Oct 2023

October 2023 MDE

3. (a) Explain the difference between *in line* and *vee* type engines. (2)

   (b) State the advantages of *vee* type engines. (2)

   (c) Sketch TWO *vee* engine bottom end arrangement types. (6)

In-Line vs. Vee Engines (a):

Here's a breakdown of the key differences between in-line and vee type engines:

In-Line Engine (Straight Engine):

- All cylinders are arranged in a single row, one behind the other, along the crankshaft.
- Common configurations include 3, 4, 5, and 6 cylinders.
- Simpler design, easier to manufacture and maintain.
- Generally smoother operation due to inherent balance.
- Can be taller and longer depending on the number of cylinders.

Vee Engine:

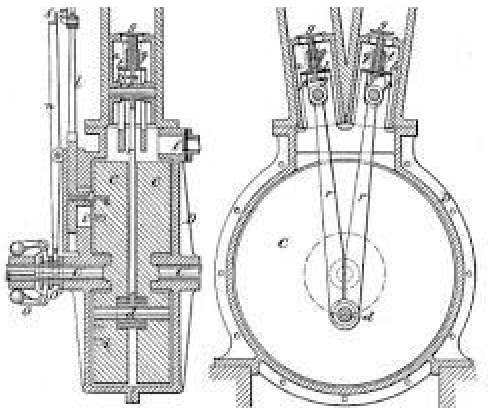
- Cylinders are arranged in two banks at an angle (usually 60 or 90 degrees) to each other, forming a "V" shape.
- pen_spark
- Common configurations include V6, V8, V10, and V12 engines.
- More compact design, especially for higher cylinder numbers, compared to in-line engines.
- Can produce more power and torque due to potential for larger displacement within a smaller footprint.
- Generally more complex design and potentially higher maintenance costs.

Advantages of Vee Engines (b):

- **Compactness:** Vee engines offer a more compact design compared to in-line engines with the same number of cylinders, allowing for better packaging in space-constrained applications like car engine bays.
- **Power and Torque Potential:** The V configuration allows for larger engine displacements within a compact space, enabling higher power output and torque compared to in-line engines of similar size.
- **Lower Center of Gravity:** The V-shaped arrangement can contribute to a lower center of gravity in vehicles, improving handling characteristics.
- **Smoother Operation (in some cases):** V6 engines can achieve inherent balance by having opposing pistons cancel out some vibration, leading to smoother operation compared to an in-line 4-cylinder. However, V8 engines and above often require balancing shafts for smooth operation.

Vee Engine Bottom End Arrangements (c):

1. 60-Degree Vee with Single Crankpin:



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60 degree vee engine with single crankpin

- This design uses a single crankpin with two connecting rods attached (fork-and-blade or side-by-side) for each cylinder bank.
- Offers a compact design but can lead to uneven firing intervals and increased vibration compared to other configurations.
- Commonly used in some V6 engines.

2. 90-Degree Vee with Individual Crankpins:

- This design uses a separate crankpin for each connecting rod in each cylinder bank.
- Provides smoother operation due to more balanced firing intervals compared to the single crankpin design.
- More complex design and potentially higher manufacturing cost.
- Commonly used in V6, V8, and other higher-cylinder-count Vee engines.

feb 2021

February 2021 MDE

3. Describe the principle of operation of a simple hydraulic governor. (10)

April 2022 MDE

4. Describe the principle of operation of a simple hydraulic governor. (10)

Simple Hydraulic Governor: Principle of Operation

A simple hydraulic governor is a mechanical device that utilizes hydraulic principles to regulate the speed of an engine, typically a diesel engine. Here's how it works:

Components:

- **Flyweights:** These are rotating masses driven by the engine's crankshaft. As engine speed increases, the flyweights tend to spread outwards due to centrifugal force.
- **Governor Shaft:** Connected to the flyweights, this shaft rotates with the engine.
- **Sleeve and Control Lever:** This sleeve slides on the governor shaft and is connected to a control lever.
- **Diaphragm and Spring:** A spring-loaded diaphragm separates the high-pressure side of the fuel system from a low-pressure chamber.
- **Fuel Control Valve:** This valve regulates the flow of fuel to the engine.
- **Hydraulic Oil Chamber and Piston:** Connected to the control lever, a piston operates within a chamber filled with hydraulic oil.

Operation:

1. **Engine Speed Increase:** As engine speed increases, the flyweights spread outwards, pushing the governor shaft and sleeve along with them.
2. **Control Lever Movement:** The movement of the sleeve actuates the control lever, which pushes against the diaphragm.
3. **Fuel Pressure Regulation:** By pushing against the diaphragm, the control lever opens the connection between the high-pressure fuel line and the low-pressure chamber. This allows some of the high-pressure fuel to bypass the engine, reducing the overall fuel reaching the cylinders and consequently slowing down the engine.
4. **Speed Regulation:** As the engine speed slows down, the flyweights move back inwards due to reduced centrifugal force. This allows the spring in the diaphragm assembly to push back on the control lever, closing the bypass passage and allowing more fuel to reach the engine, bringing the engine speed back up.

Essentially, the hydraulic governor acts like a feedback loop:

- Increased engine speed -> flyweights move out -> control lever opens bypass -> less fuel -> engine speed decreases.
- Decreased engine speed -> flyweights move in -> control lever closes bypass -> more fuel -> engine speed increases.

By adjusting the spring tension or the position of the flyweights, the governor's setpoint for desired engine speed can be fine-tuned. This ensures the engine maintains a relatively constant speed under varying loads.

Additional Notes:

- In some designs, the hydraulic oil chamber and piston might be replaced by a simpler mechanical linkage achieving the same principle of regulating fuel flow based on governor shaft movement.
- Modern governors may incorporate electronic controls for more precise speed regulation and integration with engine management systems.

april 2022

February 2022

5. Explain, with the aid of labelled sketches, how a scroll type fuel pump meters the fuel for high and low loads. (10)

Scroll type fuel pumps are positive displacement pumps commonly used in large diesel engines, particularly marine applications. They offer a simple yet efficient method for metering fuel based on engine load.

Components:

- **Spiral Groove (Scroll):** This is a helical groove machined into the inner surface of the pump housing.
- **Rotor:** A spool-shaped rotor with a tight fit inside the scroll has an eccentrically positioned cam follower pin.
- **Cam Follower:** This pin rides inside a groove on a drive sleeve connected to the engine.
- **Inlet Port:** Located at the base of the scroll, where fuel enters the pump.
- **Outlet Port:** Located at the top of the scroll, where fuel exits the pump towards the engine injectors.

Metering Mechanism:

1. **Rotation:** The drive sleeve rotates the rotor within the scroll housing.
2. **Eccentricity Effect:** Due to the eccentric cam follower pin, the rotor doesn't rotate perfectly centered within the scroll. This creates a varying volume between the rotor and the scroll during each revolution.

(a) High Load:

- **Large Pockets:** As the rotor rotates at high engine load, the eccentric position allows for the formation of larger pockets between the rotor and the scroll.
- **More Fuel Delivery:** During each rotation, these larger pockets fill completely with fuel on the inlet side and are carried towards the outlet on the discharge side. This results in a higher volume of fuel delivered per revolution, satisfying the increased fuel demand at high engine loads.

(b) Low Load:

- **Smaller Pockets:** At low engine load, the cam follower pin position creates smaller pockets between the rotor and the scroll.
- **Less Fuel Delivery:** These smaller pockets fill with less fuel during each rotation, resulting in a lower overall volume of fuel delivered per revolution, matching the reduced fuel requirement at low engine loads.

Key Points:

- The pump doesn't have an external mechanism for actively controlling fuel flow. The varying volume pockets created by the rotor's eccentric movement achieve the metering.
- Engine speed remains relatively constant, and the varying fuel delivery based on load is achieved by the scroll pump's internal design.

Additional Notes:

- The specific shape and dimensions of the scroll and rotor profile determine the pump's performance characteristics and fuel delivery curve.
- Modern scroll type pumps might incorporate control mechanisms for additional adjustments or integration with electronic engine management systems.

JAN 2023 MDE

4. (a) Sketch a scroll type fuel pump, labelling the main components. (6)

(b) Explain how the pump sketched in part (a) may vary the end of delivery. (4)

(a) Labeled Sketch:

- **Scroll Housing:** Houses the spiral groove (scroll).
- **Spiral Groove (Scroll):** Helical groove machined inside the housing.
- **Rotor:** Spool-shaped rotor with a tight fit inside the scroll.
- **Eccentric Cam Follower Pin:** Off-center pin on the rotor.
- **Cam Follower Groove:** Groove on the drive sleeve where the pin rides.
- **Drive Sleeve:** Connected to the engine, rotates the rotor.
- **Inlet Port:** Where fuel enters the pump.
- **Outlet Port:** Where fuel exits towards the engine injectors.

(b) Varying End of Delivery

The scroll type fuel pump sketched in part (a) doesn't directly control the "end of delivery" (injection timing) of fuel. Fuel injection timing is typically controlled by a separate mechanism within the engine's fuel injection system.

The scroll pump's function is to **meter the fuel quantity** delivered per engine cycle based on load. Here's how the pump design indirectly affects the end of delivery:

- **High Load:** As explained previously, larger pockets form at high load, delivering more fuel per pump revolution. This **increases the volume of fuel available** for injection during the injection window controlled by the separate injection timing mechanism.
- **Low Load:** Smaller pockets deliver less fuel per revolution, reducing the **amount of fuel available** for injection during the same injection window.

In essence, the scroll pump indirectly influences the end of delivery by providing a **variable fuel quantity** based on load, which can then be injected at the appropriate time determined by the injection timing control system.