Oct 2022

October 2022 MDE

1. Explain the meaning of EACH of the following diesel engine terms:

   (a) overlap; (2)

   (b) scavenging; (2)

   (c) afterburning; (2)

   (d) compression; (2)

   (e) expansion. (2)

june 2021

June 2021 MDE

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jan 2018

January 2018 MDE

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Here's an explanation of each diesel engine term:

(a) Overlap:

Overlap refers to the period in a four-stroke diesel engine cycle where both the intake and exhaust valves are open slightly at the same time. This timing is crucial for efficient operation:

- **Exhaust Valve Closing:** The exhaust valve starts closing near the end of the exhaust stroke.
- **Intake Valve Opening:** A little before the piston reaches the bottom of its stroke (end of exhaust), the intake valve opens. This allows some fresh air to enter the cylinder to help expel remaining exhaust gases.
- **Benefits:** The overlap period helps scavenge exhaust gases more effectively and promotes a cooler intake charge due to the incoming fresh air.

(b) Scavenging:

Scavenging is the process of removing exhaust gases from the engine cylinder and replacing them with fresh air during the engine cycle. This is essential for several reasons:

- **Combustion Efficiency:** Proper scavenging ensures a mostly fresh air charge is present in the cylinder for efficient fuel combustion during the power stroke.
- **Reduced Emissions:** By removing exhaust gases, scavenging helps minimize pollutants like unburned hydrocarbons and oxides of nitrogen (NOX) in the exhaust.
- **Cooler Operation:** Fresh air entering the cylinder helps lower the overall engine temperature.

Overlap between the exhaust and intake valve cycles plays a critical role in the scavenging process.

(c) Afterburning:

Afterburning, also known as exhaust gas treatment, is not a typical part of the four-stroke diesel engine cycle itself. It refers to additional technologies used to reduce harmful emissions in the exhaust after it leaves the engine cylinder.

Common afterburning techniques include:

- **Catalytic Converters:** These devices promote chemical reactions that convert pollutants like NOX into less harmful substances.
- **Diesel Particulate Filters (DPF):** DPFs trap soot particles in the exhaust, reducing their release into the atmosphere.

(d) Compression:

Compression is a crucial stage in the four-stroke diesel engine cycle:

1. **Intake Stroke:** The piston moves down, drawing in a mixture of air and fuel (air only in direct injection engines) through the open intake valve.
2. **Compression Stroke:** With the intake valve closed, the piston moves up, significantly reducing the volume of the air-fuel mixture within the cylinder. This compression dramatically increases the temperature and pressure of the mixture.

The high temperature and pressure created during compression are essential for efficient fuel ignition in a diesel engine without the need for spark plugs.

(e) Expansion:

Expansion is the power stroke of the four-stroke diesel engine cycle:

1. **Combustion:** Under the high pressure and temperature from compression, the injected fuel ignites spontaneously. This burning fuel rapidly expands, pushing the piston down with great force.

2. **Expansion Stroke:** The expanding hot gases from combustion force the piston down, rotating the crankshaft and generating power output from the engine.

The force exerted by the expanding gases during this stroke is what ultimately propels the engine.

Oct 2022

October 2022 MDE

5. Explain what is meant by EACH of the following terms:

    (a) cetane number; (3)

    (b) calorific value; (3)

    (c) density; (2)

    (d) viscosity. (2)

Here's a breakdown of each term related to diesel fuel:

(a) Cetane Number:

The cetane number is a critical indicator of a diesel fuel's ignition quality. It represents the **delay** between fuel injection and the start of combustion in a diesel engine. Here's a breakdown:

- **Higher Cetane Number:** Indicates a **shorter** ignition delay. This is ideal for smooth engine operation, minimizing knocking and incomplete combustion.
- **Lower Cetane Number:** Represents a **longer** ignition delay. This can lead to rough engine operation, increased noise (knocking), and incomplete combustion resulting in higher emissions.

Cetane number is similar to the octane rating used for gasoline, but they measure different properties.

(b) Calorific Value:

The calorific value, also known as heating value, refers to the amount of heat energy released when a unit mass of fuel is burned completely. It's typically expressed in units like Megajoules per kilogram (MJ/kg) or British thermal units per pound (Btu/lb).

A higher calorific value indicates the fuel contains more potential energy per unit mass. This translates to more power output from the engine for a given amount of fuel burned.

(c) Density:

Density refers to the mass of a fuel per unit volume. It's typically expressed in kilograms per liter (kg/L) or pounds per gallon (lb/gal).

Density is important for several reasons:

- **Fuel Economy:** Denser fuels store more energy per unit volume, potentially leading to better fuel economy (assuming similar calorific values).

- **Injection Systems:** Fuel injection systems are calibrated for a specific fuel density. Significant deviations can affect engine performance.

(d) Viscosity:

Viscosity refers to a fluid's resistance to flow. In the context of diesel fuel, it describes how easily the fuel flows at a given temperature. It's typically measured in units like centiStokes (cSt).

Here's how viscosity affects diesel engines:

- **Cold Starts:** At lower temperatures, higher viscosity can make it harder for the fuel to flow, hindering engine starting.
- **Injection and Atomization:** Proper fuel atomization (breaking down into fine droplets) is crucial for efficient combustion. High viscosity can hinder this process.
- **Pump Wear:** Fuel pumps rely on the fuel's lubricating properties. Very low viscosity can increase wear on pump components.

April 2023

April 2023 MDE

7. With reference to tube type heat exchangers, explain the purpose of EACH of the following:

   (a) baffle plates; (2)

   (b) sliding tube plate; (2)

   (c) tell tale ring; (2)

   (d) vent cock; (2)

   (e) anodes. (2)

In a tube-type heat exchanger, each component plays a specific role in optimizing heat transfer and ensuring safe operation. Here's a breakdown of the purposes of each term:

(a) Baffle Plates:

Baffle plates are thin metal plates placed within the shell side of the heat exchanger. They serve several purposes:

- **Direct Fluid Flow:** Baffles prevent the shell-side fluid from simply flowing straight through the heat exchanger. They force the fluid to take a longer path across the tubes, maximizing contact time for heat transfer.
- **Create Crossflow:** By strategically positioning baffles, they can create a **crossflow** pattern across the tubes. This ensures more even distribution of the shell-side fluid and improves overall heat transfer efficiency.
- **Support Tube Bundle:** Baffles also help support the tube bundle within the shell, preventing excessive movement and potential tube damage.

(b) Sliding Tube Plate:

The sliding tube plate is one of the two tube sheets (plates) holding the tubes in place. Unlike the fixed tube plate, the sliding tube plate can move slightly along a defined channel. This movement allows for:

- **Thermal Expansion Accommodation:** As the tubes heat up, they expand. The sliding tube plate allows for this expansion without putting undue stress on the shell or the tubes themselves.
- **Leak Prevention:** The slight movement also helps maintain a tight seal between the tubes and the tube sheet, minimizing the risk of leaks.

(c) Tell-Tale Ring:

The tell-tale ring is a small groove or channel machined around the edge of the fixed tube sheet where it meets the shell. It serves as an early warning system for potential leaks:

- **Leak Detection:** If a leak develops between the tube and the fixed tube sheet, the leaking fluid will travel through the tell-tale ring groove.
- **Leakage Path:** This groove provides a controlled path for the leaking fluid to exit the heat exchanger without mixing the two fluids being exchanged. This allows for easier leak detection and helps prevent potential contamination.

(d) Vent Cock:

The vent cock is a small valve located on the top of the shell of the heat exchanger. It serves two main purposes:

- **Air Venting:** During initial filling and operation, air pockets can become trapped inside the shell side of the heat exchanger. The vent cock allows for manual venting of these air pockets. Air pockets can hinder heat transfer efficiency.
- **Pressure Relief:** In some cases, the heat exchanger might be subject to pressure fluctuations. The vent cock can act as a safety relief valve, releasing excess pressure and preventing potential damage to the shell.

(e) Anodes:

Anodes are sacrificial metal components placed strategically within the shell of the heat exchanger. They play a crucial role in corrosion protection:

- **Galvanic Corrosion:** In a tube-type heat exchanger, the different metals (tubes and shell) can create a galvanic cell, leading to corrosion of the less noble metal.
- **Sacrificial Protection:** Anodes are made of a more reactive metal than the tubes or shell. They corrode preferentially, protecting the other components from electrochemical corrosion.

Anodes are typically made from materials like magnesium or zinc and require periodic replacement as they corrode.

January 2019 MDE

1. With reference to diesel engines, explain EACH of the following terms:

(a) top dead centre; (1)

(b) bottom dead centre; (1)

(c) piston stroke; (2)

(d) swept volume; (2)

(e) clearance volume; (2)

(f) compression ratio. (2)

These terms all relate to the movement of the piston within the cylinder of a diesel engine and the resulting volumes created:

(a) Top Dead Center (TDC):

This refers to the uppermost point in the cylinder that the piston reaches during its movement. At TDC, the piston is as close as it gets to the cylinder head.

(b) Bottom Dead Center (BDC):

This is the opposite of TDC and represents the lowest point in the cylinder that the piston reaches during its movement. At BDC, the piston is as far away from the cylinder head as it gets.

(c) Piston Stroke:

The piston stroke is the total distance the piston travels between TDC and BDC. It's essentially the length of the piston's movement within the cylinder.

(d) Swept Volume:

The swept volume is the theoretical volume displaced by the piston during one complete stroke (up and down) within the cylinder. It's calculated by multiplying the cylinder's bore area (π * bore radius squared) by the piston stroke.

(e) Clearance Volume:

The clearance volume is the volume remaining in the cylinder at TDC. With the piston at its highest position, there's still some space between the piston head and the cylinder head. This clearance volume is crucial for several reasons:

- **Combustion Space:** It provides the necessary space for air (or air-fuel mixture) to be compressed before ignition.
- **Piston Expansion:** The clearance volume allows room for the piston to expand slightly without contacting the cylinder head.
- **Engine Starting:** Adequate clearance volume is necessary for the engine to crank freely without the piston hitting the cylinder head.

(f) Compression Ratio:

The compression ratio is a critical parameter in a diesel engine and is calculated by dividing the total cylinder volume (swept volume + clearance volume) by the clearance volume. Here's the formula:

Compression Ratio = (Total Cylinder Volume) / (Clearance Volume)

A higher compression ratio signifies a greater compression of the air (or air-fuel mixture) in the cylinder, leading to:

- **Higher Efficiency:** Increased compression creates higher temperatures and pressures during combustion, improving fuel efficiency.
- **More Power:** The higher pressure generated during combustion translates to more power output from the engine.

However, there are limits to compression ratio due to factors like:

- **Fuel Ignition:** Very high compression ratios can cause the air to ignite spontaneously before the intended injection of fuel, leading to engine knocking.
- **Engine Design:** The engine needs to be designed to withstand the increased forces associated with higher compression.