Module 13: Mechanical Fuel Injection Diagnosis and Repair

- TERMS AND DEFINITIONS
- PARTS OF INJECTION NOZZLES
- TYPES OF NOZZLE VALVES
- OPERATION OF AN INJECTION NOZZLE
- FUEL FLOW THROUGH THE UNIT INJECTOR
- OPTIONAL FEATURES ON FUEL INJECTION PUMPS
- MAIN PARTS OF A DISTRIBUTOR-TYPE INJECTION PUMP
- FUNCTIONS OF MAIN PARTS OF A DISTRIBUTOR-TYPE INJECTION PUMP
- OPERATION OF DISTRIBUTOR-TYPE INJECTION PUMPS
- FUEL FLOW THROUGH DISTRIBUTOR-TYPE INJECTION PUMPS
- MAIN PARTS OF AN IN-LINE INJECTION PUMP
- OPERATION OF AN IN-LINE INJECTION PUMP
- OPERATION OF A CONTROL RACK AND SLEEVE
- PLUNGER AND RACK POSITIONS
- TYPES OF PT INJECTION PUMPS
- MAIN PARTS OF A PT INJECTION PUMP
- OPERATION OF A PT INJECTION PUMP
- TYPES OF PT INJECTORS
- OPERATION OF PT INJECTORS

Terms and Definitions

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- Aneroid is a smoke limiting device.
- Annular groove is a machined recess forming a ring on the pumping plunger.
- Circuit is a complete path of fuel flow.
- Delivery valve is a type of valve that provides retraction of delivery line pressure causing the nozzle valve to return to its seat, thereby preventing dribble of fuel into the combustion chamber.
- Helix is a spiraled, machined recess on the pumping plunger.
- A gallery is a long, narrow fuel or oil passage.
- Governor is a speed-sensing device that uses centrifugal force and spring tension to govern the engine speed.
- Hydraulic means operated or moved by liquid in motion.
- Maximum fuel output is the greatest amount of fuel an injector is capable of delivering as measured by a calibrator.
- Maximum full load speed is the maximum speed that an engine will reach when developing full horsepower.
- Metering is the precision measurement of fuel delivery.
- Orifice is a small hole.
- Pintle is a valve in which the end extends into a shank or pin.
- Registry is an oil passage that indexes with a port in a rotating head.
- Retraction is the act of drawing back.
- Servomechanism is an automatic device for controlling large amounts of power with small amounts of power as a piston is moved by fluid under pressure.
- Spray tip orifices are holes through the wall at the end of the tip that allow fuel to be sprayed into the combustion chamber.

Parts of Injection Nozzles

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- Retaining screw
- Gasket
- Pressure adjusting spring
- Nozzle holder body types
- Nozzle gasket
- Dowel pin
- Nozzle cap nut
- Spindle assembly
- Spring adjusting retaining cap nut
- Protection cap
- Fuel-leak off
- Lift adjusting screw
- Pressure adjusting screw
- Pressure spring
- Locating clamp
- Body seal
- Nozzle body
- Nozzle valve
- Carbon dam seal
- Spray tip

Types of Nozzle Valves

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- A single hole pintle nozzle valve is used on precombustion engines.
- A multiple orifice nozzle valve is used on direct injection engines.

Operation of an Injection Nozzle

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- Step 1: Fuel is delivered under pressure from the injection pump to the injection nozzle through a passage to the pressure chamber.
- Step 2: The spring-loaded valve is lifted allowing pressurized fuel to spray out through one or more orifices into a combustion chamber.
- Step 3: The nozzle opening pressure is adjusted by a screw or shims on the valve spring.

Fuel Flow Through the Unit Injector

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- During the first stage, fuel enters the injector through a filter cap and filter.
- In the second stage, fuel passes through drilled passages and ports into the supply chamber.
  Note: The supply chamber is that area between the plunger bushing and the spill deflector, in addition to that area under the injector plunger within the bushing.
- In the third stage, pump pressure forces fuel through small orifices in the spray tip.
- In the last stage, fuel is atomized into the combustion chamber.

Optional Features on Fuel Injection Pumps

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- Altitude compensator
- Aneroid control (smoke limiter)
- Automatic load advance
- Automatic speed advance
- Centrifugal governor
- Electric shut-off
- Torque control
- Viscosity compensator

Main Parts of a Distributor-Type Injection Pump

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- Drive shaft
- Housing
- Governor
- Pumping plungers
- Automatic advance
- Internal cam ring
- Distributor rotor
- Metering valve
- Pressure regulator
- Hydraulic head

Functions of Main Parts of a Distributor-Type Injection Pump

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- The drive shaft turns the distributor rotor in the hydraulic head.
- The metering valve regulates the quantity of fuel delivered to the cylinders.
- The hydraulic head contains the metering valve and the bore in which the rotor revolves.
- The transfer pump draws fuel from the supply tank through the inlet strainer to the injection pump.
- The pressure regulator limits the pressure of fuel to the injection nozzles.
- The distributor rotor is responsible for the rotation of the rotor, causing a pumping action of the plungers that discharge fuel when the passages index with the appropriate passages in the hydraulic head.
- The internal cam ring actuates the pumping plungers.
- The automatic advance is a hydraulic servomechanism powered by fuel pressure from the transfer pump that advances injection timing.
  Note: Not all pumps are equipped with an automatic advance.
- Pumping plungers provide pressure to transfer fuel from the rotor to the hydraulic head to the injection nozzles.
- The governor regulates the speed by positive mechanical linkage to the metering valve.

Operation of Distributor-Type Injection Pumps

READY FOR REVIEW

- During the first step, the drive shaft engages the distributor rotor in the hydraulic head.
  Note: The drive end of the rotor has two cylinder bores, each containing two plungers.
- During the second step, plungers are actuated toward each other simultaneously by the internal cam-ring to pump the fuel.
- During the third and last step, as the rotor revolves inside the hydraulic head, the discharge passage in the rotor indexes with the appropriate passage in the hydraulic head to lead to the injector nozzles.

Fuel Flow Through Distributor-Type Injection Pumps

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- Step 1: Fuel is drawn from the supply tank through filters into the pump through the inlet filter screen by the vane type fuel transfer pump.
- Step 2: Some fuel is bypassed through the pressure regulator assembly to the suction side.
- Step 3: Fuel under transfer pump pressure flows past the rotor retainers into an annulus on the rotor.
- Step 4: Fuel then flows through a connecting passage in the head to the advance and also to the charging circuit.
- Step 5: The fuel flows around the annulus through a connecting passage to the metering valve.
- Step 6: The radial position of the metering valve, controlled by the governor, regulates the flow of fuel into the charging annulus, which incorporates the charging ports.
- Step 7: As the rotor revolves, the two inlet passages register with the charging ports in the hydraulic head, allowing fuel to flow into the pumping chamber.
- Step 8: With further rotation, the inlet passages move out of registry and the discharge port of the rotor registers with one of the head outlets.
- Step 9: While the discharge port is opened, the rollers contact the cam lobes forcing the plungers together.
- Step 10: Fuel trapped between the plungers is then pressurized and delivered by the nozzle to the combustion chamber.

Main Parts of an In-line Injection Pump

READY FOR REVIEW

- The aneroid limits the fuel supply to the engine in order to prevent excess smoke.
- The individual pumping element opens or closes the helix on the plunger to meter the quantity of fuel delivered to the cylinders.
- The injection line is the supply line for fuel to the injection nozzles.
- The leak-off line is the return line for excess fuel not used by the injection nozzles.
- The pump housing is where the pumps fuel goes when bleeding the system and is commonly located on the fuel transfer pump.
- The hand primer pumps fuel when bleeding the system and is commonly located on the fuel transfer pump.
- The sediment bowl collects contaminants in the fuel system and is commonly found on the bottom of filters.
- The fuel transfer pump draws fuel from the supply tank and then sends fuel at low pressure through filters to the injection pump.
- The camshaft actuates the pumping plungers.
- The control rack rotates the sleeve, which connects to vanes on the plunger.

Operation of an In-Line Injection Pump

READY FOR REVIEW

- First, the plunger-type pump has an engine-driven camshaft rotating at half-engine speed.
- Second, the roller cam followers, riding on cam lobes, operate the plungers to supply high pressure fuel through delivery valves to the injection nozzles.

Operation of a Control Rack and Sleeve

READY FOR REVIEW

- The governor moves the rack to regulate the speed of the engine.
- The sleeve, rotated by the control rack, is fitted over the barrel and connects to the vanes on the plunger.
- The plunger rotation opens or closes the helix, which meters the quantity of fuel for delivery to the cylinder.

Plunger and Rack Positions

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- No fuel delivery
- Partial fuel delivery
- Maximum fuel delivery

Types of PT Injection Pumps

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- PT Type G: Governor controlled
- PTG-AFC: With air-fuel control
- PTG-AFC-VS: With air-fuel ratio control and variable speed

Main Parts of a PT Injection Pump

READY FOR REVIEW

- The gear pump draws fuel from the supply tank forcing it through the pump filter screen.
- The pulsation damper absorbs pulsations and smoothes the fuel flow through the system.
- The AFC valve has a manifold pressure that controls the air-fuel ratio and fuel rate.
- The throttle provides manual control of the fuel flow to the injector under all conditions in operating range.
- The governor assembly controls the flow of fuel from idle to maximum governor speed.
- The shut-down valve stops fuel flow for the shut-down of the engine and may have a manual override.

Operation of a PT Injection Pump

READY FOR REVIEW

- In the first step, a gear type fuel pump delivers fuel through a restricting throttle to the governor.
- During the second step, the fuel goes from the governor to a manifold that feeds cam-operated injectors in the cylinder head.
- During the last step, the injector raises pressure to produce a good spray and times the start of the injection.

Types of PT Injectors

READY FOR REVIEW

- STC (step timing control)
- Top stop

Operation of PT Injectors

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- Metering
  - Fuel enters the injector at the fuel inlet.
    Note: Pressure is determined by the throttle and/or governor.
  - The balance orifice controls the quantity of fuel that enters the injector cup.
    Note: Pressure is determined by the fuel pump and the time interval during which the hole supplying the fuel is uncovered by the injector plunger.
  - This is controlled by the cam profile.
- Injection
  - A downward plunger movement cuts off fuel entry into the injector cup.
  - Continued downward movement forces fuel from the injector cup through the spray orifices into the combustion chamber.
    Note: High pressures allow for almost complete burning of the fuel spray.
- Cooling
  - While the plunger is down, fuel passes through the upper hole around the undercut in the plunger through return passages to the fuel tank.
  - The plunger remains seated after the injection.
    Note: Fuel flows through the injector cooling it and warming the tank fuel through this stage.
  - The plunger rises back to metering operation.