

Assembly & Disassembly Manual

Gas Engine

Model: WP6GNA

WEICHAI AMERICA CORP.



WEICHAI



Purpose

This manual is intended to inform customers on how to assemble and disassemble the Weichai America 6 Liters naturally aspirated engine. This document will be provided to customer so they can incorporate this information into their manuals and service documents.

Maintenance Providers

Maintenance and repair services may be performed by you or any qualified engine service provider that you choose. However, your engine warranty does not cover damage or failure caused by improper maintenance or repairs.

Owner's Manual & Maintenance Records Storage & Use

Store this Owner's Manual and Maintenance Records in a safe, visible place by your engine. The maintenance log must be updated whenever your engine is serviced. If repairs are being done under warranty be sure to follow proper warranty procedures. (see Weichai America Corp Warranty Procedure Manual)



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1 Disassembly & Assembly of Engine

1.1 Safety Precautions

Please strictly comply with instructions in this manual to safely and properly disassemble and assemble the engine.

1.2 Environmental Protection Measures

Please comply with relevant laws and regulations on environmental protection when handling oil and hydrocarbon waste. For further instructions please contact your local officials.

1.3 Notes for Disassembly and Assembly of Engine

Failure in complying with safety regulations and basic safety practices causes the majority of engine-related accidents. Proper training is required for all engine operators and maintenance personnel. Any violation of instructions in this manual may result in serious injury or death.

Note: Before proceeding with any maintenance or repair operation, place a sign clearly stating “Maintenance In Progress, Do Not Use” on the engine starter switch.

Take the following precautions before using a lockout tool and beginning maintenance or repair:

- Ensure the maintenance site and surrounding area are clean and suitable for safe operation.
- Remove any rings, necklaces, watches, or other jewelry and wear appropriate close-fit work clothes before entering the maintenance site.
- Wear relevant protective devices (goggles, gloves, shoes, masks, work clothes, helmet, etc.) that are in good condition prior to entering the maintenance site.
- Do not use any defective, worn, broken, or inappropriate tools.

NOTICE: THE ENGINE MUST BE COMPLETELY SHUT DOWN PRIOR TO MAINTENANCE.

2 Fuel System

2.1 Fuel System Assembly and Disassembly

2.1.1 Fuel System Exploded View

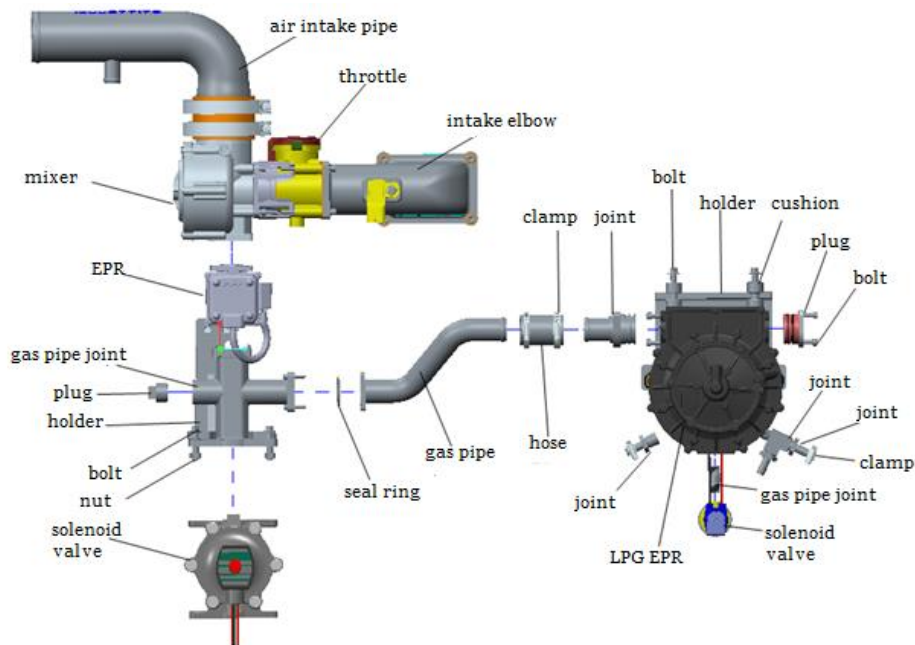


Fig. 2-1 Exploded view of gas supply system

2.1.2 Fuel System Disassembly Procedure

1. Remove ECU.
2. Remove the LPG intake system.
3. Remove the NG intake system.
4. Remove the electronic pressure regulating system.

2.1.3 Fuel System Assembly Procedure

Reverse the Disassembly Procedure (2.1.2) to assemble the Gas Supply System.

2.1.4 Fuel System Inspection and Maintenance

2.2 LPG Intake System Assembly and Disassembly

2.2.1 LPG Intake System Exploded View

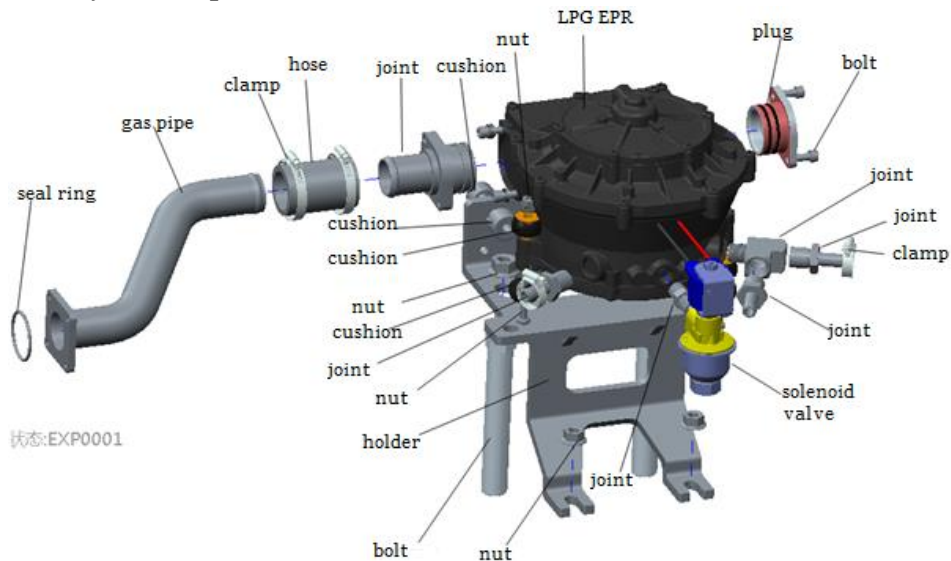


Fig. 2-2 Exploded view of LPG supply system

2.2.2 LPG Intake System Disassembly Procedure

1. Remove the clamps from the gas hose. Separate the hose from the NG intake system.
2. Remove the nuts and washers bolting the LPG bracket to the cylinder head assembly. Separate the LPG bracket and LPG evaporator from the cylinder head assembly.
3. Remove the water inlet and outlet fitting clamps. Disconnect the LPG evaporator from the water inlet and outlet hoses.
4. Remove the connecting bolts and isolator cushions between the LPG evaporator and the LPG bracket. Fully remove the LPG evaporator assembly from the LPG bracket.
5. Remove the hex nipple fitting between the LPG evaporator and LPG lock-off valve. Separate LPG evaporator and LPG lock-off valve.
6. Remove the LPG evaporator plug and adapter from the LPG evaporator.

2.2.3 LPG Intake System Assembly Procedure

Reverse the Disassembly Procedure (2.2.2) to assemble the LPG Supply System.

2.2.4 LPG Intake System Inspection and Maintenance

1. Check the LPG gas valve and hoses for leaks.

2. Check the coolant fittings and hoses for leaks.

2.3 NG Shut-Off Valve Assembly and Disassembly

2.3.1 NG Shut-Off Valve Exploded View

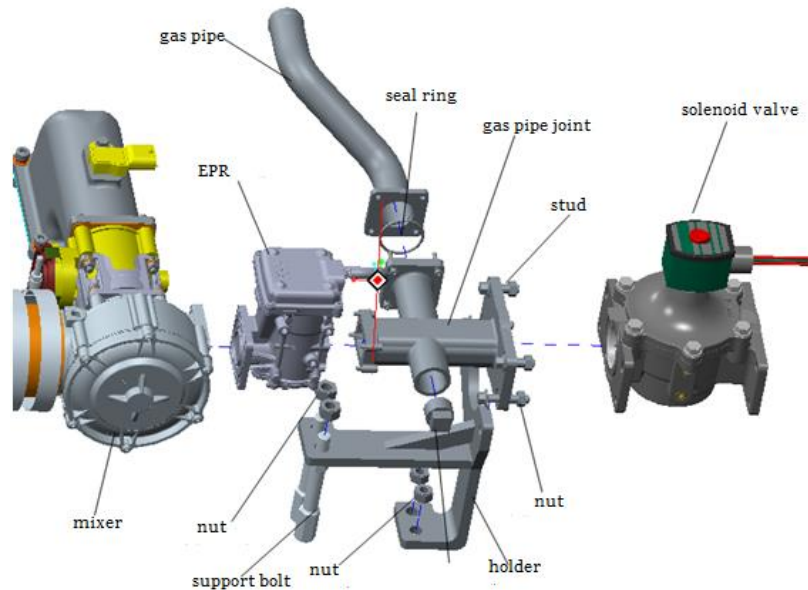


Fig. 2-3 Exploded view of electromagnetic valve

2.3.2 NG Shut-Off Valve Disassembly Procedure

1. Remove the bolts and nuts bolting the NG shut-off valve to the gas pipe joint.
2. Remove the bolts and nuts bolting the NG bracket to the NG shut-off valve. Remove the NG shut-off valve.
3. Remove the O-ring from the groove in the NG shut-off valve.

2.3.3 NG Shut-Off Valve Assembly Procedure

Replace the O-ring and reverse the Disassembly Procedure (2.3.2) to assemble the NG Electromagnetic Valve.

2.3.4 NG Shut-Off Valve Inspection and Maintenance

The inspection and maintenance of the NG shut-off valve must be performed at a special service station.

2.4 Electronic Pressure Regulator (EPR) Assembly and Disassembly

2.4.1 EPR Exploded View

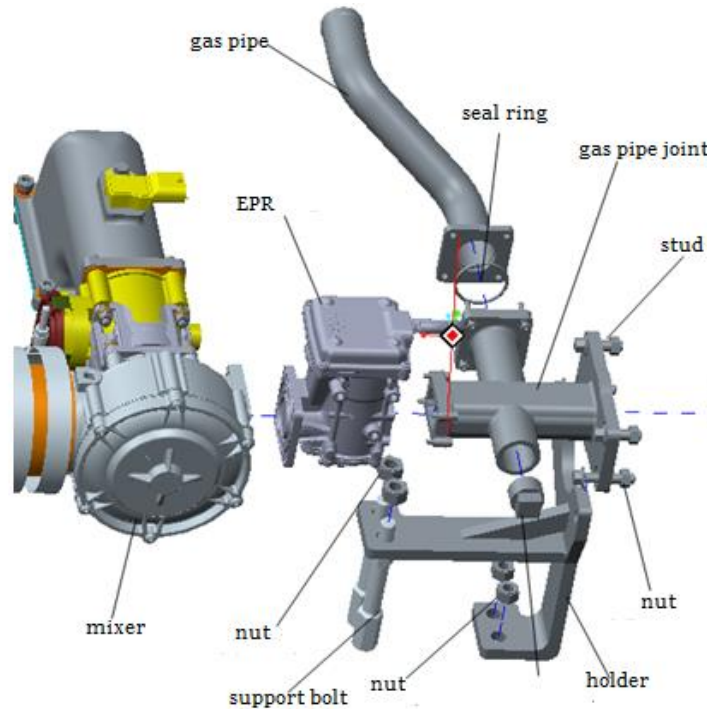


Fig. 2-4 Exploded view of electronic pressure regulating valve

2.4.2 EPR Disassembly Procedure

1. Remove the socket head bolts and washers bolting the gas pipe joint to the EPR.
2. Remove the hex bolts and washers bolting the EPR to the mixer. Remove the EPR.

2.4.3 EPR Assembly Procedure

Reverse the Disassembly Procedure (2.4.2) to assemble the EPR.

2.4.4 EPR Inspection and Maintenance

The Inspection and Maintenance of the EPR must be performed at a special service station.

2.5 Mixer Assembly and Disassembly

2.5.1 Mixer Exploded View

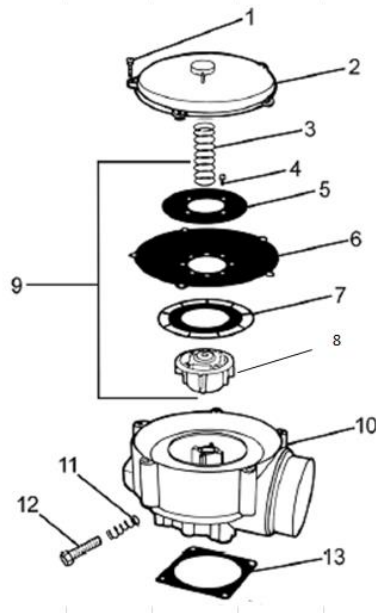


Fig. 2-5 Exploded view of mixer

No.	Part Name	No.	Part Name	No.	Part Name
1	Screws	6	Diaphragm	11	Spring
2	Mixer Cover	7	Ring	12	Adjustment Screw
3	Spring	8	Air Fuel Regulator Valve	13	Gasket
4	Screws	9	Diaphragm Assembly		
5	Board	10	Mixer body		

2.5.2 Mixer Diaphragm Disassembly Procedure

1. Remove the screws on the mixer cover. Remove the mixer cover.
2. Remove the diaphragm spring.
3. Remove the diaphragm assembly.

2.5.3 Mixer Diaphragm Assembly Procedure

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Reverse the Disassembly Procedure (2.5.2) to assemble the Mixer Diaphragm.

2.5.4 Mixer Diaphragm Inspection and Maintenance

If gas flow is insufficient:

1. Rotate the adjustment screw clockwise to increase the flow of gas.
2. Replace the gas diaphragm with a biogas diaphragm to increase the flow of gas.

To replace the mixer diaphragm according to maintenance specifications:

1. Remove the old mixer diaphragm.
2. Check the diaphragm for deformation, tears, and deficiencies. Replace it if necessary.
3. Check the diaphragm for oil contamination and corrosion. Clean it if necessary.
4. Clean the diaphragm with a special cleaning agent.



3 Intake and Exhaust System

3.1 Intake and Exhaust System Assembly and Disassembly

3.1.1 Intake and Exhaust System Exploded View

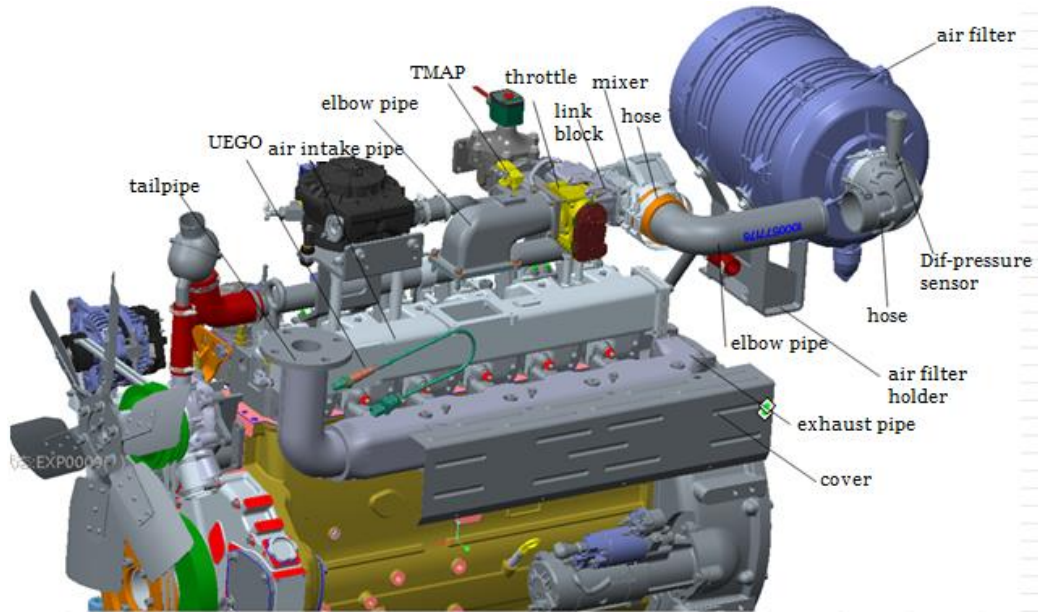


Fig. 3-1 Exploded view of intake and exhaust system

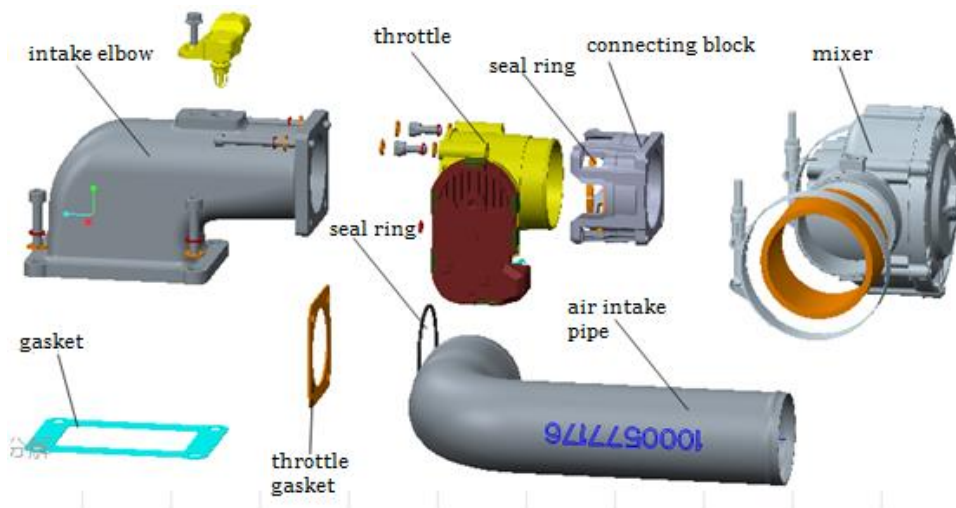


Fig. 3-2 Exploded view of intake elbow



3.1.2 Intake and Exhaust System Disassembly Procedure

1. Loosen the clamps on the air filter elbow, elbow pipe breather connection, and the mixer hose. Remove the air filter elbow, elbow pipe, and mixer hose.

2. Remove the hex bolts bolting the air filter to the air filter bracket. Remove the air filter

3. Remove the socket head bolts bolting the throttle adapter to the mixer. Remove the mixer.

Note: If the EPR has not been removed, remove the hex bolts bolting the EPR to the mixer.

4. Remove the nut and bolt bolting the intake elbow to the throttle and throttle adapter. Remove the throttle adapter and throttle together in one piece, then the throttle gasket.

Note: After removal, hold the throttle and throttle adapter together with bolt holes still aligned to prevent the O-ring from falling out.

5. Remove the bolts bolting the intake elbow to the intake manifold. Remove the intake elbow and intake elbow gasket.

6. Remove the nuts bolting the exhaust elbow to the exhaust manifold. Remove the exhaust pipe and gasket. See details in Exhaust Manifold Assembly and Disassembly (3.3).

CAUTION: The exhaust elbow will be extremely hot after engine operation.

7. Remove the bolts bolting the intake manifold to the engine block. Remove the intake manifold, cover plates, and gaskets. See details in Intake Manifold Assembly and Disassembly (3.2).

3.1.3 Intake and Exhaust System Assembly Procedure

Reverse the Disassembly Procedure (3.1.2) to assemble the Intake and Exhaust System.

3.2 Intake Manifold Assembly and Disassembly

3.2.1 Intake Manifold Exploded View

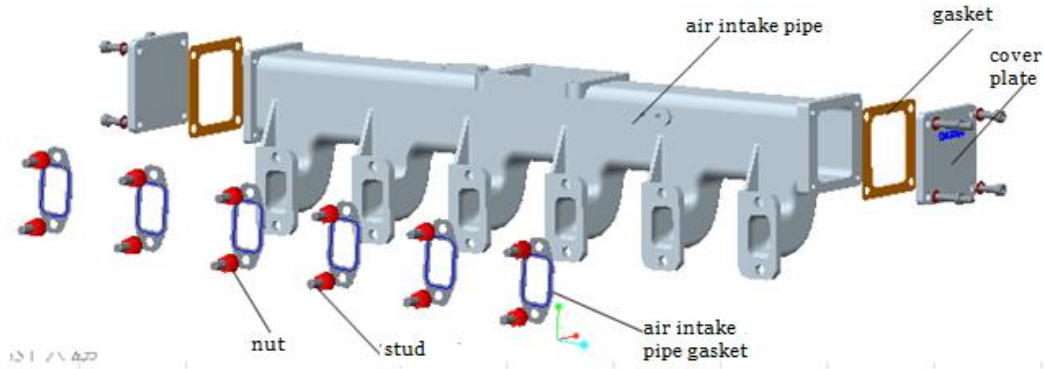


Fig. 3-3 Exploded view of intake manifold

3.2.2 Intake Manifold Disassembly Procedure

1. Remove the nuts bolting the intake manifold to the engine block. Remove the intake manifold and gaskets.
2. Remove the bolts bolting the cover plates to the intake manifold. Remove the cover plates and the gaskets.

3.2.3 Intake Manifold Assembly

Reverse the Disassembly Procedure (3.2.2) to assemble the intake pipe. Recommended tightening torque for the nuts bolting the intake pipe to the engine block is 23Nm.

3.2.4 Intake Manifold Inspection and Maintenance

1. Check the intake manifold for weld defects. Replace the pipe if necessary.
2. Check the intake pipe gaskets for damage and tears. Replace the gaskets if necessary.

3.3 Exhaust Manifold Assembly and Disassembly

3.3.1 Exhaust Manifold Exploded View

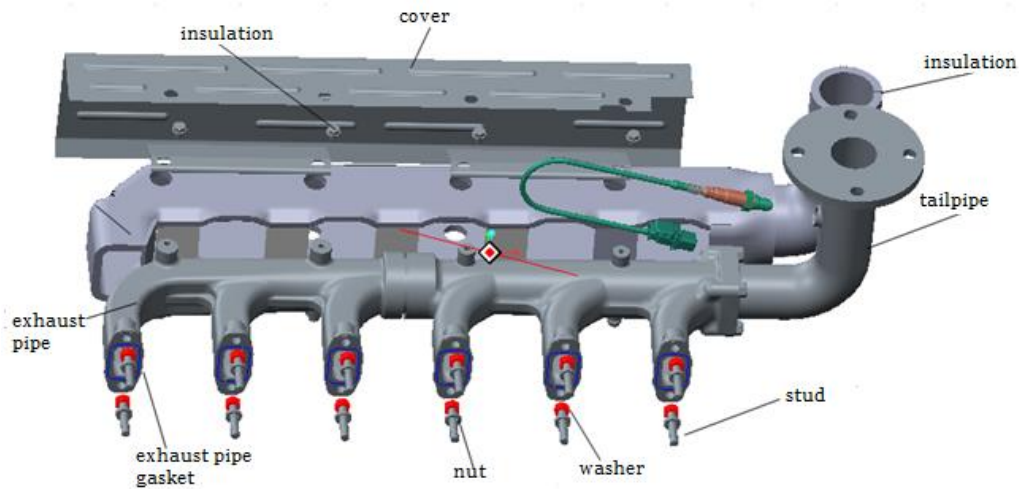


Fig. 3-4 Exploded view of exhaust manifold

3.3.2 Exhaust Manifold Disassembly Procedure

CAUTION: All parts of the exhaust manifold and exhaust elbow will be extremely hot after engine operation.

1. Remove the heat shield bolts and the heat shield.
2. Untie the exhaust elbow insulation ties. Remove the exhaust elbow insulation with the ties.
3. Loosen and remove the oxygen sensor.
4. Remove the nuts bolting the exhaust elbow to the exhaust manifold. Remove the exhaust elbow and gasket.
5. Remove the nuts bolting the exhaust manifold to the engine block. Remove the exhaust manifold.

3.3.3 Exhaust Manifold Assembly Procedure

Reverse the Disassembly Procedure (3.3.2) to assemble the exhaust pipe. Note the following during assembly:

1. Apply molybdenum disulfide to exhaust manifold bolts before use.
2. Torque the exhaust manifold attachment bolts to the recommended tightening torque of 65~80Nm.

3. Do not reuse exhaust manifold attachment bolts more than twice.

3.3.4 Exhaust Manifold Inspection and Maintenance

1. Check for cracks in the exhaust manifold and deformations in the exhaust elbow flange. Replace the exhaust manifold and exhaust elbow if necessary.
2. Check the exhaust elbow flange for any air leakage. Replace the exhaust elbow gasket if necessary.
3. Check exhaust elbow gasket for any deformation, tearing, or deficiencies. Replace it if necessary.

3.4 Ignition System Assembly and Disassembly

3.4.1 Ignition System Exploded View

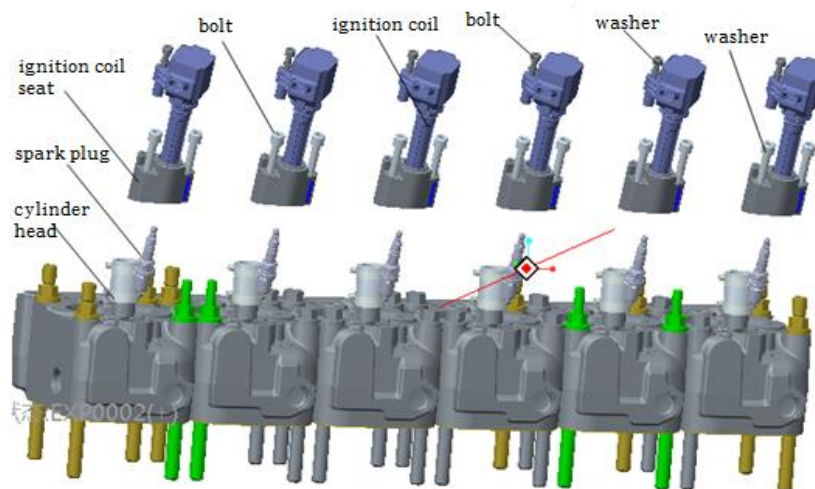


Fig. 3-5 Exploded view of ignition system

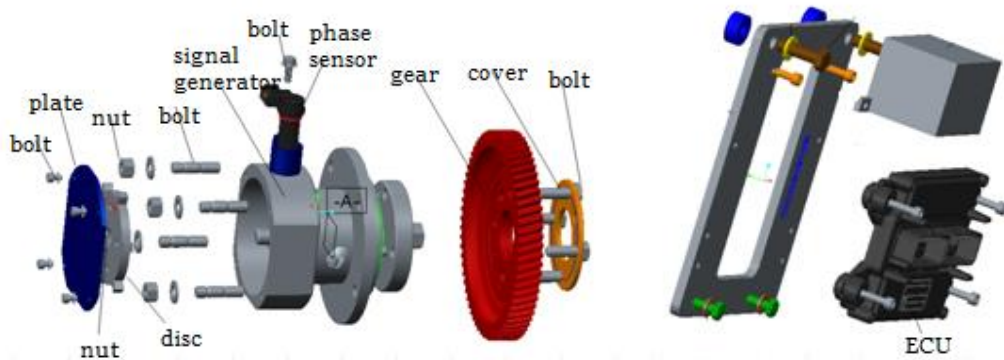


Fig. 3-6 Exploded view of ignition system

3.4.2 Ignition System Disassembly Steps

1. Unplug the wiring harness connector from the ECU and ignition coil.
2. Remove ignition coil bolts and ignition coils.
3. Remove spark plugs.
4. Remove signal generator. See Signal Generator Assembly and Disassembly (3.5) for details.

3.4.3 Ignition System Assembly Steps

Reverse the Disassembly Procedure (3.4.2) to assemble the Ignition System

3.4.4 Ignition System Inspection and Maintenance

Inspection and Maintenance of spark plugs, ignition coils, and the signal generator must be performed at a special service station.

3.5 Signal Generator Assembly and Disassembly

3.5.1 Signal Generator Exploded View

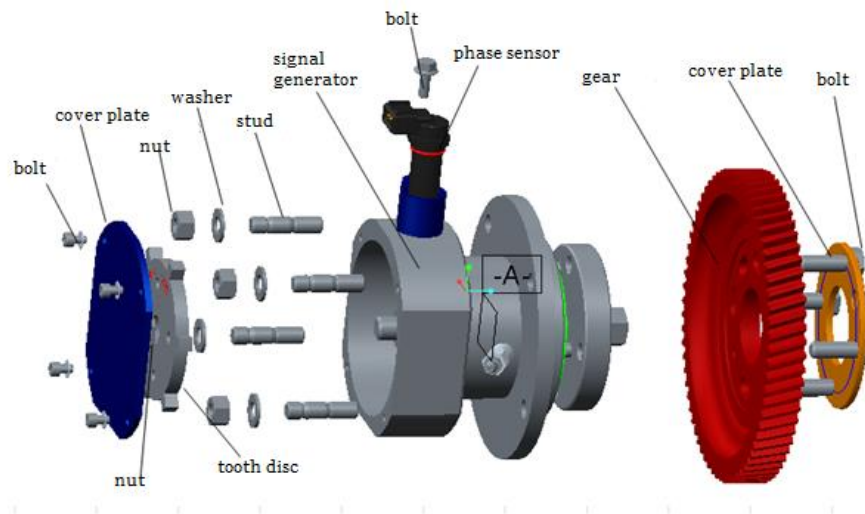


Fig. 3-7 Exploded view of signal generator

3.5.2 Signal Generator Disassembly Procedure

1. Remove the connecting bolts of the pump gear and signal generator.
2. Remove the hex nuts between signal generator flange and engine block.
3. Remove the signal generator from the engine.

3.5.3 Signal Generator Assembly Procedure

1. Adjust the crankshaft to TDC: the first cylinder piston should be in its compression stroke. Tighten the connecting bolts between the pump gear and signal generator.
2. Tighten the hex nuts between signal generator and engine block.
3. Adjust the fluted signal generator disc until its TDC mark points at the center of the speed sensor and the predetermined ignition angle is reached.
4. Tighten the locknut on the signal generator fluted disc.
5. Tighten the hex nuts on the signal generator cover plate.

3.5.4 Inspection and Maintenance of Signal Generator

1. Check for damage to the signal generator shaft threads.
2. Check that the locknuts of the signal generator fluted disc are tightened and that the ignition angle of the signal generator is correct.
3. Check for damage to the speed sensor, tooth disc, or housing.

3.6 Engine Control Unit (ECU) Assembly and Disassembly

3.6.1 ECU Exploded View

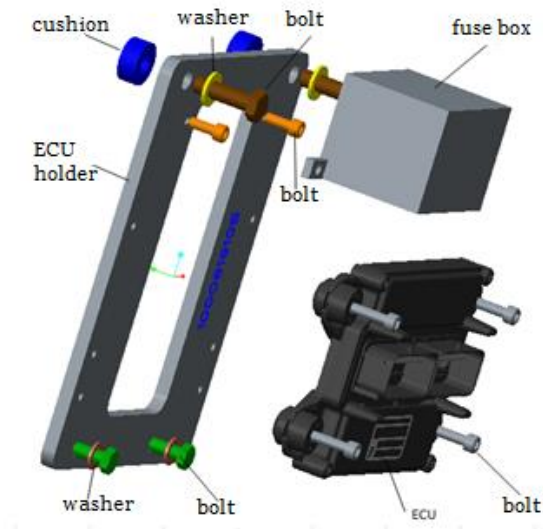


Fig. 3-8 Exploded view of ECU

3.6.2 ECU Disassembly Procedure

1. Remove the fuse box bolts. Remove the fuse box from the bracket.
2. Remove the Harness ECU Connection from the ECU.
3. Remove the ECU bolts. Remove the ECU from the bracket.

3.6.3 ECU Assembly Procedure

Reverse the Disassembly Procedure (3.6.2) to assemble the ECU

3.6.4 Inspection and Maintenance of ECU

1. Check to see if any ECU connection pins are corroded, bent, broken, missing, or damaged.
Replace the pins if necessary.
2. Check the plastic portion of the ECU connection for damage. Replace the ECU if there is any damage.

4 Starting System

4.1 Starting System Assembly and Disassembly

4.1.1 Starting System Exploded View

The starter is the core component of the starting system. The starter converts battery power to

electromagnetic torque. The ring gear mechanism drives the starting engine rotation. The starter motor's main components are the DC motor, one-way clutch, reduction gear train, electromagnetic switches, and the starter relay. See the dismantled starting system in Fig. 4-1.

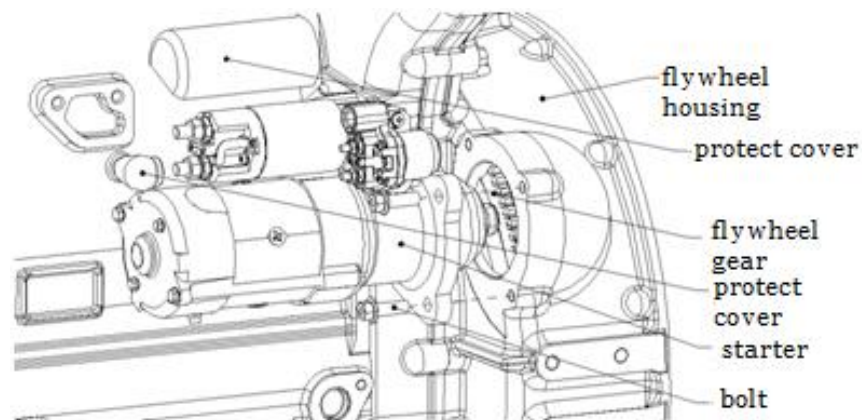


Fig. 4-1 Exploded view of starting system

4.1.2 Starting System Disassembly Procedure

1. Fully disconnect all harness connections from the starter.
2. Remove the three hex bolts between the starter and the flywheel housing.
3. Hold the starter motor firmly and pull it out from the flywheel housing.

Caution: The starter motor is heavy, so maintain a very firm grip before pulling.

4.1.3 Starting System Assembly Procedure

Reverse the Disassembly Procedure (4.1.2) to assemble the Starting System

4.1.4 Inspection and Maintenance of Starting System

1. Check the starter motor gear for damage, replace it if necessary.
2. Check the starter wiring to ensure that it is correct, tight, and secure.

5 Engine Accessory System

5.1 Engine Accessory System Assembly and Disassembly

5.1.1 Engine Accessory System Exploded View

The engine accessory system consists primarily of the belt and alternator.

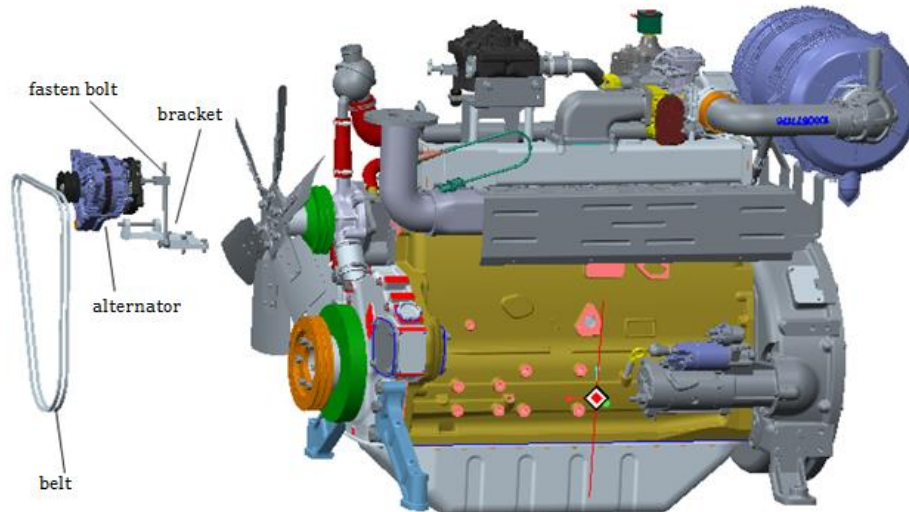


Fig. 5-1 Exploded view of engine accessory system

5.1.2 Engine Accessory System Disassembly

Refer to the Engine Accessory System Exploded View (Figure 5-1) for disassembly details.

1. Remove the alternator pulley belt, bolts, and alternator. See Alternator Assembly and Disassembly (5.2) for details.
2. Remove the alternator bracket and bolts.

5.1.3 Engine Accessory System Assembly

Reverse the Disassembly Procedure (5.1.2) to assemble the Engine Accessory System.

5.2 Alternator Assembly and Disassembly

5.2.1 Alternator Exploded View

Alternator parts include the alternator, alternator bracket, tension bolts, corresponding attachment bolts, washers, and nuts as shown in Fig. 5-2.

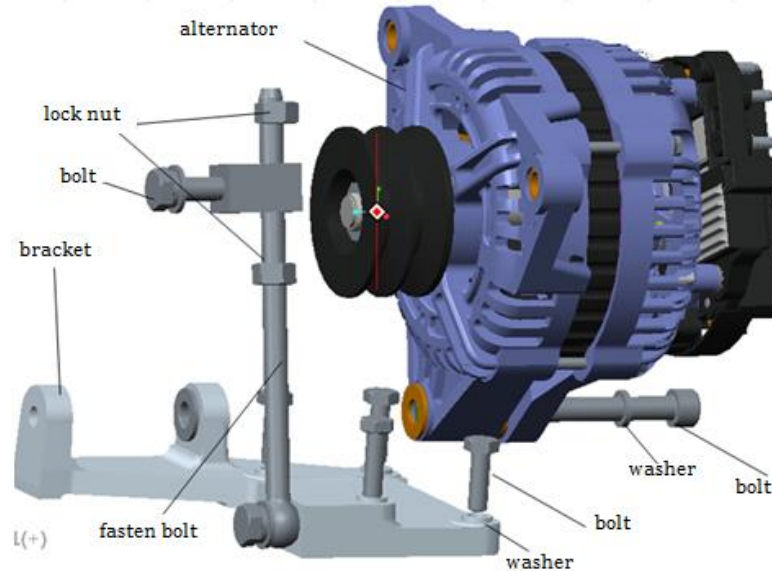


Fig. 5-2 Exploded view of generator

5.2.2 Alternator Disassembly Procedure

1. Remove the alternator lock nut to loosen the belt if it has not already been removed. Remove the belt from the alternator pulley.
2. Remove the ground cable and the battery cable from the alternator.
3. Remove all bolts bolting the alternator to the bracket. Remove the alternator from its bracket.
4. Remove the four hex bolts bolting the alternator bracket to the engine block. Remove the alternator bracket from the engine block.

5.2.3 Alternator Assembly Procedure

Reverse the Disassembly Procedure (5.2.2) to assemble the Alternator.



6 Closed Crankcase Ventilation (CCV) Breather System Assembly and Disassembly

6.1 CCV Breather System Assembly and Disassembly

6.1.1 CCV Breather System Exploded View

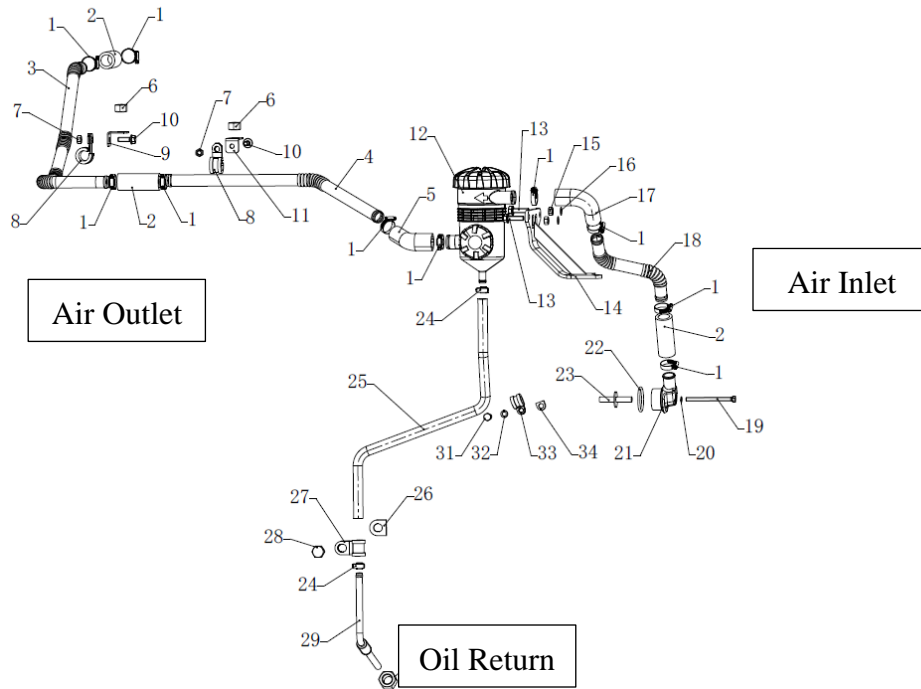


Fig. 6-1 Exploded view of CCV breather system

No.	Name	No.	Name	No.	Name	No.	Name
1	Clamp	11	Bracket	21	Bypass Port	31	Bolt
2	Rubber Hose	12	CCV Breather	22	O-Ring	32	Washer
3	Formed Hose	13	Hex Bolt	23	Bracket	33	Clamp
4	Formed Hose	14	Breather Bracket	24	Clamp	34	Washer
5	Rubber Hose	15	Hex Nut	25	Formed Rubber Hose		
6	Hex Nut	16	Washer	26	Washer		



7	Hex Nut	17	Rubber Hose	27	Clamp		
8	Clamp	18	Formed Hose	28	Bolt		
9	Bracket	19	Bolt	29	Oil Return Pipe		
10	Hex Bolt	20	Washer	30	Nut		

6.1.2 CCV Breather System Disassembly Procedure

1. Loosen the clamps on the air outlet. Remove all air outlet formed and rubber hoses.
2. Loosen the clamps on the oil return pipe. Remove the oil return pipe and hose.
3. Loosen the clamps on the air inlet. Remove all air inlet formed and rubber hoses.
4. Loosen the bolts fixing the breather to the breather bracket. Remove the breather completely.
5. Loosen the bolts fixing the breather bracket to the engine block. Remove the breather bracket.
6. Remove the bypass port from the engine block. Remove the bypass port, bolt, washer, and O-ring.

6.1.3 CCV Breather System Assembly Procedure

1. Install the bypass port with a new O-ring. Each O-ring can only be used once.
2. Install the breather bracket.
3. Install the breather.
4. Install all formed and rubber hoses, oil pipes and hoses, and clamps.

6.1.4 CCV Breather System Inspection and Maintenance

Inspection:

- 1) Check the breather system appearance for any parts that are damaged or flawed. Replace the damaged or flawed parts.
- 2) Check for any oil leakages in the system.

Check for proper air flow by blowing air into the CCV breather. If resistance is high, clean the breather element. If the problem persists, replace the breather element.

6.2 CCV Breather Assembly and Disassembly

6.2.1 CCV Breather Exploded View

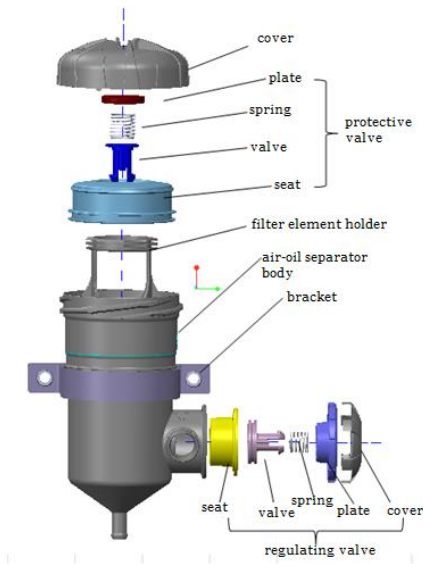


Fig. 6-2 Exploded view of CCV breather

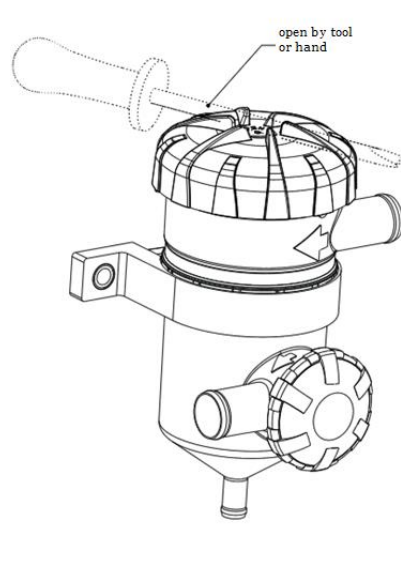


Fig. 6-3 Schematic diagram of disassembly

6.2.2 CCV Breather Disassembly

Open the top cover of the breather by tool or hand. Remove the breather filter element.

6.2.3 CCV Breather Assembly

1. Clean the inside of the breather. Insert a new breather filter element.
2. Screw the top cover back onto the breather.

6.2.4 CCV Breather Inspection and Maintenance

Check the breather filter element for any damage, replace it if necessary.

7 Cooling System

7.1 Cooling System Disassembly and Assembly

7.1.1 Cooling System Exploded View

The cooling system ensures that the engine can operate at the proper operating temperature. Forced circulation cooling is most effective at keeping the engine within the normal operating temperature range. The cooling system primarily consists of the water pump, fan, expansion water tank, water tank and thermostat.

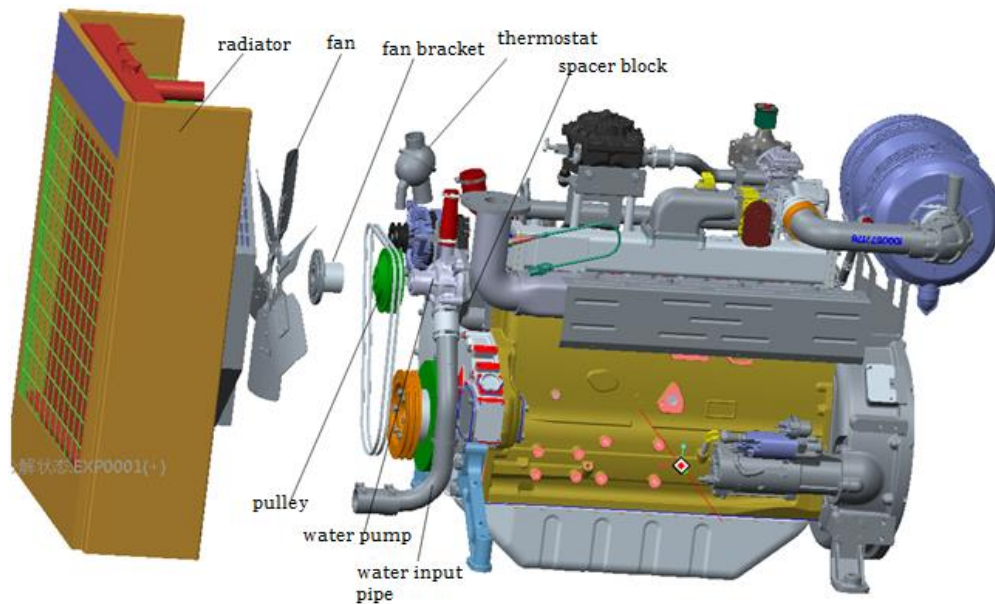


Fig. 7-1 Exploded view of cooling system

7.1.2 Cooling System Disassembly Procedure

1. Remove the water tank.
2. Remove the fan.
3. Remove the belt.
4. Remove the generator and other auxiliary parts.
5. Remove the thermostat.
6. Remove the water pump.



7. Remove the middle cushion block of water pump.

7.1.3 Cooling System Assembly Procedure

Reverse the Disassembly Procedure (7.1.2) to assemble the Cooling System.

7.2 Fan Assembly and Disassembly

7.2.1 Fan Exploded View

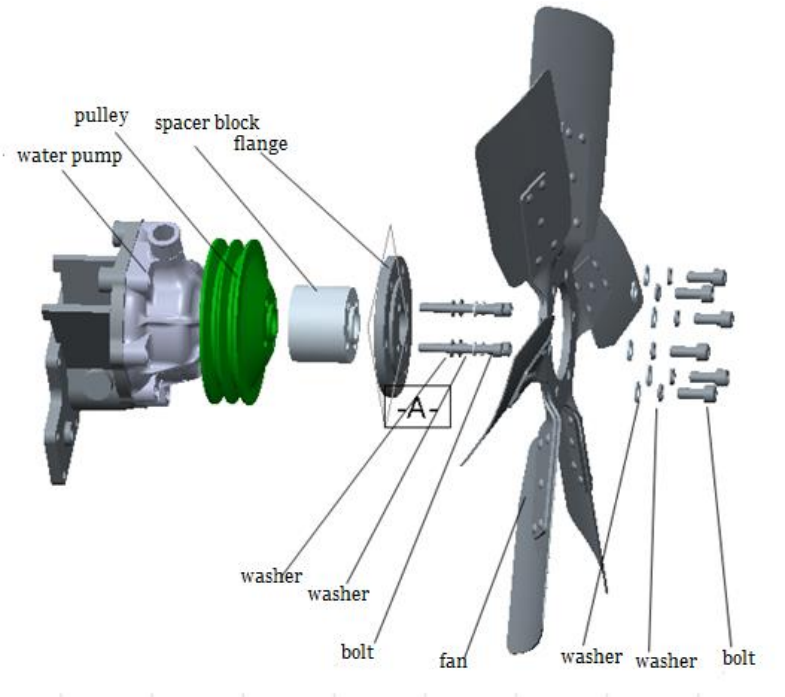


Fig. 7-2 Exploded view of fan

7.2.2 Fan Disassembly Procedure

1. Loosen the six fixing bolts on the fan. Remove the bolts, washers, and fan.
2. Loosen the bolts connection the flange to the spacer block. Remove the bolts, washers, flange, and spacer block.

7.2.3 Fan Assembly Procedure

1. Prior to assembly, check the fan, flange and fastening bolts for any manufacturing defects or damage. Replace components if necessary.
2. Reverse the Disassembly Procedure (7.2.2) to assemble the Fan.

7.2.4 Inspection and Maintenance of Fan

Check the fan, flange, and water pump pulley for any cracks or damage. Replace if necessary.



7.3 Thermostat Disassembly and Assembly

7.3.1 Thermostat Exploded View

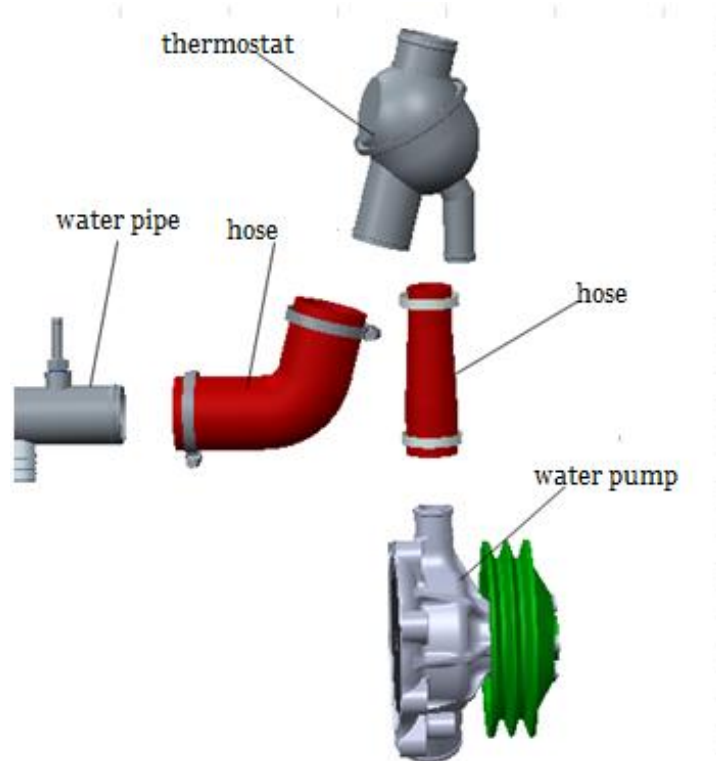


Fig. 7-3 Exploded view of thermostat

7.3.2 Thermostat Disassembly Procedure

1. Loosen the clamps around the hose connecting the water pipe and thermostat. Remove the hose.
2. Loosen the clamps around the hose connecting the thermostat and water pump. Remove the hose and thermostat.

7.3.3 Thermostat Assembly Procedure

Reverse the Disassembly Procedure (7.3.2) to assemble the Thermostat.

7.3.4 Thermostat Inspection and Maintenance

1. Check the clamps to ensure good condition. Replace any if necessary.
2. Check the coolant rubber hoses for cracks or damage. Replace them if necessary.
3. Check the thermostat for fracturing or damage. Replace it if necessary.

7.4 Water Pump Assembly and Disassembly

7.4.1 Water Pump Exploded View

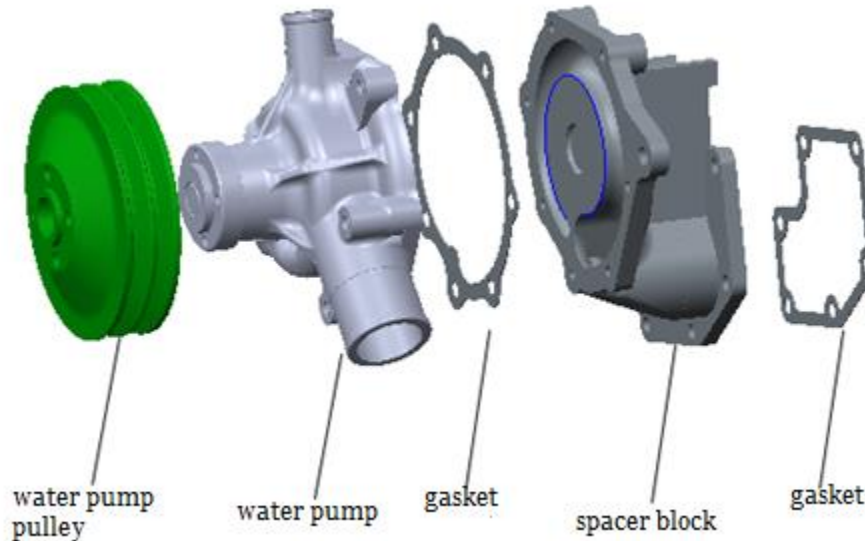


Fig. 7-4 Exploded view of water pump

7.4.2 Water Pump Disassembly Procedure

1. Remove the water pump pulley.
2. Remove thermostat connecting hose and clamps.
3. Remove the hexagon bolts on the pump.
4. Remove water pump, gasket and middle cushion block.

7.4.3 Water Pump Assembly Procedure

Reverse the Disassembly Procedure (7.4.2) to assemble the Water Pump.

7.4.4 Water Pump Inspection and Maintenance

1. Check the water pump gasket for any cracks or damage. Replace it if necessary.
2. Check the bolts and studs for any damage to the threads. Replace any if necessary.
3. Check water pump and middle cushion block for cracks. Replace them if necessary.

8 Front Cover Components

8.1 Torque Vibration Damper and Crankshaft Pulley Assembly and Disassembly

8.1.1 Torque Vibration Damper and Crankshaft Pulley Exploded View

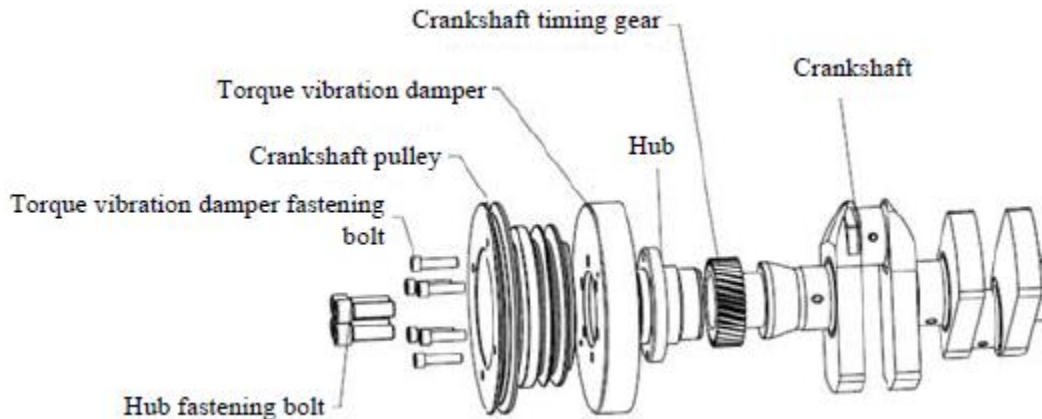


Fig. 8-1 Exploded view of damper, pulley, and hub

8.1.2 Torque Vibration Damper and Crankshaft Pulley Disassembly Procedure

1. Remove the six damper fastening bolts. Remove the crankshaft pulley and torque vibration damper in the order listed.
2. Remove the four hub fastening bolts. Remove the hub from the crankshaft.

8.1.3 Torque Vibration Damper and Crankshaft Pulley Assembly Procedure

Install the hub, torque vibration damper and crankshaft pulley as follows:

1. Fasten the hub to crankshaft with the hub fastening bolts and tighten.
2. Torque the hub fastening bolts:
 - Bolt specification M16-12.9 (×4);
 - Tightening torque: 300~310Nm;
 - Test value: 300~360Nm.
3. Fasten the torque vibration damper and crankshaft pulley to the hub with the damper fastening bolts and tighten.
4. Torque vibration damper fastening bolts:
 - Bolt specification M10-10.9 (×6);



Tightening torque: 60~70Nm;

Test value: 65~80Nm.

8.1.4 Torque Vibration Damper and Crankshaft Pulley Inspection and Maintenance

1. Check the crankshaft pulley for any damage and distortion. Replace if necessary.
2. Check the torque vibration damper and hub for damage. Replace either if necessary.
3. Check the hub fastening bolts and damper fastening bolts for damaged. Replace any if necessary.

8.2 Gear Housing Assembly and Disassembly

8.2.1 Gear Housing Exploded View

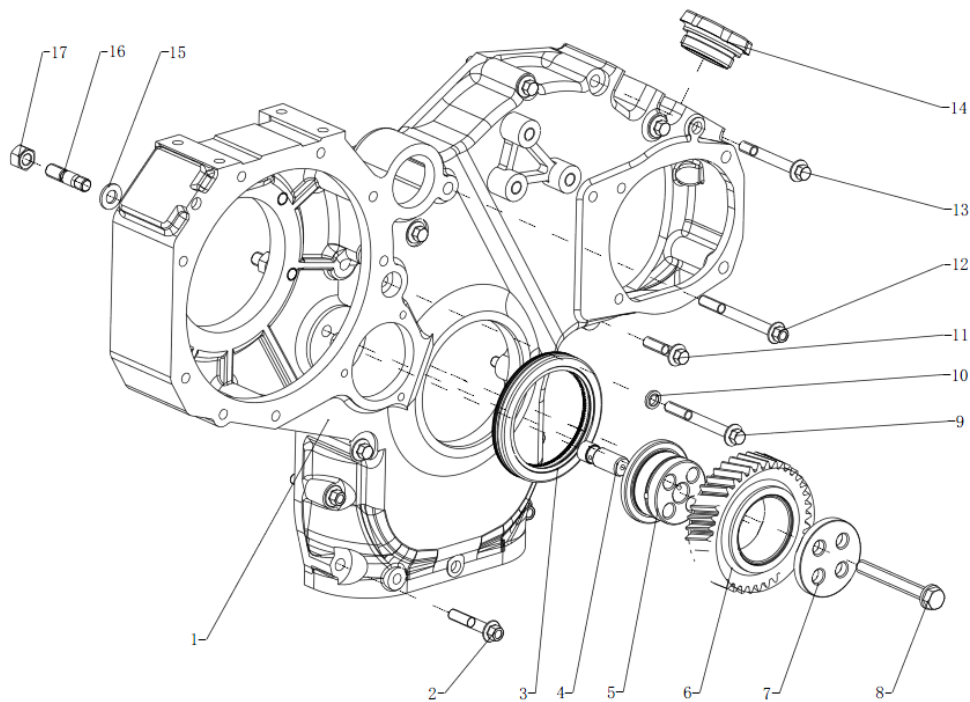


Fig. 8-2 Exploded view of Gear Housing

No.	Name	No.	Name
1	Front Cover	10	Washer

2	Bolt	11	Bolt
3	Front Oil Seal	12	Bolt
4	Shaft	13	Bolt
5	Intermediate Shaft	14	Oil Fill Plug
6	Intermediate Gear	15	Washer
7	Plate	16	Stud
8	Bolt	17	Nut
9	Bolt		

8.2.2 Gear Housing Disassembly Procedure

1. Remove the intermediate gear.
2. Remove the front cover plate (See Key Point 1 under section 8.2.4).
3. Remove the front oil seal (See Key Point 2 under section 8.2.4).

8.2.3 Gear Housing Assembly Procedure

Reverse the Disassembly Procedure (8.2.2) to assemble the Gear Housing.

8.2.4 Gear Housing Inspection and Maintenance

Key Point 1:

Inspection:

Check the gear housing to ensure that it is clean and without any damage or burrs on the fitting surface. Check the O-Rings to ensure that they are in good condition. Replace the O-Rings if necessary.

Assembling:

- (1) Knock the locating pins into place, as shown in the figure below;



Fig. 8-3 Locating pin installation for Gear Housing

(2) Apply sealant on the sealing surface of the Gear Housing. Ensure that the sealant is evenly distributed and continuous.



Fig. 8-4 Sealing surface of Gear Housing

(3) Place the gear housing with alignment pins in the pin holes. Knock the cover edge gently with a nylon rod such that the cover and engine block can fit together closely.



Fig. 8-5 Gear Housing installation

(4) Place the bolts with gaskets in their corresponding holes. Tighten them with a pneumatic impact wrench and an open-end wrench.

Key Point 2:

Assembling:

Oil seals and seal rings should be checked before assembling. Ensure there is no damage or dirt. For a tight seal, apply some clean engine oil on the shaft first, and then press the seal in slowly with the dedicated tool, ensuring that the pressing force is evenly distributed on the seal.

Disassembling:

The removed oil seal can not be reused; replace it with a new one.

8.3 Intermediate Gear Assembly and Disassembly

8.3.1 Intermediate Gear Exploded View

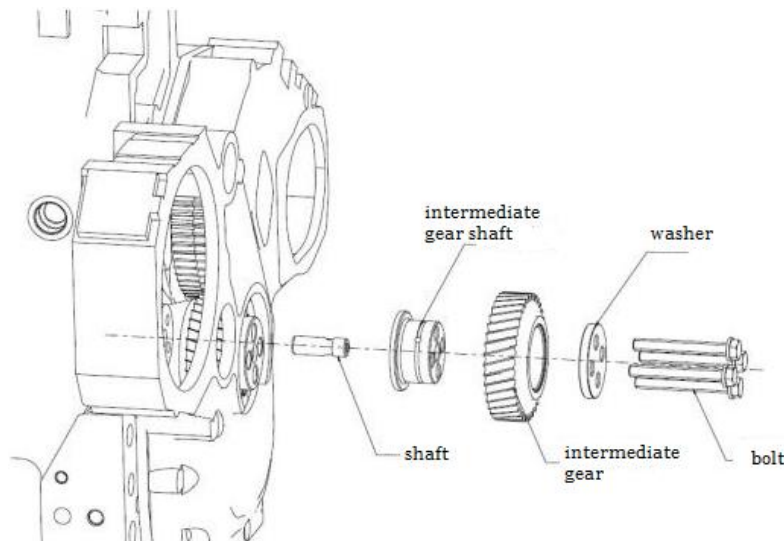


Fig. 8-6 Exploded view of intermediate gear

8.3.2 Intermediate Gear Disassembly Procedure

1. Locate the four M10 bolts to be removed.
2. Remove four bolts and the washer.
3. Insert a M8 bolt into the pin-shaft. Pull the pin-shaft out along this bolt. Take care to ensure that the intermediate gear does not slide off and get damaged.

8.3.3 Intermediate Gear Assembly Procedure

1. Assemble the front cover according to the front cover assembly procedure (8.2.3).
2. Assemble the intermediate gear. Apply oil on the contact surface of the intermediate gear and intermediate shaft.
3. Put the intermediate gear module in the front cover. Install the pin-shaft.
4. Insert the four M10 bolts after installing the washer. Torque the bolts to 65~70 Nm.
5. Rotate the gear by hand after tightening the bolts. Check the clearance and ensure the gear turns smoothly.

8.3.4 Intermediate Gear Inspection and Maintenance

1. Check the bolts to ensure that they are threaded and tightened properly.
2. Check the tooth of the gear for any damage or spalling.
3. Check the intermediate shaft and the interface between the intermediate shaft and the bushing

or pin-shaft for any wear. Check the oil passage for any blockage.

9 Cylinder Heads and Valves

9.1 Lifting Lugs Assembly and Disassembly

9.1.1 Lifting Lugs Exploded View

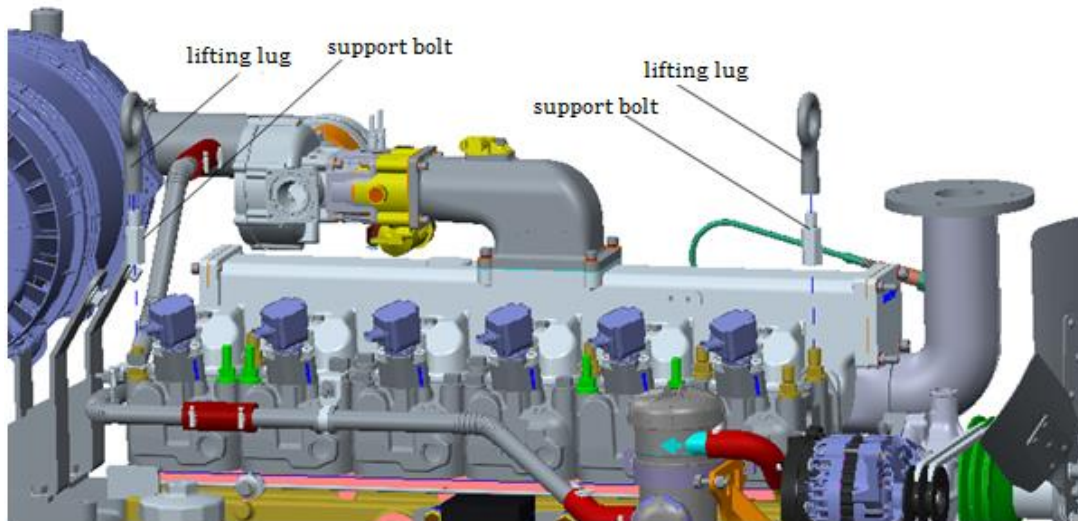


Fig. 9-1 Exploded view of lifting lugs

9.1.2 Lifting Lugs Disassembly Procedure

Loosen and remove the lifting lugs.

9.1.3 Lifting Lugs Assembly Procedure

Check the lifting lugs and standoffs for any damaged threads. Replace either if damage is found.

Tighten the lugs after installing them.

9.2 Cylinder Head Cover Assembly and Disassembly

9.2.1 Cylinder Head Cover Exploded View

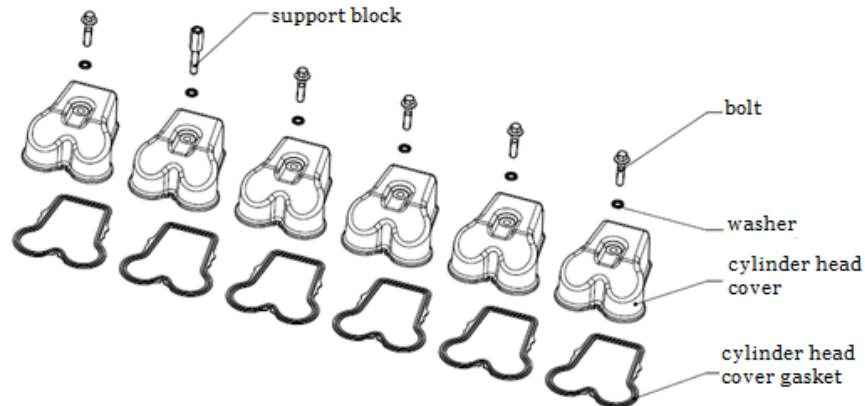


Fig. 9-2 Exploded view of cylinder head cover

9.2.2 Cylinder Head Cover Disassembly Procedure

- 1) Loosen the cylinder head cover bolts. Remove the bolts and the washers.
- 2) Pull the covers up vertically to remove them. Remove all gaskets.

9.2.3 Cylinder Head Cover Assembly Procedure

- 1) Use new cylinder head cover gaskets for all assemblies and inspect them for any defects or damage prior to assembly.
- 2) Clean the upper surface of the cylinder head. Install cylinder head cover gaskets.
- 3) Clean and install cylinder head cover.
- 4) Install the bolts and fasten. The required torque is 10~15Nm.

9.2.4 Cylinder Head Cover Inspection and Maintenance

Key point 1: Assembling

Cylinder head cover gaskets are disposable, and should be replaced during maintenance.

Key point 2: Inspection

- 1) Check the covers for any cracks or other damage. Replace if damaged.
- 2) If there is leakage through the cylinder head cover gaskets, then all gaskets should be checked and replaced.

9.3 Rocker and Rocker Shaft Assembly and Disassembly

9.3.1 Rocker and Rocker Shaft Exploded View

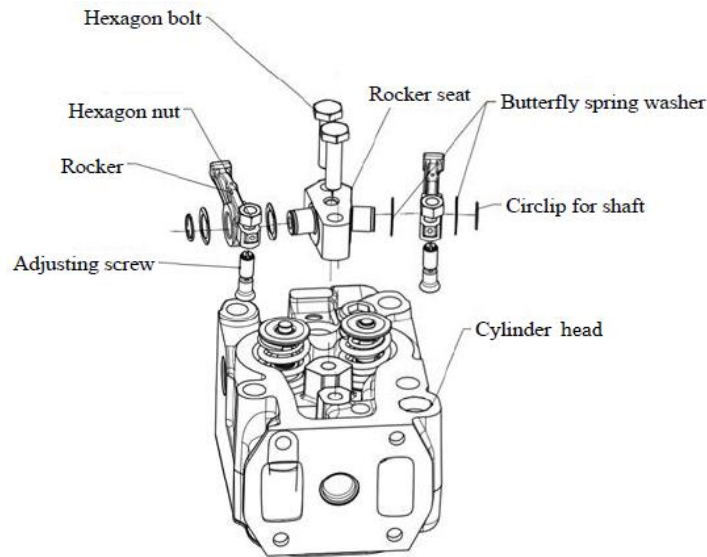


Fig. 9-3 Exploded view of rocker and rocker shaft

9.3.2 Rocker and Rocker Shaft Disassembly Procedure

1. Rotate the crankshaft to ensure that the rocker moves smoothly.
2. Measure each valve clearance, and check any changes in valve clearance.
3. If the rocker is not flexible or the valve clearance is too big, loosen the hex screw and then remove the rocker seat, shaft circlip, butterfly spring washer, rocker and the other butterfly spring washer. Mark the items to prevent improper assembly.

9.3.3 Rocker and Rocker Shaft Assembly Procedure

- ① Check whether all to-be assembled parts are clean, free of bump damage, scratch and rust;
- ② Install rocker adjusting screw and lock nut, the screw should be fully screwed in, while the lock nut only needs to be screwed in for 2~3 thread pitches;
- ③ Apply lubricating oil on rocker seat and rocker inner hole, and install butterfly spring washer, rocker assembly, the other butterfly spring washer and circlip for shaft on rocker seat;
- ④ Loose-fit rocker seat on cylinder cover with hexagon bolts;

- ⑤ Install valve pushrod, refer to assembly of valve pushrod for details;
- ① Pre-tighten rocker seat, align rocker adjusting screw socket head to valve pushrod round head, tighten the hexagon bolts to 40~45Nm.
- ◆ Inspection and maintenance valve lash
- ① Rotate the crankshaft until phase pointer points at 0 tick on phase plate, observe and make sure 0 tick of crankshaft timing gear is engaged with 0 tick of camshaft gear. Then adjust valve clearance of No. 1-2-3-6-7-10 rocker (count from the front end), intake valve adjustment: firstly fill in a 0.2mm plug gauge, and tighten the nuts with torque spanner to 20 ± 5 Nm, pull out the gauge (make sure the gauge can be easily pulled out), and check the clearance with a 0.25mm plug gauge (make sure the gauge cannot get through), adjusting of intake valve is finished. Exhaust valve adjustment: firstly fill in a 0.3mm plug gauge, and tighten the nuts with torque spanner to 20 ± 5 Nm, pull out the gauge (make sure the gauge can be easily pulled out), and check the clearance with a 0.35mm plug gauge (make sure the gauge cannot get through), adjusting of exhaust valve is finished.
- ② Further rotate crankshaft until phase pointer points at 0 tick on phase plate, observe and make sure 0 tick of crankshaft timing gear is engaged with the symmetry point of 0 tick (180°) on camshaft gear. Then adjust valve clearance of No. 4-5-8-9-11-12 rocker (count from the front end), refer to ① for adjusting method.

9.3.4 Rocker and Rocker Shaft Inspection and Maintenance

1. Clean the rocker and check for any cracks.
2. Check the rocker inner hole for abrasion and scratches and measure its diameter.
3. Check the rocker adjusting screw and the other end arc surface for abrasion.
4. Check to ensure that all oil galleries are smooth.
5. Measure the diameter of rocker inner hole and rocker shaft. Calculate the fitting clearance.

9.4 Tappet and Pushrod Assembly and Disassembly

9.4.1 Tappet and Pushrod Exploded View

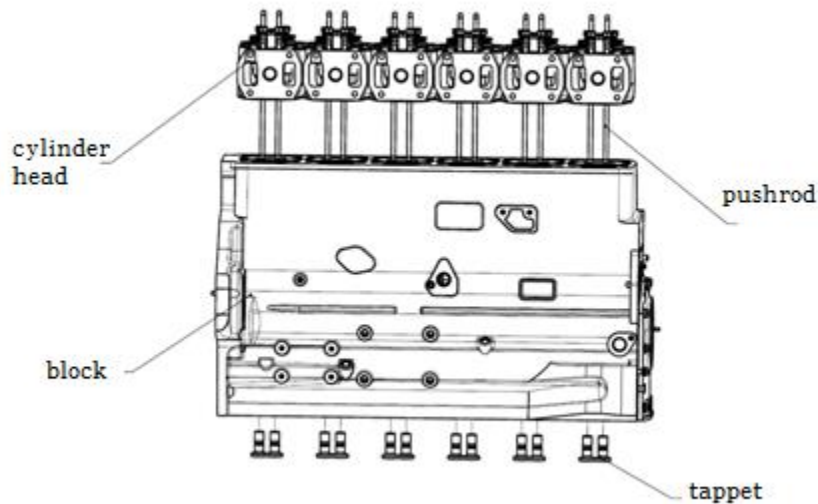


Fig. 9-4 Exploded view of tappet and pushrod

9.4.2 Tappet and Pushrod Disassembly Procedure

1. After removing rockers and rocker shafts, pull the pushrods out vertically.
2. After removing camshaft, directly take out valve tappet, place them orderly;

9.4.3 Tappet and Pushrod Assembly Procedure

1. Check valve tappets and pushrod, replace them if necessary. Before installing the tappet, it must be cleaned with compressed air. Check to ensure that the oil channel is smooth.
2. Apply clean lubricating oil evenly onto the engine block tappet-fitting hole and valve tappet fitting surface.
3. Install the valve tappet into the engine block tappet-fitting hole. The tappet should rotate freely in the hole. Install the camshaft, refer to camshaft assembly (11.9.3) for details.
4. Loosely fit the rocker seat onto the cylinder cover. Check to ensure that the pushrod is clean and the welding area is intact;
5. Apply clean lubricating oil on the pushrod and ensure that the round head is applied with sufficient oil.
6. Install the pushrod by putting the pushrod into the valve tappet through the cylinder cover.

9.4.4 Tappet and Pushrod Inspection and Maintenance

1. Clean the valve tappet and pushrod.

2. Ensure that the oil channels of valve tappet and pushrod are smooth.
3. Ensure that the pushrod is not crooked. Check wear condition on the outside surface.
4. Ensure that the two ends of the pushrod are not worn.
5. Ensure that the valve tappet surface and undersurface are not worn.
6. Ensure that the valve tappet inner socket head is not worn.

9.5 Cylinder Heads Assembly and Disassembly

9.5.1 Cylinder Heads Exploded View

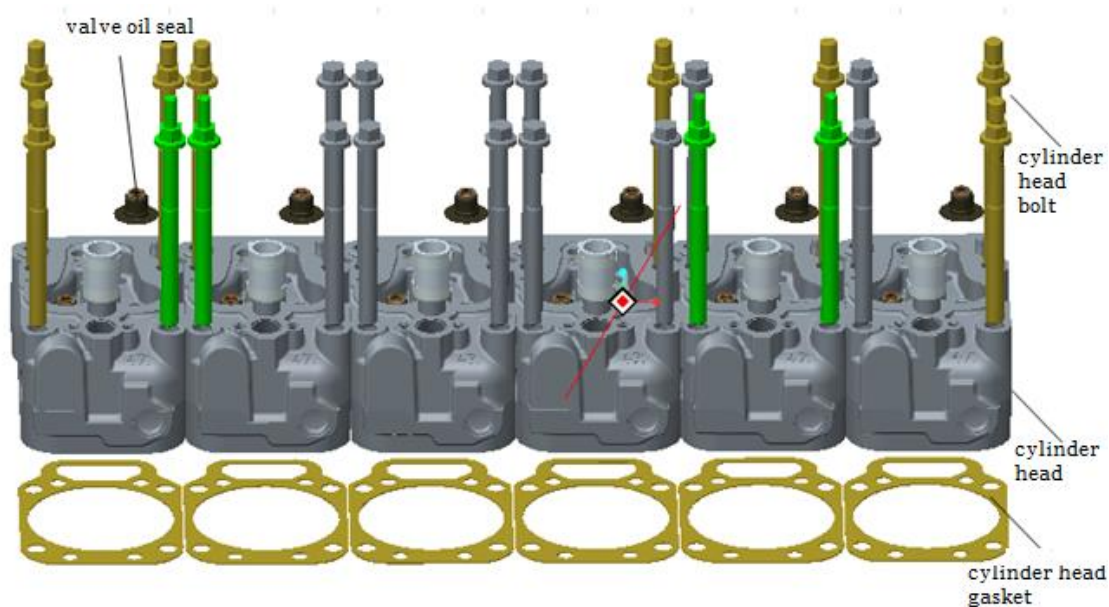


Fig. 9-5 Exploded view of cylinder heads

9.5.2 Cylinder Heads Disassembly Procedure

1. Loosen the cylinder head bolts and remove them.
2. Pull the cylinder head up vertically to take it down. If the cylinder head gasket is attached on the removed cylinder head, remove it and place it back on engine block. Put the removed cylinder head on cardboard to prevent damage to the upper surface of the combustion chamber and other sealing surfaces. If more than one cylinder head needs to be disassembled, mark the cylinder number on the head for reference.

3. Remove the cylinder head gasket. If more than one cylinder head gasket needs to be disassembled, mark the cylinder number on the gaskets for reference.
4. Remove the intake and exhaust valve module. Refer to disassembly of valve mechanism (9.6) for details
5. Remove the valve seal. Valve seals can't be reused.

9.5.3 Cylinder Heads Assembly Procedure

1. Insert the seal valve into the valve guide pipe.
2. Install the intake valve and exhaust valve onto the cylinder head.
3. Install new cylinder head gaskets. Cylinder head gaskets cannot be reused.
4. Assemble the cylinder head to the engine block.
5. Thread the cylinder head bolts into the cylinder head.
6. Tighten the cylinder head bolts (See Key Point 1 in 9.5.4).

9.5.4 Inspection and maintenance of cylinder head

Key point 1: Assembling

1. Refer to Figure 9-5 for the bolt pre-tightening and tightening order for each individual cylinder head. The cylinder heads should be tightened in the order 3-4-5-2-1-6.

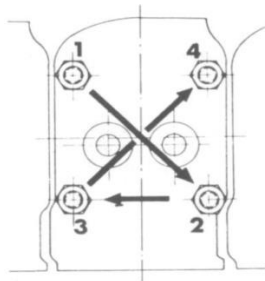


Fig. 9-6 Individual Cylinder Head Tightening Order

2. The cylinder head bolt will stretch and deform between 0.2~0.6mm after tightening. The bolt can't be reuse if the length over 160.5mm.
3. Install the valve oil seal.

Key point 2: Inspection



Clean the cylinder head, focusing on the combustion chamber surface, valve seat, intake and exhaust valves, and intake and exhaust passages. Remove the carbon deposits and mucilage glue, and check the surface condition.

1. Appearance Inspection:

Check the cylinder cover for any discoloration or cracks. If any cracks are discovered, a leak test should be done.

2. Valve Recession:

Valve recession is the vertical distance between valve undersurface and cylinder cover undersurface. Any difference between the measured and required values of valve recession can reflect the degree of wear on the valve and valve seat. A depth micrometer can be used to measure valve recession, as shown in Figure 9-7 below:

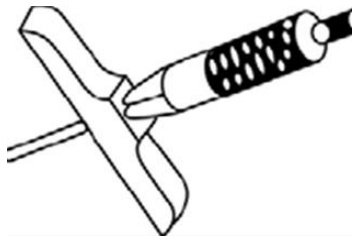


Fig. 9-7 A Depth Micrometer

Reference Table 9-1 for valve recession requirements. If valve recession exceeds the allowed range, the cylinder cover must be replaced to ensure engine reliability. If valve recession doesn't exceed allowed range, disassemble the valve and check the sealing surface between the valve and valve seat for wear and abnormal damage.

Table 9-1 Valve Recession Specifications

	Required value of valve recession (mm)
Intake valve	1.00~1.45
Exhaust valve	1.00~1.45

3. Clearance between valve rod and valve guide pipe:

Internal surface of valve guide pipe is the contacting surface between valve rod and valve guide pipe, if clearance between valve rod and valve guide pipe exceeds allowed value due to abrasion, then the guide effect will at state, which may affect reliability of the engine. The inner diameter of guide pipe can be measured with an inside micrometer, as shown in Fig. 3-5. Outer diameter of valve rod can be measured with an outside micrometer. Both allowed ranges for clearance between intake valve rod and its guide pipe, exhaust valve rod and its guide pipe are 0.03~0.06mm. If clearance exceeds allowed range, the cylinder cover must be replaced to ensure reliability of diesel engine.

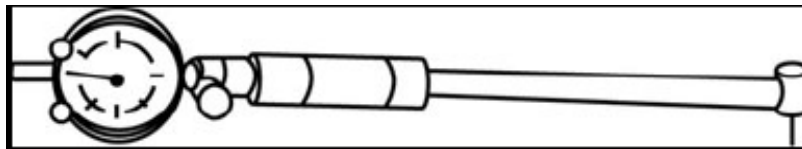


Fig. 9-8

4. Cylinder head gasket:

If there is air leakage, water leakage or oil leakage in cylinder head gasket, then the gasket should be checked and replaced; Check the gasket for visible damage and analyze the cause, cylinder cover gaskets are disposable, and should be replaced during maintenance.

9.6 Assembly and disassembly of valve

9.6.1 Exploded view of valve

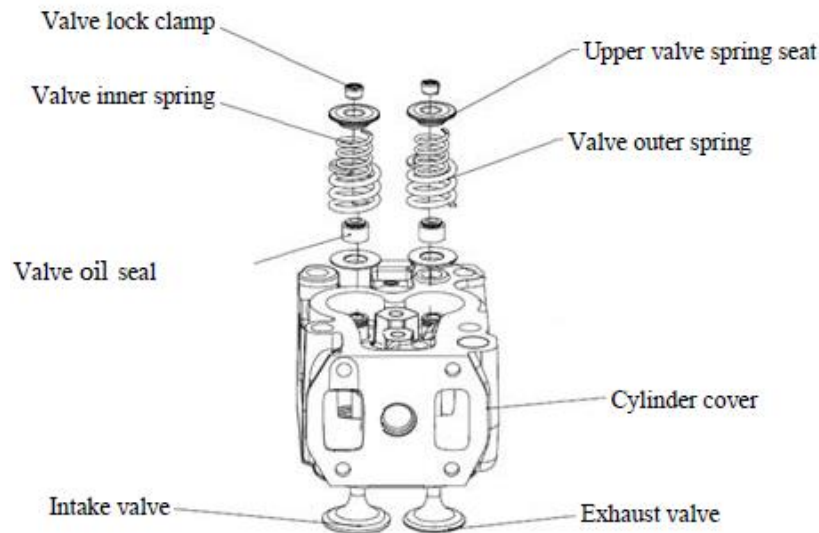


Fig. 9- 9 Exploded view of valve

9.6.2 Steps to disassemble valve

- ① Depress valve springs with valve spring compressor or valve overhead plier or other tools, take out valve lock clamp, upper valve spring seat and lower valve spring seat and valve springs orderly;
- ② Take valve out of valve seat.

9.6.3 Steps to assemble valve

A valve with severe wear or carbon deposit or sintering should be replaced.

Apply molybdenum disulfide cream on intake and exhaust valve rod, and then install intake and exhaust valve into cylinder cover, ensure the valve can slide smoothly in valve guide pipe;

NOTICE: Check and ensure spring in valve rod seal cartridge is in good condition before assembling.

- ② Install valve inner and outer spring;
- ③ Assemble upper valve spring seat, depress the springs and install valve lock clamp;
- ④ Knock the valve with rubber hammer to settle the lock clamp, if the valve lock clamp or upper valve spring seat cannot be settled, please find out the cause and eliminate it.



9.6.4 Inspection and maintenance of valve

- ① Check whether valve rod and its end faces are worn;
- ② Check whether valve conical surface is worn or damaged;
- ③ Check valve conical surface and retainer end faces for carbon deposit;

10 Oil & Lubrication System

10.1 Assembly and disassembly of oil sump.

10.1.1 Exploded view of oil sump.

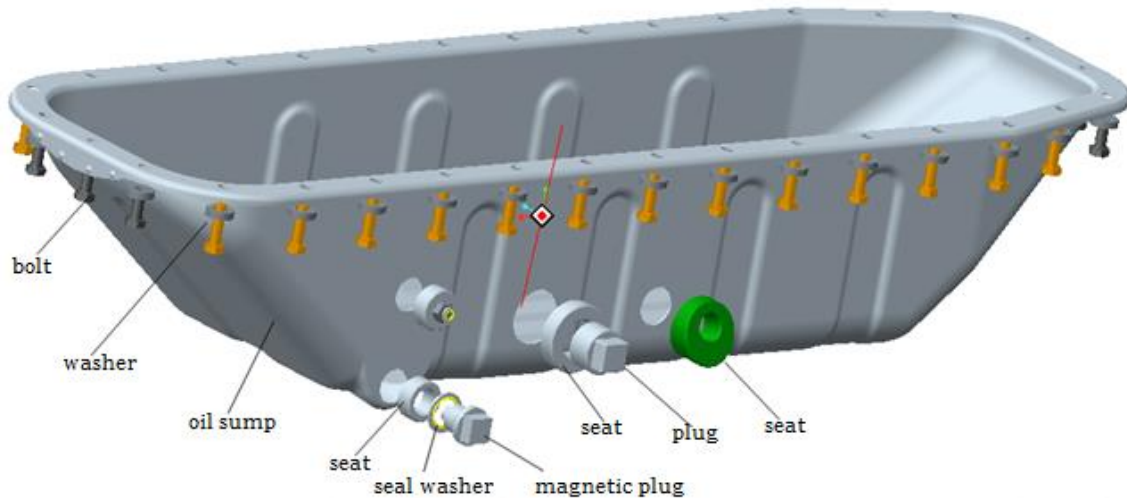


Fig. 10-1 Exploded view of oil sump

10.1.2 Steps to disassemble oil sump.

- ① Turn over engine to keep oil sump upward (key point 1)
- ② Remove fixing bolts of oil sump.
- ③ Remove oil sump.
- ④ Remove the combination gasket and magnetic screw plug assembly.

10.1.3 Steps to assemble oil sump.

Assembling steps are contrary to disassembling ones.

10.1.4 Inspection and maintenance of oil sump.

Key point 1: Disassembling

Before the disassembling, all engine oil should be drained out. Put an engine oil container under drain screw plug of oil sump, screw off the plug with a plug wrench to drain oil out.

Key point 2: Assembling

- (1) Apply sealant on fitting surface of engine block and partially apply sealant on oil sump, place sealing gasket on the fitting surface.
- (2) Lift and place oil sump, be careful and avoid crashing the fitting surface.
- (3) Place bolts and gaskets, and tighten the bolts with pneumatic impact wrench to 20~35.5Nm.

10.2 Disassembly and Assembly of Engine Oil Strainer

10.2.1 Exploded View of Engine Oil Strainer

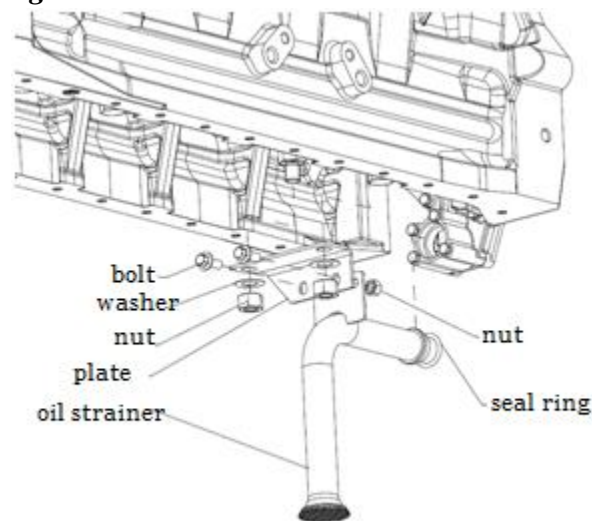


Fig. 10-2 Exploded view of engine oil strainer

10.2.2 Steps to Disassemble Engine Oil Strainer

Screw off two hexagon flange bolts and the 2-type hexagon nuts on the bended plate, take down the oil strainer, as shown in Fig. 10-2.

10.2.3 Steps to Assemble Engine Oil Strainer

- ① Check the strainer before assembling, make sure there is no manufacturing defect and damage. Replace new O-ring at the same time.
- ② Clean up the oil supply hole of oil pump and the strainer inner cavity.
- ③ Install the strainer.
- ④ Assemble and tighten the two hexagon flange bolts and the 2-type hexagon nuts.

10.2.4 Inspection and Maintenance of Engine Oil Strainer

Check the strainer for crack damage, replace it if necessary.

10.3 Disassembly and Assembly of Lubricating System

10.3.1 Exploded View of Lubricating System

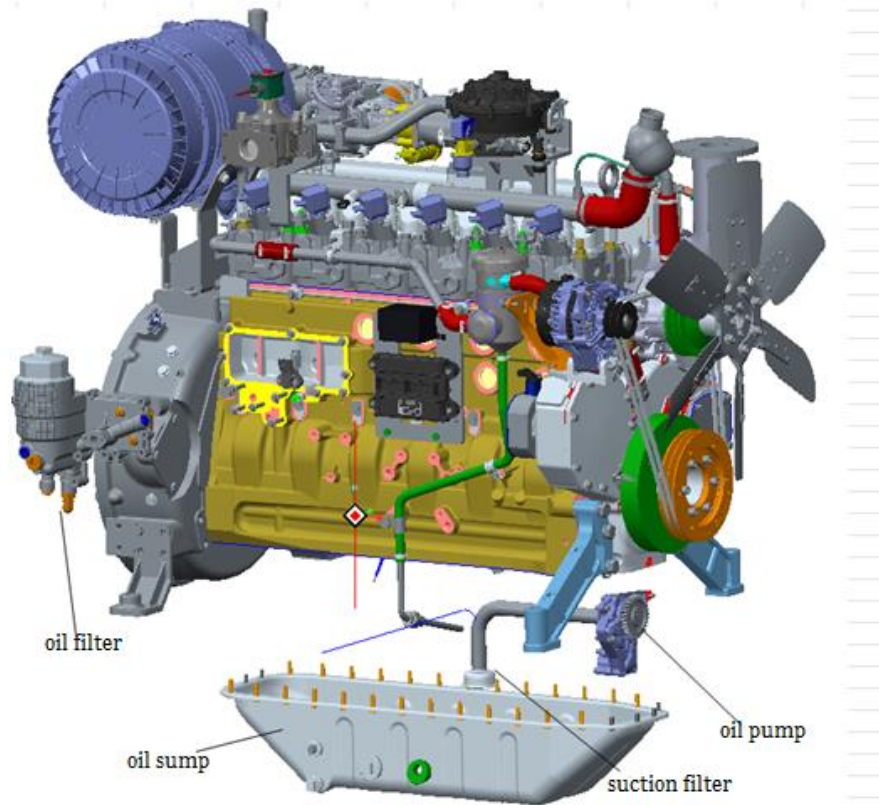


Fig. 10-3 Exploded view of lubricating system

10.3.2 Steps to Disassemble Lubricating System

- ① Remove oil sump, refer to disassembly of oil sump for details.
- ② Remove gearbox, refer to disassembly of gearbox for details.
- ③ Remove engine oil pump.
- ④ Remove the cooling module of engine oil filter.

10.3.3 Steps to Assemble Lubricating System

Assembling steps are contrary to disassembling ones.

10.4 Assembly and disassembly of piston nozzle.

10.4.1 Exploded view of piston nozzle

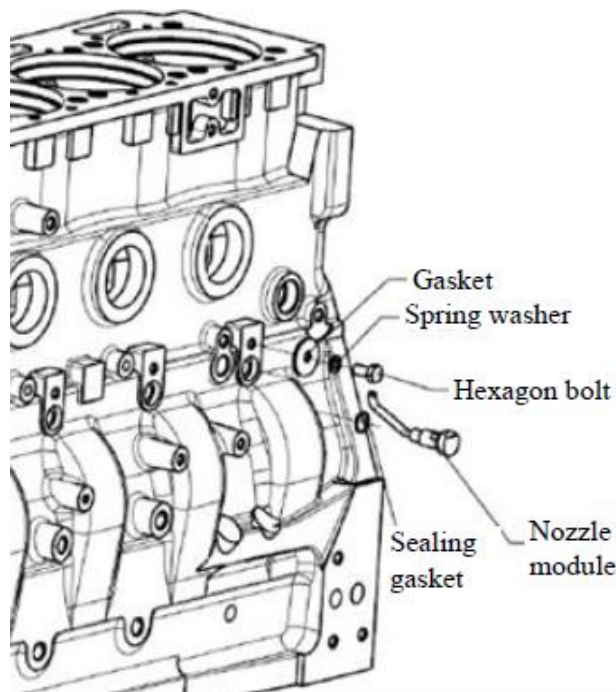


Fig. 10- 4 Exploded view of piston nozzle

10.4.2 Steps to disassemble piston nozzle.

- ① Remove the hexagon bolt (key point 1)
- ② Remove the piston nozzle (key point 2)

10.4.3 Steps to assemble piston nozzle

Assembling steps are contrary to disassembling ones.

10.4.4 Inspection and maintenance of piston nozzle.

Key point 1:

Assembling:

- (1) Compress nozzle module tightly with bolt (with spring washer) and pressing plate;
- (2) Place the pressing plate in nozzle end face groove.
- (3) Bolts tightening

Key point 2:

Inspection: Check O-shape seal ring for damage; make sure the nozzle is clean and free of burr.

10.5 Disassembly and Assembly of Engine Oil Pump

10.5.1 Exploded View of Engine Oil Pump

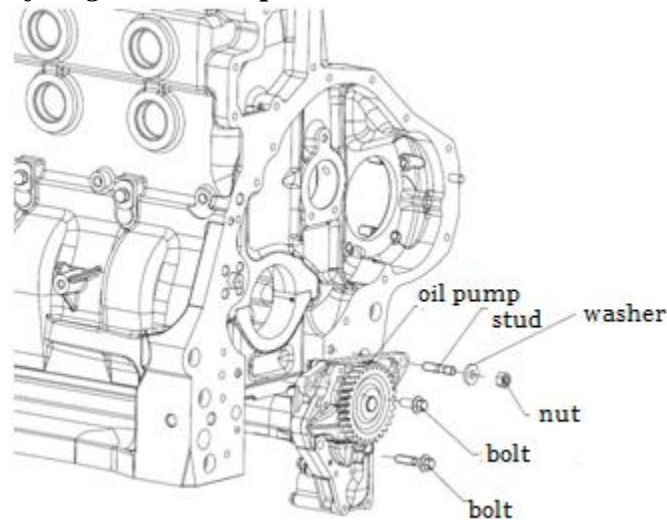


Fig. 10-5 Exploded view of engine oil pump

10.5.2 Steps to Disassemble Engine Oil Pump

Remove the two hexagon bolts and self-locking nut, take down engine oil pump, as shown in Fig. 10-5.

10.5.3 Steps to Assemble Engine Oil Pump

- 1) Check the pump before assembling, make sure there is no manufacturing defect and damage.
- 2) Clean up the fitting surface between oil pump and engine block.
- 3) Install engine oil pump.
- 4) Install and tighten the two toothed hexagon bolts and self-locking nut.

10.5.4 Inspection and Maintenance of Engine Oil Pump

- 1) Check the engine oil pump for crack damage, check whether its inner cavity is smooth, replace it if necessary.
- 2) Check whether engine oil pump shaft can rotate smoothly, replace it if necessary.

10.6 Disassembly and Assembly of Engine Oil Filter

10.6.1 Exploded View of Engine Oil Filter

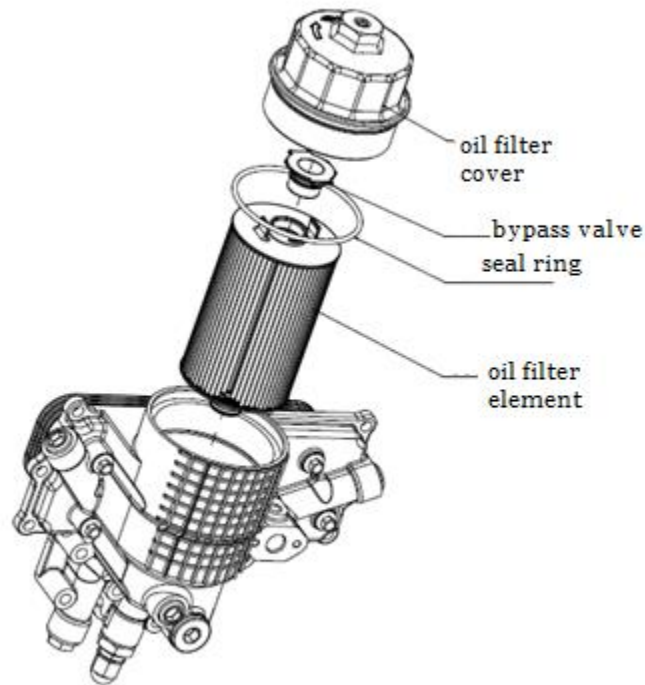


Fig. 10-6 Exploded view of engine oil filter

10.6.2 Steps to Disassemble Engine Oil Filter

Remove the filter with dedicated tool, as shown in Fig. 10-6.

10.6.3 Steps to Assemble Engine Oil Filter

- 1) Check the O-shape seal ring of engine oil filter before assembling, make sure there is no manufacturing defect and damage, replace the O-ring if necessary.
- 2) Tighten the filter according to the requirements on filter cap.

10.6.4 Inspection and Maintenance of Engine Oil Filter

Check the engine oil filter assembly for damage, replace it if necessary.

10.7 Disassembly and Assembly of Engine Oil Cooler

10.7.1 Exploded View of Engine Oil Cooler

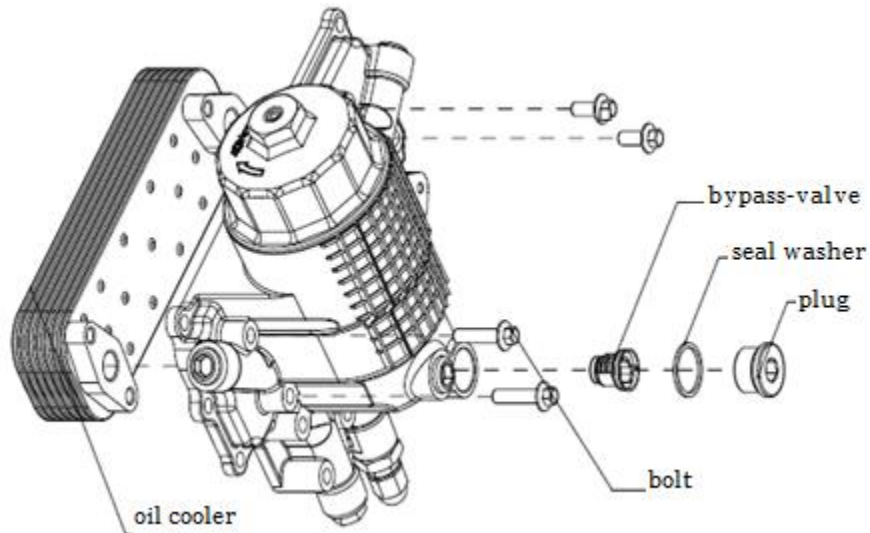


Fig. 10-7 Exploded view of engine oil cooler

10.7.2 Steps to Disassemble Engine Oil Cooler

Loose the connecting bolts and take down the cooler, as shown in Figure 10-7.

10.7.3 Steps to Assemble Engine Oil Cooler

- ① Check the cooler before assembling, make sure there is no manufacturing defect and damage.
- ② Clean up the fitting surface between engine oil cooler and filter seat.
- ③ Install engine oil cooler and the connecting thread sleeve, tighten it.

10.7.4 Inspection and Maintenance of Engine Oil Cooler

Check the engine oil cooler for crack damage, replace it if necessary.

Check whether the oil cooler bypass valve has sluggish phenomenon, replace it if necessary.

10.8 Disassembly and Assembly of Main Oil Gallery Pressure Limiting Valve

10.8.1 Exploded View of Main Oil Gallery Pressure Limiting Valve

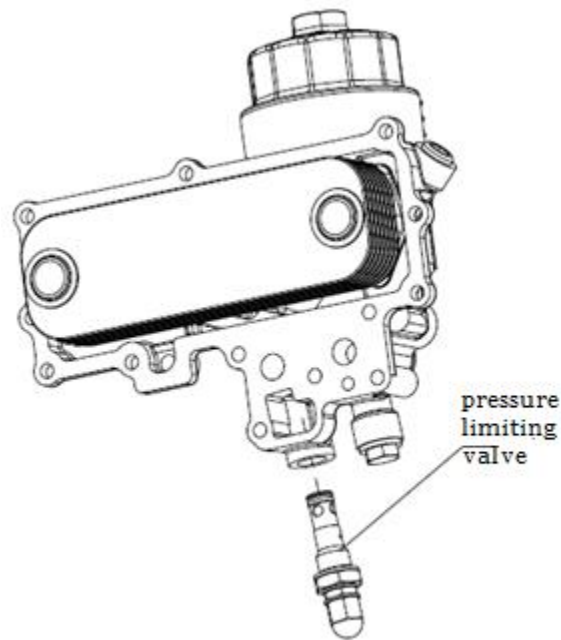


Fig. 10-8 Exploded View of Main Oil Gallery Pressure Limiting Valve

10.8.2 Steps to Disassemble Main Oil Gallery Pressure Limiting Valve

Screw off main oil gallery pressure limiting valve, as shown in Fig. 10-8

10.8.3 Steps to Assemble Main Oil Gallery Pressure Limiting Valve

- ① Check the valve before assembling, make sure there is no manufacturing defect and damage.
- ② Clean up the pressure limiting valve and pressure limiting valve fitting hole on the module.
- ③ Install the valve and tighten it.

10.8.4 Inspection and Maintenance of Main Oil Gallery Pressure Limiting Valve

- ① Check service condition of the valve spring, replace the spring if necessary.
- ② Check the valve for crack damage, replace it if necessary.

10.9 Disassembly and Assembly of Deputy Oil Pressure Limiting Valve

10.9.1 Exploded View of Deputy Oil Pressure Limiting Valve

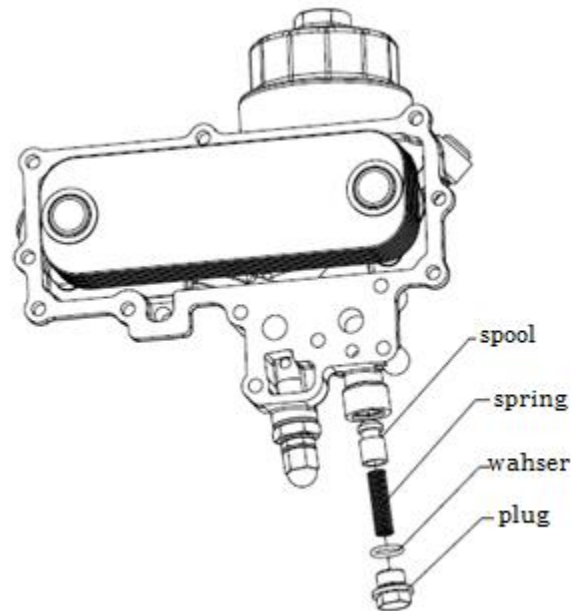


Fig. 10-9 Exploded view of deputy oil pressure limiting valve

10.9.2 Steps to Disassemble Deputy Oil Pressure Limiting Valve

Screw off and take down deputy oil pressure limiting valve, as shown in Fig. 10-9.

10.9.3 Steps to Assemble Deputy Oil Pressure Limiting Valve

- 1) Check the valve before assembling, make sure there is no manufacturing defect and damage
- 2) Clean up the pressure limiting valve and pressure limiting valve fitting hole on the module.
- 3) Install the valve and tighten it.

10.9.4 Inspection and Maintenance of Deputy Oil Pressure Limiting Valve

- 1) Check service condition of the valve spring, replace the spring if necessary.
- 2) Check the valve for crack damage, replace it if necessary.

11 Crank-rod mechanism

11.1 Assembly and disassembly of flywheel housing

11.1.1 Exploded view of flywheel housing

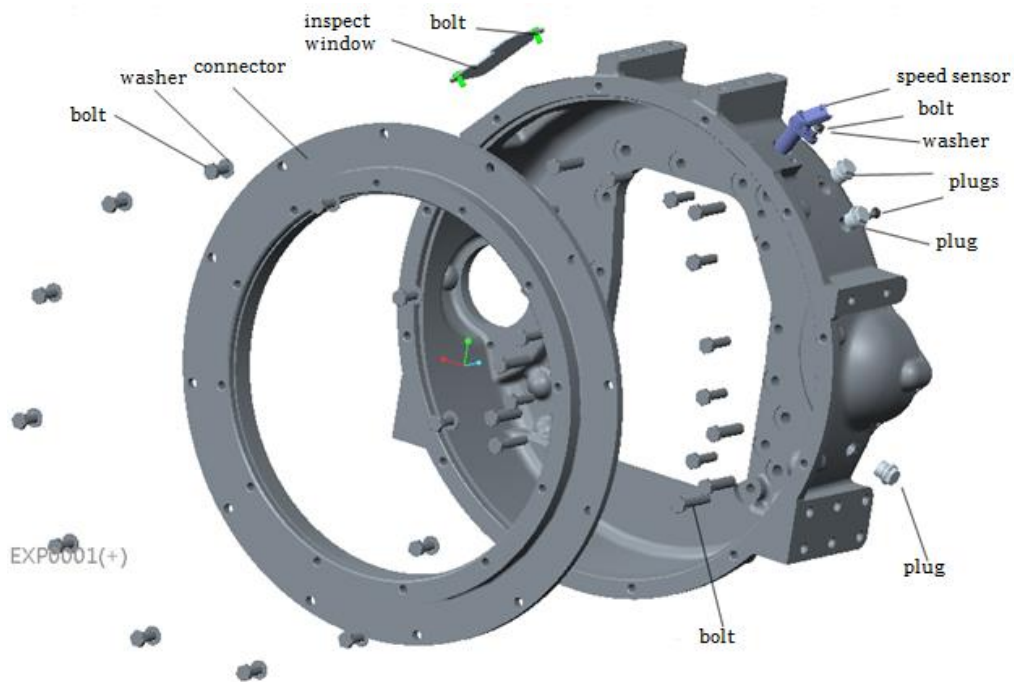


Fig. 11-1 Exploded view of flywheel housing

11.1.2 Steps to disassemble flywheel housing

- ① Remove fixing bolts of flywheel housing (Key point 1).
- ② Remove speed sensor
- ③ Remove fixing bolts of monitoring window cap on flywheel housing, take down the cap;
- ④ Remove flywheel housing (key point 2).

11.1.3 Steps to assemble flywheel housing.

Assembling steps are contrary to disassembling ones.

11.1.4 Inspection and maintenance of flywheel housing.

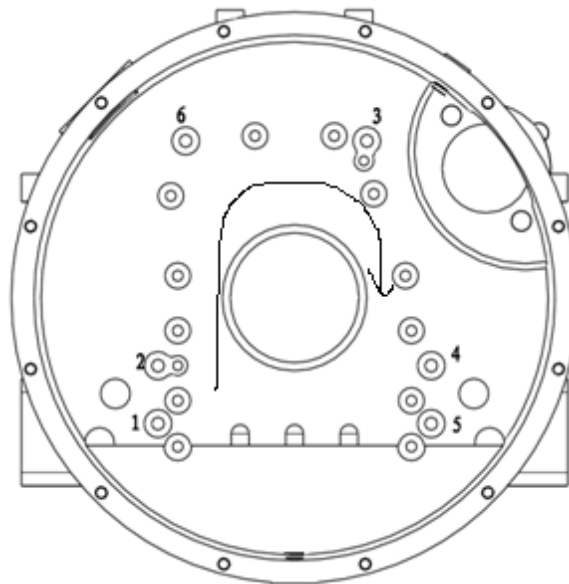
Key point 1: Assembling

Check whether flywheel is cleaned up. Debur the corresponding fitting surface on engine block with 240# fine oil stone and clean the surface with ethyl alcohol. Apply sealant on fitting surfaces of

flywheel housing and engine block. Bolts and tools: M10-10.9 hexagon bolts (×12), M12-10.9 hexagon bolts (×6), 17mm and 19mm socket spanner.

Step 1: Preassemble the bolts

Step 2: Follow the sequence of arrow to tighten the M10 bolts, tighten torque for M10 bolts is 80~85Nm. And then tighten the M12 bolts according to the marked order 1-2-3-4-5-6, tighten torque for M12 bolts is 140~145Nm.



NOTICE: For the strengthening bolts listed above, the thread and bearing surface of each bolt should be applied with lubricating oil before assembling.

11.2 Assembly and disassembly of flywheel and ring gear

11.2.1 Exploded view of flywheel and ring gear

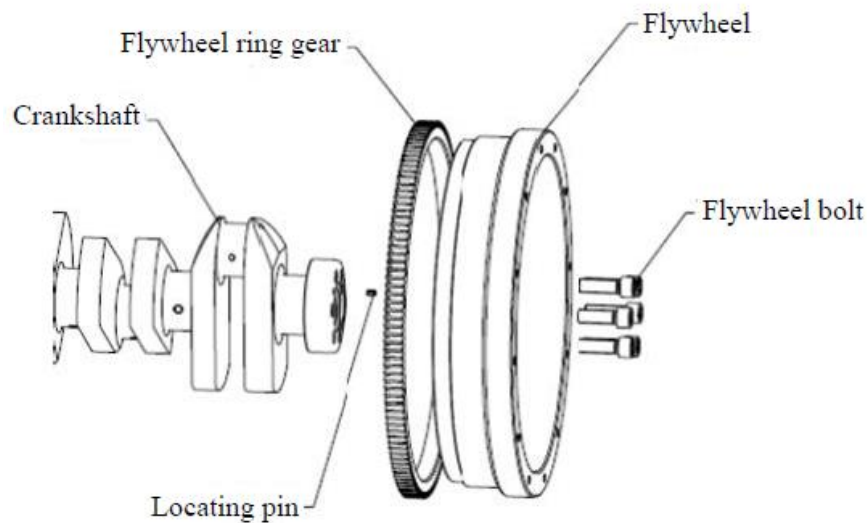


Fig. 11 - 2 Exploded view of flywheel and ring gear

11.2.2 Steps to disassemble flywheel and ring gear

Disassembling steps are contrary to assembling ones.

11.2.3 Steps to assemble flywheel and ring gear.

- ① Fix the flywheel ring gear on flywheel with bolts;
- ② Knock the pin into crankshaft rear end fully.
- ③ After inserting flywheel guide rod into crankshaft threaded hole, install flywheel and pre-tighten the bolts diagonally.

Apply lubricating oil on bolt thread and bearing surface.

Flywheel bolts:

Bolt specification M16-12.9 (×6); Tightening torque: 285~295Nm; Test value: 285~340Nm.

11.2.4 Inspection and maintenance of flywheel and ring gear

- ① Check whether there is failure like thread damage on flywheel bolts.
- ② Check flywheel surface for conquassation.

- ③ Check whether flywheel ring gear is damaged.

11.3 Assembly and disassembly of front oil seal and rear oil seal

11.3.1 Exploded view of front oil seal and rear oil seal.

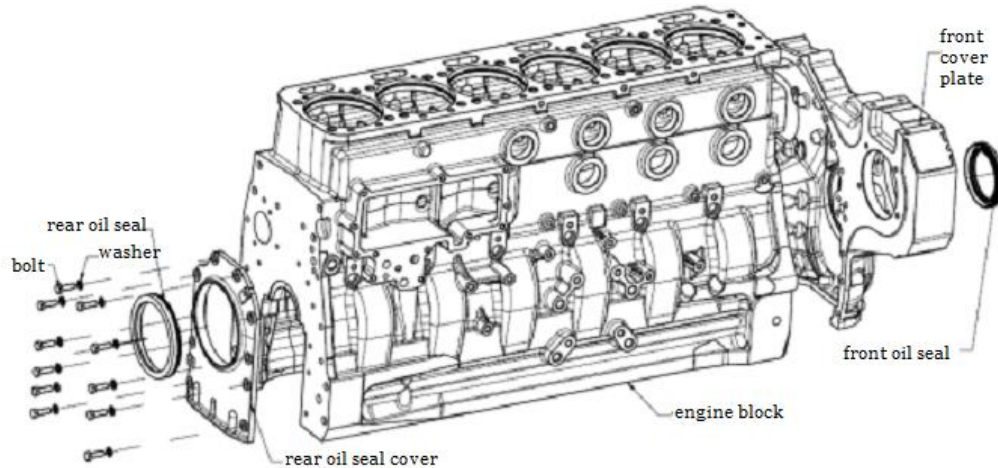


Fig. 11- 3 exploded view of front oil seal and rear oil seal

11.3.2 Steps to disassemble front and rear oil seal

- 1) Remove gear housing plate
- 2) Remove engine front oil seal
- 3) Remove engine rear oil seal cover (Key point 1)
- 4) Remove engine rear oil seal (key point 2)

11.3.3 Steps to assemble front and rear oil seal

Assembling steps are contrary to disassembling ones.

11.3.4 Inspection and maintenance of engine front and rear oil seal.

Key point 1:

Inspection

Check whether the junction surface between rear oil seal cover and engine body is cleaning or knocking wound.

Assembling

- 1) Clean the junction surface and install 2 pins into engine body.
- 2) Apply sealant on the junction surface of rear oil seal cover.
- 3) Apply oil on surface of crankshaft flange, assemble rear oil seal and tighten bolt. Bolt tightening sequence is: 1-2-6-7-3-4-5-8-9-10。

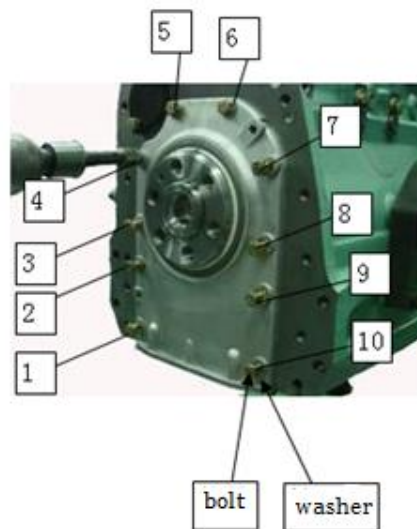


Fig. 11- 4 tightening sequence of rear oil seal cover bolt

Key point 2:

Inspection:

Oil seals and seal rings should be checked before assembling, make sure there is no damage. Check whether rear oil seal cover is clean and whether its finished surface is free of obvious scratch.

Assembling

Apply sealant on the rear oil seal outer ring first, and then press-in the seal slowly with dedicated tool.
NOTICE: Do not damage the seal during assembling, and seal outer ring should be parallel and level to oil seal cap plane.

11.4 Assembly and disassembly of crank-rod mechanism.

11.4.1 Exploded view of crank-rod mechanism.

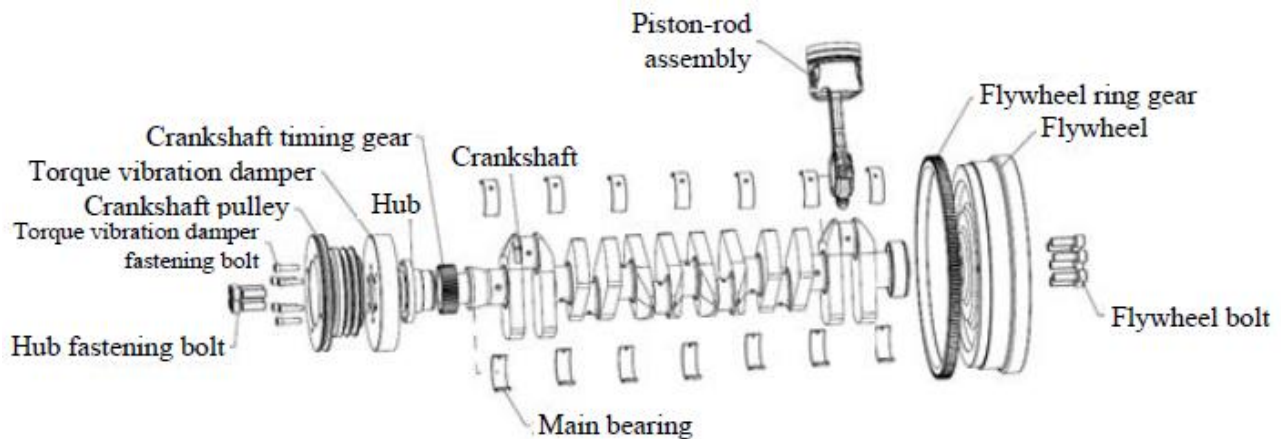


Fig. 11-5 Exploded view of crank-rod mechanism

11.4.2 Steps to disassemble crank-rod mechanism

- ① Check before disassembling. Check connecting rod axial backlash, check tightening torque of connecting rod bolts; Tilt and lay the engine on its side, rotate the flywheel until the to-be removed piston is in BDC, remove connecting rod bolts and cap; Rotate the flywheel until the to-be removed piston is in TDC, knock the piston out with wooden hammer, proceed with caution to avoid jamming cylinder block with connecting rod tip. Remove other pistons in the same way, number and place them orderly.
- ② Screw off fastening bolts of torque vibration damper and fastening bolts of hub, take down crankshaft pulley, torque vibration damper and hub.
- ③ Screw off flywheel bolts, take down flywheel assembly, bearing, etc.

11.4.3 Steps to assemble crank-rod mechanism

Assembling steps are contrary to disassembling ones.

11.5 Assembly and disassembly of piston-rod assembly

11.5.1 Exploded view of piston-rod assembly

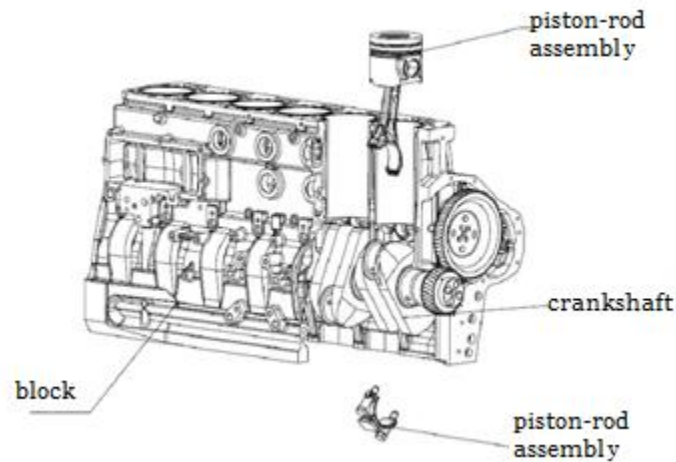


Fig.11-6 Schematic diagram of piston-rod assembly

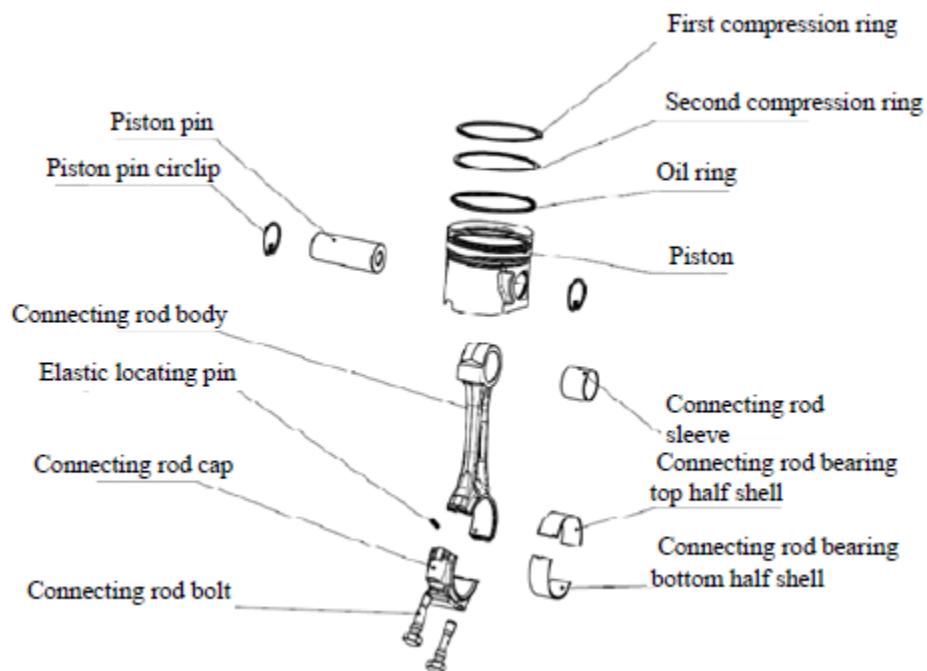


Fig. 11-7 Exploded view of piston-rod assembly

11.5.2 Steps to disassemble piston-rod assembly

- 1) Check before disassembling. Check connecting rod axial backlash, check tightening torque of connecting rod bolts;

- 2) Tilt and lay the engine on its side, rotate the flywheel until the to-be removed piston is in BDC, and then remove connecting rod bolts and cap;
- 3) Rotate the flywheel until the to-be removed piston is in TDC, knock the piston out with wooden hammer, proceed with caution to avoid jamming cylinder block with connecting rod tip.
- 4) Remove other pistons in the same way, number and place them orderly.
- 5) Remove circlip on two sides of piston with internal circlip plier and push piston pin out, take down the connecting rod body. Number the piston pins, connecting rod bodies and place them orderly.
- 6) Remove first compression ring, second compression ring and oil ring with piston ring plier and mark them.

11.5.3 Steps to assemble piston-rod assembly

- 1) Install one circlip into piston circlip groove with internal circlip plier, and rotate the circlip to ensure it is properly fitted. The end with corner angle should face inward, and its opening should be upward.
- 2) Insert small end of connecting rod into piston inner cavity and align it to piston pin holes, and then install piston pin, finally install the other circlip to the other side of the piston. Note that connecting rod oblique incision and piston cooling oil gallery inlet should be in the same direction, apply proper clean lubricating oil on connecting rod small end hole and piston pin.
- 3) Arrange the assembled piston-rod assembly in cylinder number order, and then install oil ring, second compression ring and first compression ring into piston ring grooves orderly with piston ring plier. The face with mark "TOP" should be upward, and the ring should be flexible in ring groove.
- 4) Clean up cylinder inner wall, crankshaft connecting lever and piston-rod assembly, and apply clean lubricating oil on each motion pair.
- 5) Adjust opening direction of each ring: The opening direction of first compression ring should be 30° to piston pin center line, opening direction of the second compression ring should be

120° to that of the first compression ring, and opening direction of oil ring should be 120° to both that of first compression ring and second compression ring, also should be perpendicular to piston pin center line. As shown in Figure below.

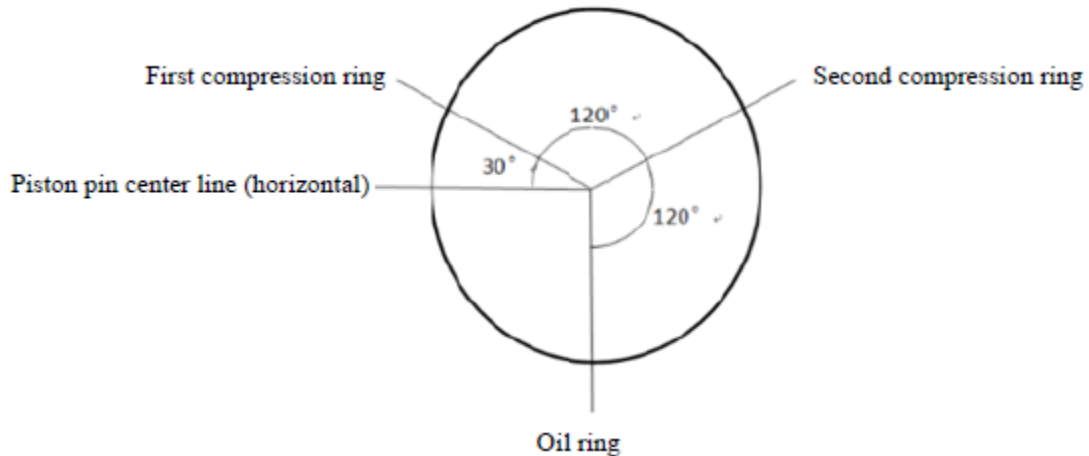


Fig. 11-8 Schematic diagram for installation of piston rings

- 6) Rotate the flywheel with external force until cylinder 1, 6 get to BDC, install thrust plates of cylinder 1 and 6, and screw on connecting rod bolts. Rod parting surface should face left side of cylinder block (i.e. engine oil cooler side). The numbered pistons should not be mixed, install each piston to the corresponding cylinder; connecting rod cap and connecting rod should be used in pairs, apply clean lubricating oil on connecting rod bolts before assembling.
- 7) Tighten connecting rod bolts:
 - a, Machine-cut connecting rod: Firstly tighten the bolts to 30Nm in symmetry, and then tighten each bolts for another 58°~65°, in the meantime tighten torque should be up to 85~135Nm. Assemble other piston-rods in the same way.
 - b, Fracture-split connecting rod: Firstly tighten the bolts to 30Nm in symmetry, and then tighten each bolts for another $120 \pm 5^\circ$, in the meantime tighten torque should be up to 67~107Nm. Assemble other piston-rods in the same way.

11.5.4 Inspection and maintenance of piston-rod assembly

- 1) Check whether there is crack on combustor throat fillet and piston pin boss; Check piston skirt and piston head for cylinder scoring phenomenon; Check wear condition of piston pin hole.
- 2) Check wear condition of piston ring outer edge; Check wear condition of piston ring upper and lower end face.
- 3) Check wear condition of piston pin external surface.
- 4) Check whether there is crack on connecting rod tip bottom hole, connecting rod body and connecting rod small end oil hole; Check alloy layer of connecting rod shell for abnormal wear and peeling phenomenon; Check wear condition of connecting rod side faces, check crooking condition of connecting rod body.
- 5) Check wear condition of connecting rod bearing shell, check its alloy layer for discoloration, peeling and slippage phenomenon.

11.6 Assembly and disassembly of crankshaft system

11.6.1 Exploded view of crankshaft system

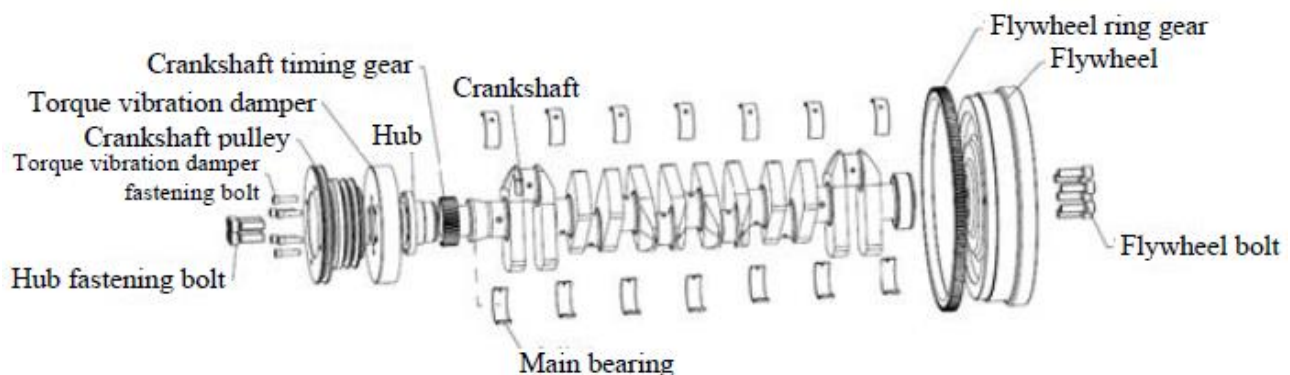


Fig. 11- 9 Exploded view of crankshaft system

11.6.2 Steps to disassemble crankshaft system

- ① Put the engine crankcase upward, and then remove main bearing bolts and place them orderly;

- ② Take down crankshaft and flywheel, remove front and rear thrust plates and flywheel bearing. Remove oil seals; place the crankshaft on bracket (for long time storage, the crankshaft should be placed vertical);
- ③ Classify the removed parts according to the requirements

11.6.3 Steps to assemble crankshaft system

- ① Clean up cylinder bottom holes.
 - ② Press main bearing upper shell into cylinder bottom holes and clean up scraped foreign matters
- 2.1 The bearing shell should be strictly inspected for bump damage before assembling, and shell with bump damage should not be reused even if repaired.
 - 2.2 The assembled upper bearing shell should be aligned to oil hole and oil groove on cylinder body, misalignment exceeds 1/5~1/4 of oil hole is strictly forbidden. The assembled upper bearing shell should be closely fit with cylinder bottom holes.
- ③ Apply clean lubricating oil on inner surface of upper bearing shell.
 - ④ Clean up undersurface of cylinder block, and make sure there is no grease.
 - ⑤ Apply sealant on undersurface of cylinder block properly.
 - ⑥ Lift up crankshaft, and clean up oil holes with compressed air, wipe out main journal and connecting rod journal with a towel, and then drop the crankshaft into cylinder body slowly, prevent crashing the crankshaft in this process.
 - ⑦ Clean up upper thrust plate and press it into cylinder body. Then side with oil groove should face outward (face to crankshaft).
 - ⑧ Check and make sure the oil seal is flat and free of distortion, and then place it into seal groove on cylinder undersurface with dedicated tool.

- ⑨ Press lower bearing shell and lower thrust plate (the side with oil groove should face crankshaft) into crankcase and assemble the crankshaft.
- ⑩ Apply clean lubricating oil on crankcase bolt bearing surface and main bearing bolt thread. Place main bearing bolts and pre-tighten them according to the order shown in Figure below. Firstly pre-tighten to 70Nm, and then tighten each bolt for another $90^{\circ} \pm 4^{\circ}$. Assembly of crank shaft is finished.

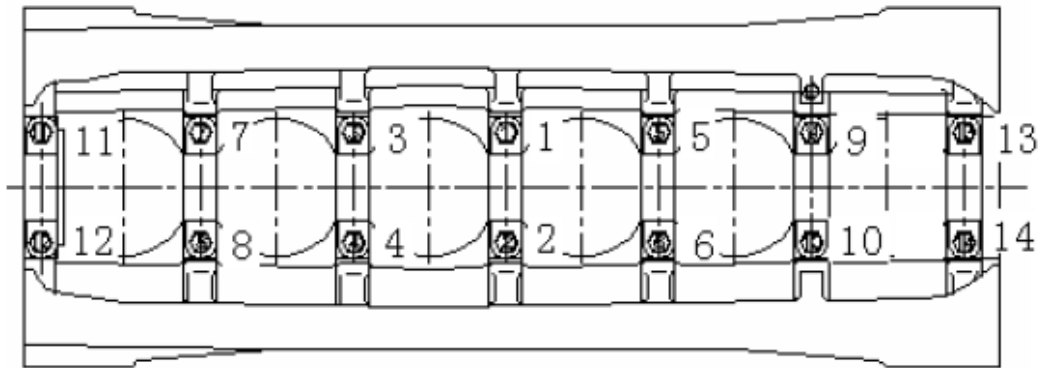


Fig. 11- 10 Tighten order of main bearing bolts

11.6.4 Inspection and maintenance of crankshaft system

- ① Check whether there is crack on fillet area of crankshaft main journal and neck of crankshaft;
Check the joint part of crankshaft and main bearing for crack, check and dredge the oil gallery.
- ② Check the wear condition of crankshaft main journal and neck of crankshaft, and check whether there is line-like puckering, metal peeling and crack.
- ③ Check the wear condition of front and rear oil seals.
- ④ Check whether there is failure like thread damage on main bearing bolts
- ⑤ Check crankshaft flange bolt holes for crack.
- ⑥ Check wear condition of crankshaft journal, check bend and distortion condition of crankshaft.

11.7 Assembly and disassembly of crankshaft bearing shell

11.7.1 Exploded view of crankshaft bearing shell

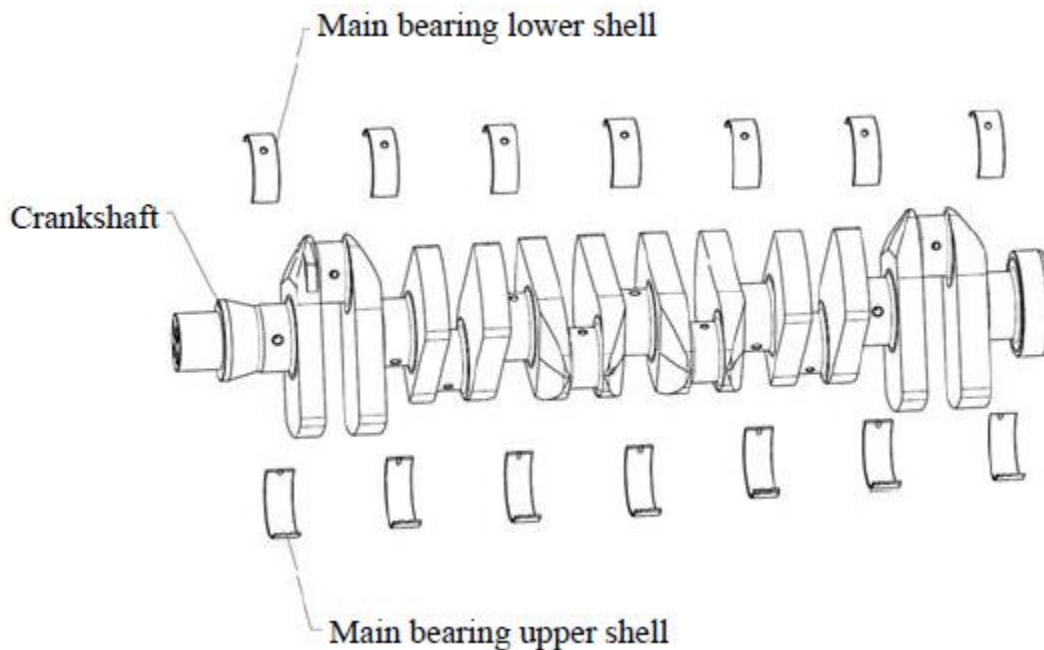


Fig. 11- 11 Exploded view of crankshaft bearing shell

11.7.2 Steps to disassemble crankshaft bearing shell

Push the shells out with hand, and mark the removed shells (should be corresponded with holes on engine block and crankcase).

11.7.3 Steps to assemble crankshaft bearing shell

- ① Clean up main bearing shells and the fitting holes.
- ② If no shell is replaced, then install the two shells into engine block (upper) and crankcase (lower) respectively (pay attention to the mark, shells should be installed into corresponding holes on engine block and crankcase), do not mix upper and lower shells, the one with oil groove is upper one. The shell lips should be aligned and applied with engine oil.

11.7.4 Inspection and maintenance of crankshaft bearing shell

- ① Clean the bearing shells and check their wear condition
- ② Check and ensure there is no peeling, locating lip damage and transverse crack on the shell.

11.8 Assembly and disassembly of thrust plates.

11.8.1 Exploded view of thrust plates.

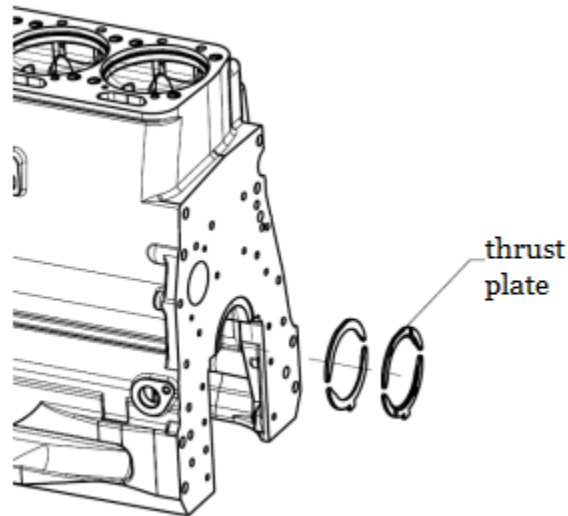


Fig. 11- 12 Exploded view of thrust plates

11.8.2 Steps to disassemble thrust plates

- ① Remove main bearing cap (refer to disassemble engine block module steps)
- ② Remove crankshaft (refer to disassemble crankshaft steps)
- ③ Remove thrust plates (key point 1)

11.8.3 Steps to assemble thrust plates

Assembling thrust plate steps are contrary to disassembling ones.

11.8.4 Inspection and maintenance of thrust plates

Key point 1: Assembling

Thrust plate should be used in pairs and the side with oil groove should be outward during assembling.

Put the anti-misloading lug in corresponding groove of thrust bearing cap.

11.9 Assembly and disassembly of camshaft

11.9.1 Exploded view of camshaft

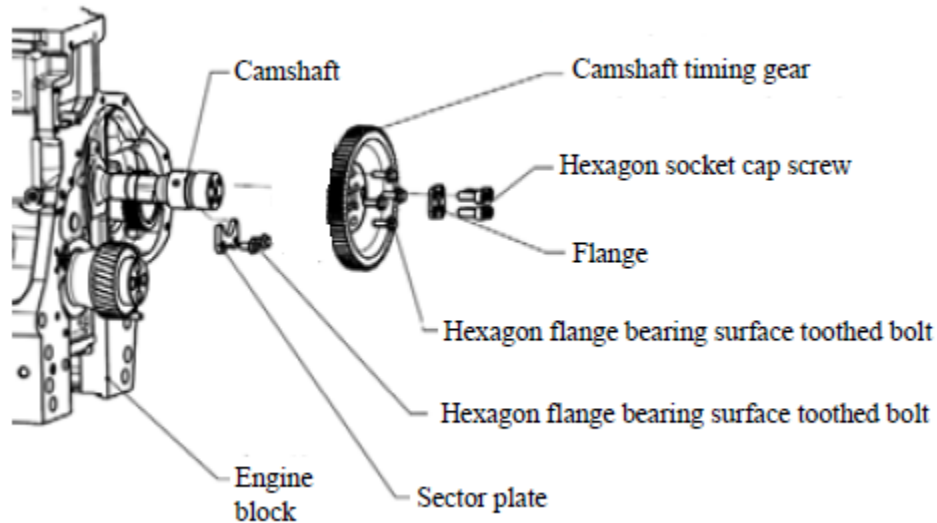


Fig. 11- 13 Exploded view of camshaft

11.9.2 Steps to disassemble camshaft

Disassembling steps are contrary to assembling ones.

11.9.3 Steps to assemble camshaft

After disassembling, examine camshaft and timing gear, and part with wear or large parameter deviation should be repaired or replaced.

- ① Check camshaft for blur and bump damage, and make sure there is no rust, scratch and scrap iron.
- ② Apply clean engine oil on camshaft hole and tappet hole inner surface. Install camshaft, do not damage camshaft surface and engine block hole during the push-in process of camshaft and the push-in strength should be equally, the end with thread should be on gear housing side.
- ③ Install sector plate, tightening torque of bolts should be $35\pm 10\text{Nm}$, seal up the bolts with lacquer.

- ④ Install gaskets, flange, washers and hexagon bolts on camshaft threaded end. Measure the axial clearance of camshaft, which should be 0.1~0.29mm, if the clearance is too small, check whether there is burr between camshaft and sector plate. If fail to adjust the clearance to required range after deburring, then the camshaft should be replaced.
- ⑤ Rotate the crankshaft until 0 tick on timing gear is closest to camshaft, install camshaft timing gear, make sure 0 tick of timing gear is engaged with 0 tick of crankshaft gear;

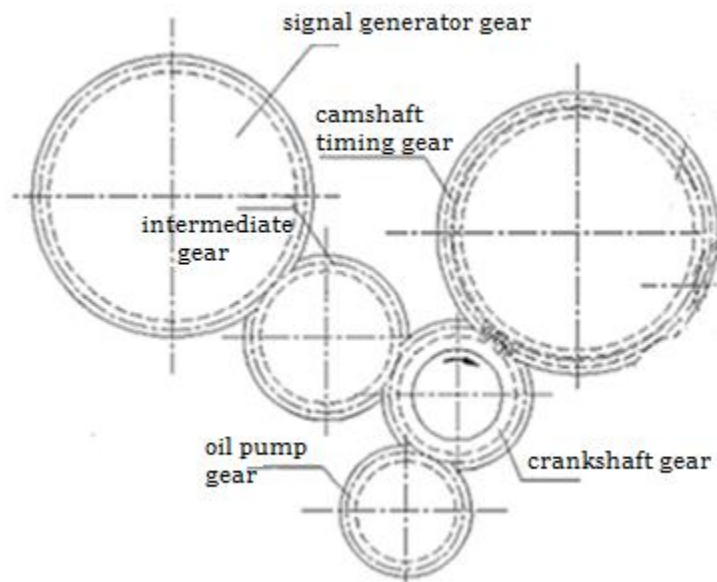


Fig. 11- 14 Crankshaft gear and camshaft meshing diagram

- ⑥ After correctly installed the gears, mark 0 tick position of camshaft timing gear and crankshaft timing gear with a marking pen.
- ⑦ After adjusting the holes, install camshaft bolts (cleaned and applied with KB277 sealant) through flanges holes; pre-tighten camshaft timing gear fixing bolts with pneumatic impact wrench, and pre-tighten connecting bolts between camshaft timing gear and fuel injection pump driven gear. Tighten the bolts with torque spanner, tightening torque for M10 bolts: 85~90Nm, tightening torque for M8 bolts: 55~60.5Nm, seal up the bolts with lacquer after tightening.



Rotate crankshaft to check whether 0 tick of each gear is normally engaged.

11.9.4 Inspection and maintenance of camshaft

- ① Check whether there is wear trace on cam face that contacting tappet, check main journal for seizure and abrasion.
- ② Check whether timing gear and hexagon bolts are distorted.

12 Engine block assembly

12.1 Disassembly and assembly of engine block assembly

12.1.1 Exploded view of engine block assembly

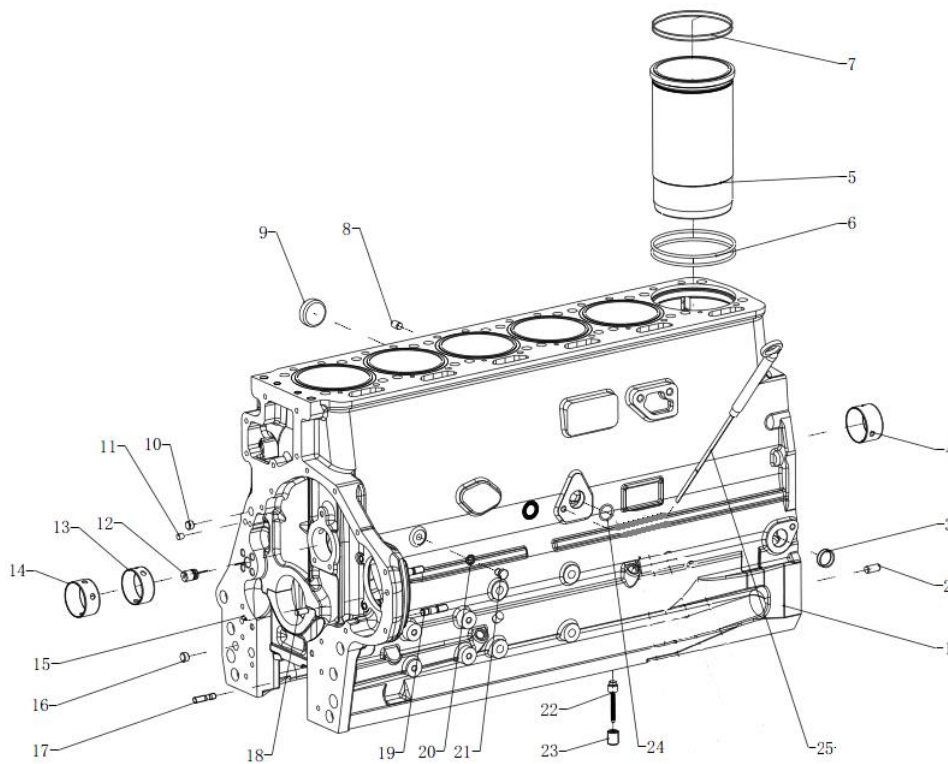


Fig. 12- 1 Exploded view of engine block assembly

No.	name	No.	name	No.	name
1	Engine block	11	Rivet	21	Plug
2	Pin	12	shaft	22	Rivet

3	Cup pulg	13	Camshaft bushing	23	Stud
4	Camshaft bushing	14	Camshaft bushing	24	Cup plug
5	Cylinder liner	15	Pin	25	Dipstick
6	O seal ring	16	Plug		
7	O seal ring	17	Stud		
8	Seal plug	18	Pin		
9	Cup plug	19	Stud		
10	Rivet	20	washer		

12.1.2 Steps to disassemble engine block:

- 1) Remove cylinder head bolt (key point 1)
- 2) Remove oil dipstick assembly.
- 3) Remove oil pipe plus screw and swivel nut
- 4) Remove cylinder liner (key point 2)
- 5) Remove camshaft bushing

12.1.3 Steps to assemble engine block assembly

Assembling steps are contrary to disassembling ones.

12.1.4 Inspection and maintenance of engine block assembly

Key point 1: Assembling

Apply oil on connecting area and thread of cylinder head bolt, then tightening them as below:

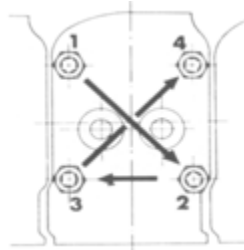
(1) Tightening by machine:

- a. Pre-tighten to 15N.m
- b. Tighten to 60N.m,
- c. Turn $230^{\circ} \pm 4^{\circ}$

(2) Tightening by torque spanner:

- a. Pre-tighten to 30N.m b. turn $120^{\circ}\pm 4^{\circ}$ c. turn $120^{\circ}\pm 4^{\circ}$ again.

The figure below show the tightening sequence of cylinder head bolt in every cylinder head.



(3) The tightening sequence of cylinder head is:

3-4-5-2-1-6

(4) The torque range of cylinder head bolt should be:

M14—12.9: (230~300)N·m

M14—10.9: (190~285)N·m

Key point 2:

Inspection:

1) Measure the protrusion of cylinder sleeve (0.05mm~0.10mm is qualified).

Note that protrusion of cylinder sleeve is average value of X direction and Y direction; and the measurement should be done without seal rings. Cylinder sleeve for the same engine should be uniform.

2) No corrosion, scratch and crash damage is allowed for fitting surface and friction surface, wipe them out and apply clean lubricating oil or grease before assembling.

Assembling:



Place cylinder sleeve vertically on engine block, install seal rings on the sleeve and engine block and then assemble the sleeve, knock it to the right place evenly with nylon rod.

Key point 3:

Disassembling:

Use dedicated tool to disassemble the camshaft sleeve, and try to protect other sleeves during disassembling.

Inspection:

Before assembling, grease on sleeve back, bush surface and fitting hole inner surface must be wiped out, and make sure there is no burr, overlap and scrap iron.

Assembling:

Apply oil on engine block hole, put camshaft sleeve into the dedicated tool and guide it into engine block, in the meantime align oil gallery holes on the sleeve and engine block.

12.2 Steps to Assemble and disassemble Engine Block Module

12.2.1 Exploded View of Engine Block Module

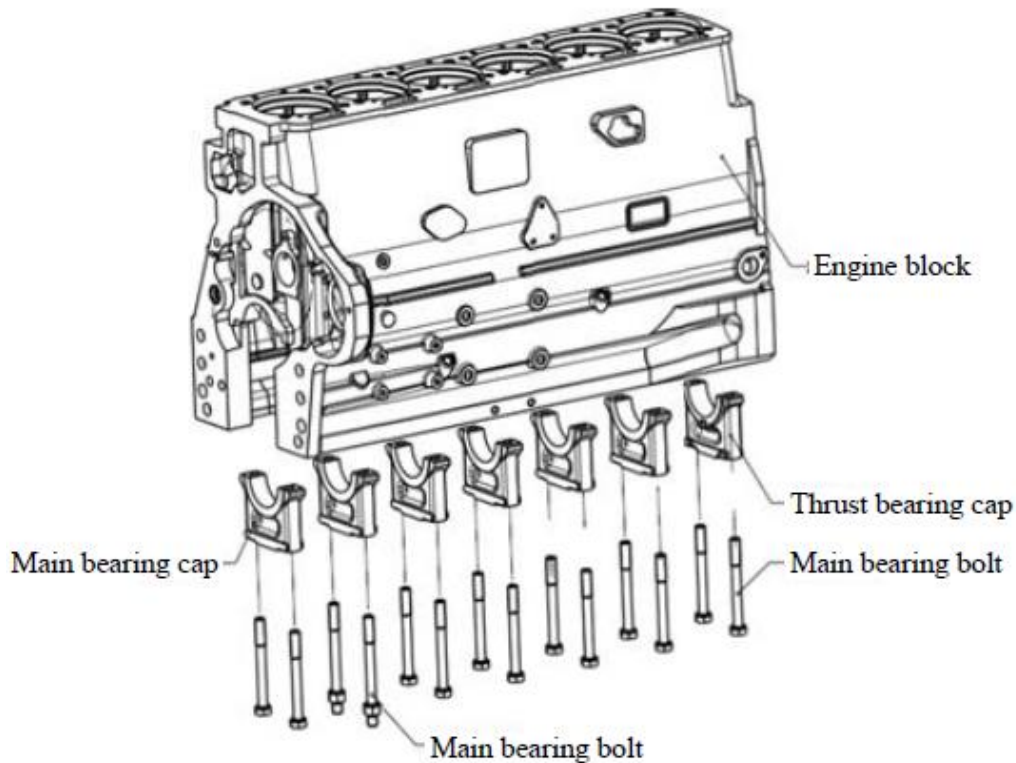


Fig. 12-2 Exploded view of engine block

12.2.2 step to disassemble Engine Block Module

- (1) Remove main bearing bolts (key point 1);
- (2) Remove main bearing caps (key point 2);

12.2.3 Steps to assemble engine block module.

Assembling steps are contrary to disassembling ones.

12.2.4 Inspect and repair engine block module.

Key point 1:

Inspection:

Check and clean engine block. Including but not limited to: Assembly environment must be clean; check engine block finished surfaces for crash damage, scratch and rust; do not bump and scratch the parts during assembling, and besides special requirements, sharp corner and edge on parts must be smoothed.

Assembling:

For 6-cylinder engine, 14 M14—10.9 main bearing bolts are used to fix the bearings. As shown in Fig. 4-3, start with middle bearings, do the tightening work from middle to two ends evenly, follow the procedures below: Firstly pre-tighten each bolt to 70Nm, and tighten the bolts for further $90^{\circ}\pm 4^{\circ}$.

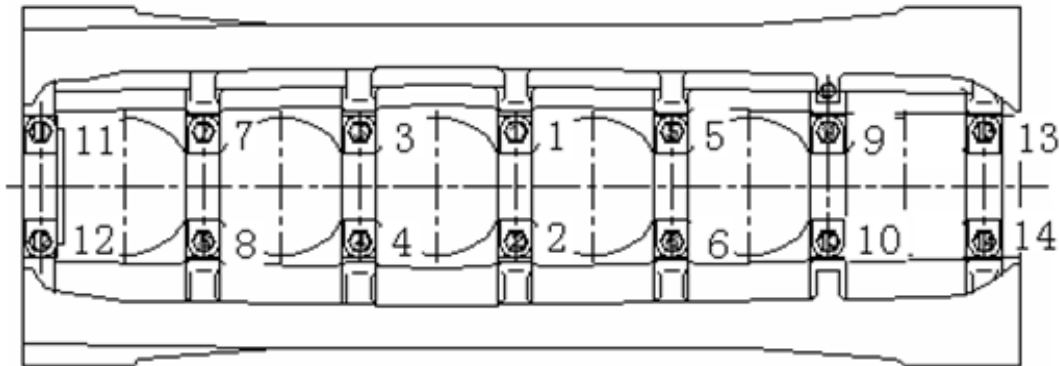


Fig.12- 3 Tighten order of main bearing bolt

Key point 2:

Assembling:

Install the thrust bearing cap on rear end of engine block, and the others are non-thrust bearing cap.

Take the cap two ends as locating basis when assembling; the main bearing bolts cannot be screwed on if the cap is inversely placed.

13 APPENDIX A

Appendix A: Torsional Torque and Tightening Method for Main Bolts and Nuts

Bolts	Bolts Specification	Tightening torque(N·m)	Inspect value (N·m)
Intake manifold bolt	M10	45~50	40~60
Exhaust manifold bolt	M10	45~50	45~60
Flywheel bolt	M16-10.9	285~295	285~340
Fastening bolt of crankshaft pulley	M16-12.9	300~310	300~360
Damper fastening bolt	M10-10.9	65~70	65~80
Camshaft gear bolt	M10×1.25-12.9	85~90	85~110
Bolt of Intermediate Gear Shaft	M10	65~70	65~80
Fastening Nut of Injection Pump Driving Gear	M10-10.9	65~70	65~80
Nuts of Injection Pump Shaft	M14×1.5	85~100	85~110
	M18×1.5	100~110	100~120
Hexagon bolts and stud of flywheel	M12-12.9	140~145	140~170
	M10-12.9	80~85	80~95
Bolts of Oil Pan	M8-8.8	20~25	20~35
Socket head screws of oil pan	M8-10.9	30~35	30~45
Bolts of Oil Pump	M8-12.9	30~40	30~50
Stud with self-locking nuts	M8-8.8	20~25	20~35
Bolt of Rocker-Arm Seat	M10-8.8	40~45	40~55
Rocker adjusting nut	M9×1	20~25	20~35
Fastening bolt of cylinder head cover	M8-8.8	10~15	10~25
Fastening bolt of pulley on hub	M10-10.9	65~70	65~80

14 APPENDIX B

Appendix B: Tolerance Clearance for Main Parts of Gas Engine (Reference value)

#	Items		Theoretical value (mm)
1	Main bearing clearance		0.05~0.11
2	Connecting rod bearing clearance		0.045~0.09
3	Crankshaft axial clearance		0.04~0.25
4	Connecting rod planar axial clearance		0.30~0.50
5	Clearance between the connecting rod small end bushing and piston pin		0.03~0.08
6	Clearance between piston pin hole and piston pin		0.003~0.015
7	Clearance between valve stem and valve guide pipe		0.03~0.06
8	Piston ring's gap in cold state	The first (top) ring	0.35~0.55
		The second ring	0.75~1.05
		Oil ring	0.3~0.6
9	Piston ring end face gap in cold state	The first (top) ring	—————
		The second ring	0.06~0.095
		Oil ring	0.05~0.085
10	Plane values of valve bottom recess cylinder head		1.0~1.45
11	Plane values of cylinder liner top above the engine body		0.05~0.10
12	Camshaft axial clearance		0.10~0.29
13	Camshaft bearing clearance		0.04~0.08
14	Clearance between valve tappet and tappet hole		0.006~0.035
15	Plane clearance between the piston top and the cylinder head bottom		0.88~1.11
16	Plane values of piston top above the engine block		0.25~0.57
17	Valve clearance (cold state)	Intake	0.2
		Exhaust	0.3
18	Clearance between rocker arm and rocker arm shaft		0.016~0.052
19	Gear backlash between timing gear and the intermediate gear		0.07~0.24
20	Clearance between positive and negative electrodes of the spark plug		0.35±0.05

15 APPENDIX C

Appendix C: The Evaluation Criteria for Main Friction Wear of Gas Engine (Reference value)

	Wear limit (mm)	Clearance limit (mm)	Parts life (hours)
Closed clearance of the first (top) ring	1.70	-	
The height of first ring	0.10	-	
Closed clearance of the second ring	1.50	-	
The height of second ring	0.10	-	
Closed clearance of oil ring	1.50	-	
The height of oil ring	0.15	-	
The outer diameter of the piston skirt	0.25	0.60	
The inner diameter of the cylinder liner	0.50		
The outer diameter of the piston pin	0.04	0.10	
The inner diameter of the piston pin hole	0.08		
The inner diameter of connect rod small end bushing	0.08		
The inner diameter of camshaft main journal	0.06	0.10	
The inner diameter of camshaft bushing	0.06		
The height of cam peach tip	2.00	-	
The outer diameter of the cam base circle	0.05	-	
The outside diameter of crankshaft journal	0.12	0.15	
The diameter of connecting rod bearing bore	0.10		
The outer diameter of the crankshaft main journal	0.08	0.15	
The inner diameter of main bearing bore	0.10		
Thickness of thrust bearing	0.40	-	
The subsidence value of intake valve	0.04*d ₍₁₎		
Intake valve seals	0.75		
Intake valve seat	0.75		
The subsidence value of exhaust valve	0.04*d ₍₁₎		
Exhaust valve seals	0.85		
Exhaust valve seat	0.85		
The inner diameter of the intake valve guide	0.06	0.1	
The outer diameter of the intake valve stem	0.06		
The inner diameter of the exhaust valve guide	0.06	0.1	
The outer diameter of the exhaust valve stem	0.06		
The inner diameter of rocker arm shaft bushing	0.10	0.12	
The outer diameter of rocker arm shaft	0.05		

(1) d is the diameter of intake or exhaust valve plate

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