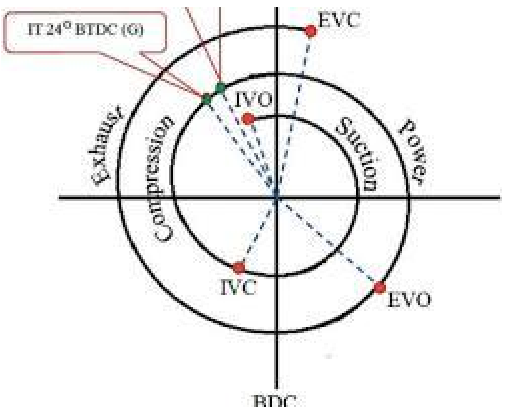
Feb 2022

February 2022

1. (a) Sketch a four stroke timing diagram, showing the position of fuel valve, exhaust valve and inlet valve operation. (8)

(b) Explain the meaning of the term *valve overlap*, stating its purpose. (2)

Here's a sketch of a four-stroke timing diagram showing valve operation:



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Four stroke timing diagram

pen_spark

Labeling:

- **TDC (Top Dead Center):** Highest point of piston travel in the cylinder.
- **BDC (Bottom Dead Center):** Lowest point of piston travel in the cylinder.
- **Intake Valve:** Controls the flow of air-fuel mixture into the cylinder.
- **Exhaust Valve:** Controls the release of exhaust gases from the cylinder.
- **Intake Stroke:** Piston moves down, drawing in air-fuel mixture.
- **Compression Stroke:** Piston moves up, compressing the air-fuel mixture.
- **Combustion Stroke (Power Stroke):** Ignition occurs, burning the compressed mixture and pushing the piston down.
- **Exhaust Stroke:** Piston moves up, forcing exhaust gases out of the cylinder.

Valve Operation:

- **Intake Stroke:** Intake valve opens just before TDC (Top Dead Center) of the intake stroke and closes after BDC (Bottom Dead Center) of the intake stroke.
- **Compression Stroke:** Both valves are closed throughout the compression stroke.
- **Combustion Stroke (Power Stroke):** Both valves are closed throughout the combustion/power stroke.
- **Exhaust Stroke:** Exhaust valve opens just before TDC of the exhaust stroke and closes after BDC of the exhaust stroke.

Valve Overlap (b)

Valve Overlap refers to the period during the engine cycle where both the intake and exhaust valves are open slightly at the same time. This typically occurs near the end of the exhaust stroke and the beginning of the intake stroke, or near the end of the intake stroke and the beginning of the compression stroke, as shown in the diagram.

Purpose of Valve Overlap:

- **Improved Scavenging:** During the overlap at the end of the exhaust stroke and beginning of the intake stroke, some fresh air from the intake valve can help push out any remaining exhaust gases trapped in the cylinder. This improves scavenging and cylinder purging, leading to a more complete intake of fresh air-fuel mixture.
- **Reduced Pumping Losses:** The slight overlap at the end of the intake stroke and beginning of the compression stroke allows some of the already inducted air-fuel mixture to flow back out, reducing the pumping work required to fill the cylinder completely. This can improve engine efficiency at higher RPMs.

Note: The amount of valve overlap is carefully designed by the engine manufacturer to optimize performance and efficiency based on the engine's intended application.

May 2021

May 2021 MDE

1. Describe the working principle of the four stroke cycle. (10)

may 2018

May 2018 MDE

1. Describe the working principle of the four stroke cycle. (10)

The four-stroke cycle is the operating principle behind most internal combustion engines, including gasoline and diesel engines. It utilizes four distinct strokes of the piston within the cylinder to achieve combustion and produce power. Here's a breakdown of the four strokes:

1. Intake Stroke (Suction):

- The piston moves downward from Top Dead Center (TDC) towards Bottom Dead Center (BDC).
- The intake valve opens, allowing an air-fuel mixture (gasoline engines) or fresh air (diesel engines) to be drawn into the cylinder by the increasing volume created by the descending piston.
- The exhaust valve remains closed throughout the intake stroke.

2. Compression Stroke:

- The piston moves upward from BDC towards TDC.
- Both the intake and exhaust valves are closed.
- The trapped air-fuel mixture (or air in diesel engines) is compressed by the rising piston, significantly increasing its pressure and temperature.

3. Combustion Stroke (Power Stroke):

- Shortly before TDC on the compression stroke, a spark plug ignites the compressed air-fuel mixture in gasoline engines. In diesel engines, the high pressure and temperature cause the injected fuel to spontaneously combust.
- The combustion process rapidly expands the hot gases, forcing the piston down with significant force, creating the power output of the engine.
- Both the intake and exhaust valves remain closed throughout the combustion stroke.

4. Exhaust Stroke:

- The piston moves upward from BDC towards TDC.
- The exhaust valve opens.
- The burned exhaust gases are pushed out of the cylinder by the rising piston.
- The intake valve remains closed throughout the exhaust stroke.

Repeating Cycle:

- Once the exhaust stroke is complete, the piston reaches TDC again, and the cycle repeats, continuously drawing in fresh air/fuel mixture, compressing it, combusting it for power generation, and expelling the exhaust gases.

Key Points:

- The crankshaft is connected to the piston by a connecting rod and converts the reciprocating motion of the piston into rotary motion for driving the wheels or other applications.
- The four strokes occur in two complete revolutions of the crankshaft.

- Precise timing of valve opening and closing is crucial for efficient engine operation and is controlled by a camshaft or other valve actuation mechanisms.

This four-stroke cycle efficiently converts chemical energy stored in the fuel into mechanical work that can be used to power vehicles, generators, and other machinery

April 2022

April 2022 MDE

3. (a) Sketch a cross section through a four stroke diesel engine piston, labelling the MAIN components. (6)

   (b) Describe the transfer of gas force from piston crown through to the crankshaft. (4)

October 2018 MDE

3. (a) Sketch a cross section through a four stroke diesel engine piston, labelling the MAIN components. (6)

   (b) Describe the transfer of gas force from piston crown through to the crankshaft. (4)

The provided sketch depicts a cross-section through a four-stroke diesel engine piston, labeled with the following main components:

- **Piston Crown:** The top, flat surface of the piston that directly receives the force from the burning fuel mixture in the cylinder.
- **Piston Rings:** These are typically three rings that fit into grooves around the outer circumference of the piston. They slide within the cylinder wall and perform several crucial functions:
  - **Top Ring (Compression Ring):** Seals the combustion chamber by preventing high-pressure gases from leaking past the piston into the crankcase.
  - **Second Ring (Compression Ring):** Provides additional sealing and helps maintain compression in the cylinder.
  - **Scraper Ring (Oil Control Ring):** Scrapes excess oil from the cylinder wall as the piston moves, returning it to the crankcase and preventing excessive oil consumption.
- **Piston Skirt:** The lower portion of the piston that slides within the cylinder bore. It helps maintain proper piston alignment and minimize friction between the piston and cylinder wall.
- **Piston Pin Boss:** A reinforced area on the piston where the piston pin is fitted. This area is designed to handle the forces transmitted from the connecting rod.
- **Piston Pin:** A hollow steel pin that connects the piston to the connecting rod. It allows the piston to pivot slightly within the cylinder while maintaining its connection to the connecting rod.

Gas Force Transfer to Crankshaft (b):

The force generated by the burning fuel mixture in the cylinder is transferred to the crankshaft through a series of connected components:

1. **Piston Crown:** The combustion pressure acts on the piston crown, pushing it downwards with significant force.
2. **Piston Pin:** This force is then transmitted through the piston pin, which connects the piston to the small end of the connecting rod.
3. **Connecting Rod:** The connecting rod acts as a lever arm. As the piston pushes down on the piston pin, the angle between the connecting rod and the crankshaft changes. This causes the crankshaft to rotate on its axis. The big end of the connecting rod is connected to a bearing that sits on the crankshaft journal (a smooth, round surface).
4. **Crankshaft:** The combined force and leverage from the connecting rod create a turning moment on the crankshaft journals. This turning moment causes the crankshaft to rotate, converting the reciprocating (up-and-down) motion of the piston into rotary motion used by the engine to deliver power.

In simpler terms, the combustion force acts like a push on one end of a lever (connecting rod), causing the other end (crankshaft) to rotate. The design of the piston crown, connecting rod, and crankshaft plays a crucial role in efficiently transferring this force and generating usable power for the engine.

Jan 2019

January 2019 MDE

2. With reference to four stroke diesel engine exhaust valves:

(a) explain the effects of EACH of the following:

(i) too large a tappet clearance; (4)

(ii) too small a tappet clearance; (4)

(b) explain why double (nested) valve springs may be fitted. (2)

October 2021 MDE

1. With reference to four stroke diesel engine exhaust valves:

(a) explain the effects of EACH of the following:

(i) too large a tappet clearance; (4)

(ii) too small a tappet clearance; (4)

(b) explain why double (nested) valve springs may be fitted. (2)

Four-Stroke Diesel Engine Exhaust Valves and Tappet Clearance (a):

Tappet clearance refers to the gap between the valve stem and the rocker arm (or other valve actuation mechanism) when the cam lobe is not pushing on the valve. Here's how incorrect tappet clearance affects exhaust valves in a four-stroke diesel engine:

(i) Too Large Tappet Clearance:

- **Delayed Valve Opening:** With excessive clearance, the rocker arm takes longer to contact the valve stem and push it open. This leads to a delayed opening of the exhaust valve, causing hot exhaust gases to remain in the cylinder for a longer duration. This can result in:
    - **Increased Cylinder Temperatures:** Excessive heat can damage pistons, valves, and other engine components.
    - **Reduced Power Output:** Incomplete exhaust gas evacuation can reduce the efficiency of the next intake stroke, leading to lower power output.
    - **Increased Fuel Consumption:** Incomplete combustion due to higher cylinder temperatures and inefficient gas exchange can lead to increased fuel consumption.
- **Increased Valve Train Noise:** The extra space allows for more play between the valve stem and rocker arm, creating knocking or clattering sounds during engine operation.

(ii) Too Small Tappet Clearance:

- **Premature Valve Opening:** With minimal clearance, the valve might remain slightly open even when the cam lobe is not pushing on it. This can lead to:
    - **Loss of Compression:** Premature opening allows some compressed air to escape the cylinder during the compression stroke, reducing engine efficiency and power output.
    - **Burned Exhaust Valve:** Hot exhaust gases can leak past a slightly open valve, burning the valve seat and damaging the valve itself.
    - **Valve Sticking:** In extreme cases, tight clearance can cause the valve to stick open due to heat expansion, leading to severe engine damage.

Double (Nested) Valve Springs (b):

Double or nested valve springs are commonly used in diesel engines for several reasons:

- **High Exhaust Gas Pressure:** Diesel engines experience significantly higher exhaust gas pressures compared to gasoline engines. Double springs provide the necessary force to overcome these high pressures and ensure proper valve closure against the valve seat.
- **Control Valve Dynamics:** The dual springs allow for a more precise control of valve opening and closing. The spring rates and characteristics can be designed to achieve the desired valve opening profile, optimizing engine performance and reducing valve train noise.
- **Safety and Reliability:** In case one spring breaks or weakens, the other spring can still provide some level of valve control, preventing catastrophic engine failure due to a completely open exhaust valve.

By utilizing a combination of high spring force and controlled valve dynamics, double valve springs help ensure proper exhaust valve operation under the demanding conditions of a diesel engine.

june 2021

June 2021 MDE

8. (a) State the safety precautions necessary before removing a four stroke diesel engine cylinder head. (4)

(b) Explain the procedure for removing a four stroke diesel engine cylinder head. (6)

Before removing a four-stroke diesel engine cylinder head, it's crucial to prioritize safety. Here are some essential precautions:

- **Allow Engine to Cool Completely:** Hot engine components can cause severe burns. Ensure the engine has cooled down for several hours before beginning any work.
- **Disconnect Battery:** Disconnect the negative battery terminal to prevent accidental electrical sparks or equipment malfunctions while working on the engine.
- **Drain Coolant:** Drain the engine coolant system to avoid spillage and potential burns when removing hoses connected to the cylinder head.
- **Drain Engine Oil:** Drain the engine oil to prevent contamination and allow for easier removal of components around the cylinder head.
- **Relieve Cylinder Pressure:** Open the decompression valve (if equipped) or crank the engine with the spark plugs (diesel engines: glow plugs) removed to release any remaining pressure trapped in the cylinders.
- **Wear Safety Glasses and Gloves:** Wear safety glasses to protect your eyes from falling debris or fluids. Use appropriate gloves to protect your hands from cuts and abrasions during the removal process.
- **Have a Clear Work Area:** Ensure a clean and organized workspace with enough room to maneuver the cylinder head safely.
- **Use Appropriate Tools:** Gather all the necessary tools for the job, including wrenches, sockets, a torque wrench, a gasket scraper, and a head bolt removal tool (if required).

Procedure for Removing a Cylinder Head (b):

Once the safety precautions are in place, follow these general steps for removing a four-stroke diesel engine cylinder head:

1. Disconnect External Components:

- **Disconnect all wiring harnesses and electrical connectors** attached to the cylinder head.
- **Disconnect and remove any hoses or pipes** connected to the cylinder head, such as coolant hoses, fuel lines, and vacuum lines. Label them for easier reassembly.
- **Remove the exhaust manifold** by loosening and removing the nuts or bolts that secure it to the cylinder head and exhaust system.

2. Remove Rocker Arm Assembly (if applicable):

- Depending on the engine design, there might be a rocker arm assembly on top of the cylinder head.
- Loosen and remove the nuts or bolts holding the rocker arms in place.
- Carefully remove the rocker arm assembly and store it in a safe place, keeping the components organized for proper reassembly.

3. Remove Cylinder Head Bolts:

- Locate the cylinder head bolts and identify the proper removal sequence specified in the engine's service manual. This sequence is crucial to ensure even pressure release on the head and prevent warping.
- Using the appropriate socket or wrench, and possibly a head bolt removal tool if necessary, loosen the cylinder head bolts in the specified order, typically starting from the center and working outwards in a gradual pattern. Don't completely remove the bolts yet.
- Once all bolts are slightly loose, loosen them further in small increments following the sequence again until they are completely removed.

4. Lifting and Removing the Cylinder Head:

- With all the bolts removed, carefully lift the cylinder head slightly to break the seal between the head and the engine block. A pry bar might be needed for initial leverage, but use caution to avoid damaging the head or block surfaces.
- Depending on the engine weight and design, you might need an assistant or a lifting hoist to safely remove the cylinder head.
- Once lifted, carefully maneuver the head away from the engine block, being mindful of any remaining hoses or wires that might snag.

5. Cleaning and Inspection:

- Once removed, place the cylinder head on a clean, flat surface.
- Use a gasket scraper to carefully remove the old cylinder head gasket material from both the head and the engine block surfaces. Ensure all surfaces are clean and free of debris before refitting a new gasket.
- Inspect the cylinder head for any cracks, warpage, or signs of damage. If necessary, the head might require resurfacing or replacement.

Important Note:

This is a general procedure, and specific steps might vary depending on the engine make, model, and year. Always refer to the engine's service manual for detailed instructions and proper torque specifications when refitting the cylinder head.

oct 2018oct 2021feb 2022

February 2022

3. (a) Describe the procedure for setting tappet clearance on diesel engine inlet/exhaust valves. (6)

(b) Explain the importance of tappet clearances. (4)

Setting Tappet Clearance on Diesel Engine Valves (a):

Here's a general procedure for setting tappet clearance on diesel engine inlet and exhaust valves. **Always refer to the specific service manual for your engine** for exact steps and torque specifications.

Tools:

- Feeler gauges (various thicknesses)
- Wrenches (socket or spanner) for adjusting tappet screws/nuts
- Optional: Magnetic parts tray

Steps:

1. **Engine Cool Down and Preparation:** Ensure the engine is cool and off. Disconnect the battery for safety.
2. **Identify Valve Train Components:** Locate the rocker arms, tappet screws/nuts, and pushrods (if applicable) for the valves you're adjusting. Consult the service manual for specific locations.
3. **Reference Valve Adjustment Sequence:** The service manual will specify the recommended order for adjusting valve clearances on all cylinders. This sequence is crucial for maintaining even stress on the head and valves.
4. **Top Dead Center (TDC) Positioning:** For each cylinder you're adjusting, rotate the crankshaft using the appropriate tool (refer to the manual) until the piston for that cylinder reaches Top Dead Center (TDC) of the compression stroke. TDC is usually indicated by alignment marks on the flywheel or crankshaft pulley and a corresponding mark on the engine block.
5. **Intake/Exhaust Valve Selection:** Depending on the engine design, you might adjust both intake and exhaust valves at TDC, or there might be a specific TDC position for each valve type. Refer to the service manual for your engine.
6. **Feeler Gauge Selection:** Choose the appropriate feeler gauge size specified in the service manual for the specific valve (intake or exhaust) you're adjusting.
7. **Checking and Adjusting Clearance:**
    - Insert the chosen feeler gauge between the rocker arm and the valve stem (or tappet adjuster if applicable).
    - There should be a slight drag on the feeler gauge as you move it back and forth. This indicates the correct clearance.
    - If the gauge is too loose (no drag) or too tight (gauge won't fit), use the wrench to adjust the tappet screw/nut accordingly. Tighten the nut while holding the screw to prevent it from turning.
    - Re-check the clearance with the feeler gauge after adjustment.
8. **Repeat for All Valves:** Following the specified sequence, repeat steps 4-7 for all the valves that require tappet clearance adjustment.
9. **Recheck Clearances:** Once all valves have been adjusted, it's recommended to re-check the clearances on all valves after a complete cycle to ensure everything remains within specifications.
10. **Reassemble and Tighten:** Reassemble any removed components like valve covers and tighten them to the specified torque using a torque wrench. Reconnect the battery.

Important Notes:

- This is a general guide, and specific steps and tools might vary based on the engine design.
- Always refer to the manufacturer's service manual for detailed instructions, proper torque specifications, and any special procedures for your specific engine.
- Double-check your work to ensure all clearances are set correctly for optimal engine performance.

Importance of Tappet Clearance (b):

Tappet clearance, also known as valve lash, plays a critical role in the proper operation of a four-stroke diesel engine:

- **Valve Timing:** Correct clearance ensures the valves open and close at the precise moments during the engine cycle (intake, compression, combustion, exhaust). Incorrect clearance can lead to delayed or early valve opening/closing, disrupting the engine's breathing and combustion efficiency.
- **Sealing and Compression:** Proper clearance allows the valves to fully seat against their corresponding seats, creating a tight seal for compression and preventing leakage of combustion gases or intake air.
- **Wear and Tear:** Optimum clearance minimizes wear on the valve train components like rocker arms, pushrods (if applicable), and valve stems.
- **Engine Performance:** Correct tappet clearance contributes to smoother engine operation, improved fuel efficiency, and optimal power output.
- **Noise Reduction:** Excessive clearance can create a knocking or clattering sound during engine operation due to excessive play in the valve train.

Regular inspection and adjustment of tappet clearance are essential for maintaining a healthy and efficient diesel engine.