frac{dv}{dt}$$

The entropy balance has a generation term

$$\frac{dS}{dt} = \sum_{in} m_i s_i - \sum_{out} m_j s_j + \frac{\dot{Q}}{T} + \dot{S}_{gen}$$

The internal combustion engine cycles that use fossil fuel

Otto Cycle: uses gasoline, combustion takes place at constant volume, the work is extracted by constant entropy expansion, the exhaust process is done at constant pressure and fresh air is compressed at constant entropy.

Diesel cycle: Uses Diesel fuel, combustion is at constant pressure, followed by a constant entropy expansion. Exhaust is done at constant volume, followed by intake and constant entropy compression of the fresh air.

Brayton cycle: Uses jet fuel, constant pressure combustion is followed by a constant entropy expansion. The exhaust and intake are at constant pressure. The cold air is compressed at constant entropy.

Calculate

1. Determine the efficiency of an Otto cycle which received 100 kJ/mol of working fluid heat input, and the lowest temperature is 300 K lowest pressure is 1 atm. The maximum allowable pressure in this engine is 20 atm.
2. Determine the efficiency of a Diesel cycle which received 100 kJ/mol of working fluid heat input, and the lowest temperature is 300 K lowest pressure is 1 atm. The maximum allowable pressure in this engine is 20 atm.
3. Determine the efficiency of a Brayton cycle which received 100 kJ/mol of working fluid heat input, and the lowest temperature is 300 K lowest pressure is 1 atm. The maximum allowable pressure in this engine is 20 atm.

Evaluate

1. What is the impact of the fossil conversion processes if all of it is burned and ends up in air?
2. How efficient is to ship a cargo of 100 kg by car? How much does a car weigh? How much weigh does the car haul to ship the cargo? Include in your analysis the efficiency of Otto cycle as well.
3. How efficient is o ship a cargo of 100 kg by train? Note that 40 trucks each with 40 tons of cargo can be pulled on the railroads. What is the fraction of the weight of the train itself in comparison to the total weight it can carry? What is the efficiency of shipping 100 kg cargo by train? Include the efficiency of the Diesel cycle in your analysis.
4. How efficient is to ship a cargo of 100 kg by air? What is maximum take-off weight? What percentage of the takeoff weight is the cargo and the passengers? Include the efficiency of the Brayton cycle in your analysis?

Bibliography

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