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Chapter I The Working Principle of D10 Engine

Section I Working Principle of Diesel Engine

Engine is the power source of automobile, which changes the energy in certain form into the mechanical energy. The engine for automobile is a device which converts the thermal energy into the mechanical energy. As the combustion is carried out inside the engine (i.e. in the cylinder), the engine is also called internal combustion engine.

As for combustion modes, there are two kinds of internal combustion engines, i.e. spark ignition engine (gasoline engine) and compression ignition engine (diesel engine). For the spark ignition engine, the gasoline and air are mixed at first, and then spark ignition is carried out at the proper time; for the diesel engine, the diesel oil is injected into combustion chamber in time and then mixed with air, so that the automatic combustion can be carried out with the help of high temperature arising from compression.

With high performance on compression and power, the diesel engines are extensively applied to heavy-duty trucks.

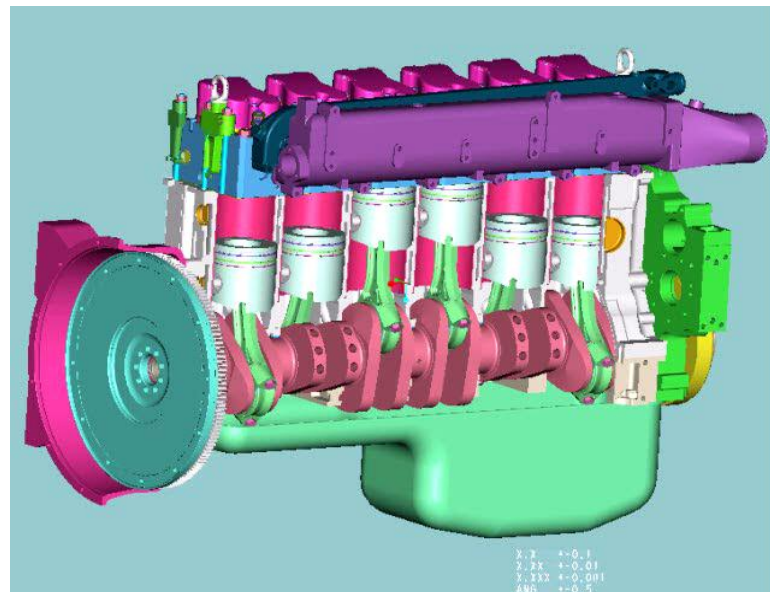


Fig. 1-1 D10 Series Engine

I. Terms:

- 1. Top Dead Center:** The position where the piston top is located in cylinder when the piston is set at the outmost position away from the slewing center of crankshaft, namely when the piston is set at the highest position.
- 2. Bottom Dead Center:** The position where the piston top is located in cylinder when the piston is set at the nearest position away from the slewing center of crankshaft, namely when the piston is set at the lowest position.
- 3. Stroke:** It means the movement of piston from one dead center to the other dead center for one time.
- 4. Stroke of Piston:** It means the distance of piston movement from one dead center to the other dead center. Usually, it is expressed as the letter "S". During one circle of rotation of crankshaft, the piston will reciprocate in the cylinder for 2 strokes.
- 5. Cylinder Capacity:** It means the room formed by movement of piston from top dead center to bottom dead center. The capacity of multi-cylinder engine is the capacity sum of all cylinders. The engine capacity (also called displacement) indicates the capacity sum of

Lowering the combustion noise: One of the reasons for selecting the common rail fuel injection system is that the common rail system can do better in controlling the engine noise; and the pilot injection is a very good means. The pilot injection fuel being injected into the cylinder beforehand has adequate combustion readiness time, and the pilot injection fuel has a very small quantity, which brings little premixed fuel gas in the preliminary combustion. This greatly improves the generally inevitable and inherent situation that the diesel engine has not only high preliminary combustion value and great combustion noise. As a result, the pilot injection of the common rail fuel injection system can obviously lower the combustion noise. In addition, the electronically-controlled common rail system can precisely compensate the unbalance between the fuel injections of various cylinders, which cannot be achieved by the mechanical pump and greatly improve the shock situation of the engine as a result.

Enhancing shock absorbing behavior and reducing noise: The improved design of the cylinder body and crankcase fully strengthens its rigidity; and through the three-dimensional finite-element vibratory response analysis and actual testing, it effectively reduces the vibration and noise of the cylinder body assembly, and noise radiation. The noise reduction measures are fully weighed in designing the parts like rocker arm bonnet.

Shock absorbing measures: The crankshaft vibration damper is redesigned through analyzing the former torsional vibration system of the crankshaft.

JOCOBS Electronically-Controlled Brake System

The engine is provided with the exhaust type brake device of Jacobs (U.S.A), working with the exhaust brake at the same time; when the engine speed reaches 2200r/min, a braking power not less than 146 kW can be obtained which obviously enhances the brake power of the vehicle and improves the vehicle security.

New generation of cold starting apparatuses

The electronic control system can automatically indicate whether the engine is in a starting state, and automatically adjust the advance angle and fuel injection quantity in accordance with the air and water temperature, and therefore, the cold starting performance of the engine is obviously promoted.

The resistance air preheater can, under the control of the electronic control system, perform the heating in advance before the engine starts, and automatically continues to heat for some time in accordance with the engine speed after the engine runs, which not only greatly enhance the cold starting performance of the engine but also obviously reduce the phenomenon (inevitable for traditional diesel engines) in which the unburned diesel gives out white smoke in case of low temperature start.

Excellent driving and controlling performance

The electronic control system can automatically adjust the fuel injection of the injection nozzle according to the different working conditions such as engine starting, idle speed, departure, acceleration, steady speed, neutral position, astern running, air conditioner using, and power take off, and thus the driving and controlling performance is greatly enhanced.

The electronic control system can, in accordance with the difference in the rotation speeds of various cylinders in operation, automatically balance the fuel injection quantities of various cylinders to make the rotation speeds of various cylinders in operation become exactly the same so as to enable the engine to achieve a very steady idle speed.

CEVB Technology

As an auxiliary braking apparatus, the EVB system is an engine retarder and based on the traditional exhaust auxiliary braking apparatus of the butterfly valve, and it can further enhance the braking efficiency of the engine.



Fig. 2-1 Outside View of Common Rail Engine

II. Fundamental Structure of Common Rail Engine

1. Engine Body

Based on the wide type cylinder body of the original design of Steyr in compliance with Euro II Emission Standard, the engine is greatly altered in order to further lower the engine noise, and significantly improved to promote the thermal load of the engine. However, the improvement is mainly embodied by the alteration to the casting blank, and what is related to the machine tooling is altered little; and therefore, the cost of the cylinder body is equivalent to that of the cylinder body in compliance with Euro II Emission Standard.

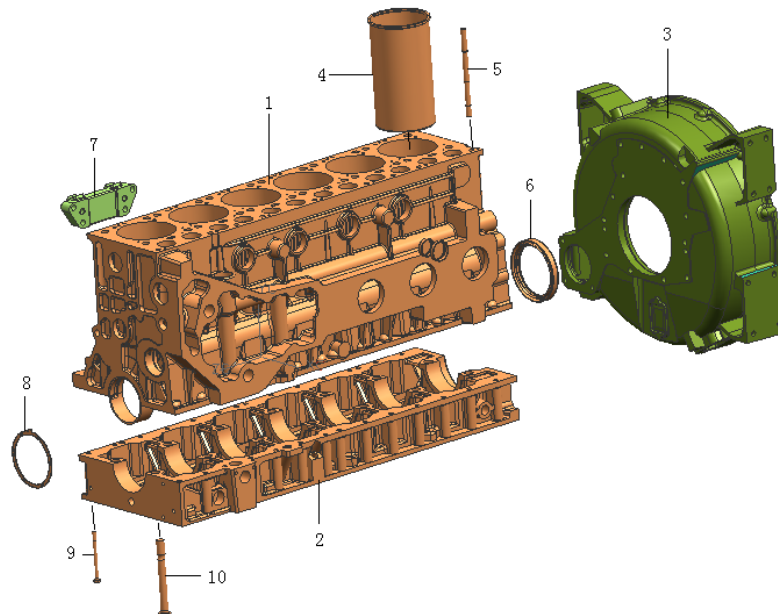


Fig. 2-2 Engine body, crankcase, and flywheel casing

Main parts: 1. Engine body 2. Crankcase 3. Flywheel casing 4. Cylinder casing 5. Cylinder head stud 6. Rear oil seal 7. Fuel injection pump bracket 8. Thrust plate 9. Hexagon bolt 10. Main bearing stud

The dry type cylinder casing is applied to the engine body, and it is transition fit between the cylinder casing and the cylinder holes of the engine body. The thin-wall cylinder casing is manufactured by abrasion-proof alloy cast iron, with a wall thickness of 2 mm; and the testing of the cylinder casing demands the dedicated measuring unit. The internal surface of the cylinder casing is covered by specially-made overlapping curves, and this brings good effect on the acceleration of running-in and abrasion-proof performance.

The front end of the engine body is connected to the timing gear chamber while its rear

(3) Main oil passage pressure limiting valve:

The main oil passage pressure limiting valve is located at the right lower position of crankcase and protrudes in the inner chamber of oil pan. It adjusts the gasket to ensure the opening pressure of $500 \pm 50\text{kPa}$. The valve has been corrected before the assembly, so the user can not change it randomly.

(4) Engine oil filter:

The large-capacity oil filter can adapt to the more smoke of Euro III engine.

(5) Engine oil pump:

Oil pump is some kind of gear pump, and the number of teeth is 10. The thickness of single-stage pump is 45mm. In addition to the dual-stage structure of road all-wheel drive vehicle, other vehicle models are equipped with single-stage pump.

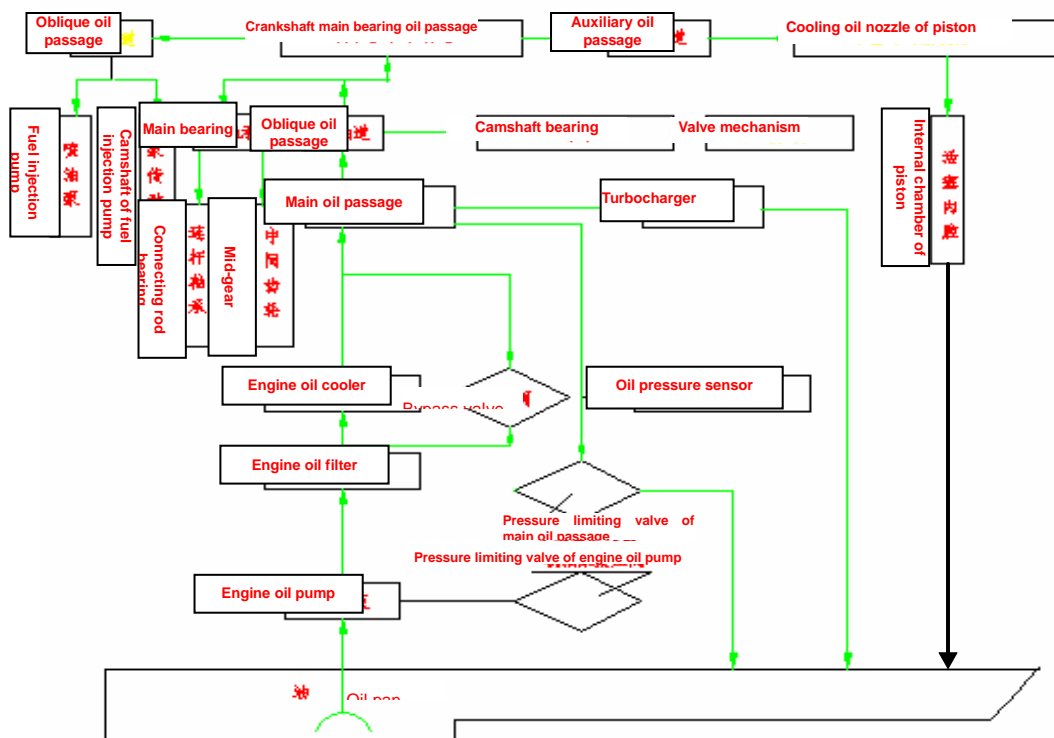
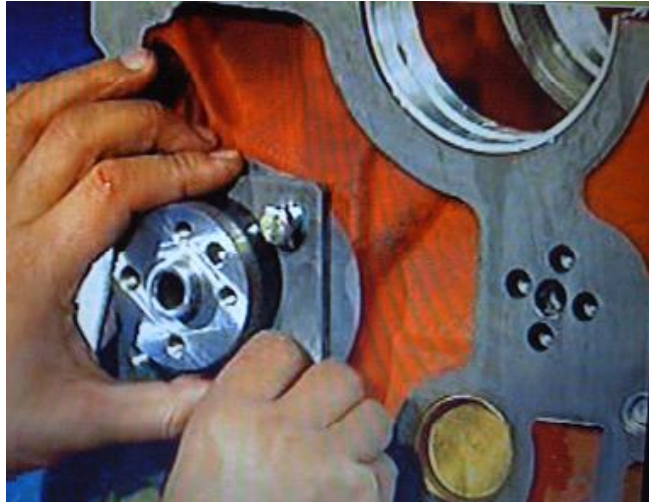


Fig. 2-6 Lubrication System

6. Cooling System

(1) Water pump:

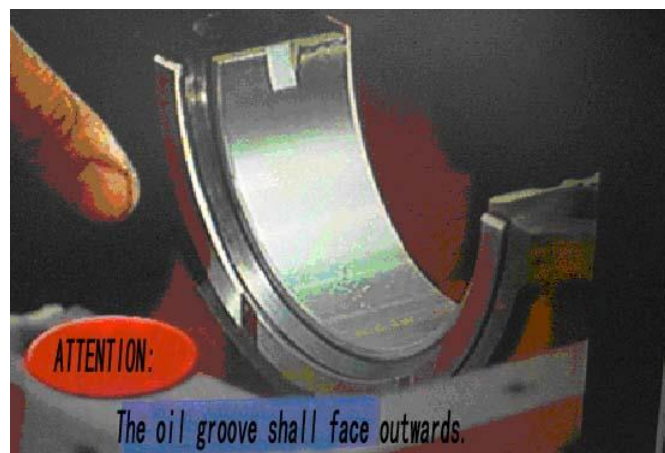
The water pump of D10 series of diesel engine is installed at the front of engine with the volute casing cast as a whole above the timing gear chamber. The water out of volute casing directly flows into the water chamber at the right side of body, and the coolant crosses over the oil cooler and flows into the water interlayer of cylinder barrel through the passage hole at the right bottom to cool the cylinder barrel and then flows into the water chamber of cylinder head through the upper water hole to cool the cylinder head, and finally is discharged from the water outlet of cylinder head into the water outlet pipe of which end is equipped with a thermostat. The thermostat has two outlets, of which one leads to the water tank and the other leads to the inlet of water pump (that is, the small cycle). When the coolant temperature is at $80 \pm 2^\circ\text{C}$, the thermostat starts to open and fully open when the temperature reaches 95°C , and at this point, all of the coolant is pumped into the body after being cooled by the radiator, but when the coolant temperature is below $80 \pm 2^\circ\text{C}$, the thermostat would cut off above channel, so the coolant would directly flow into the inlet of water pump to make the diesel engine warm up as soon as possible

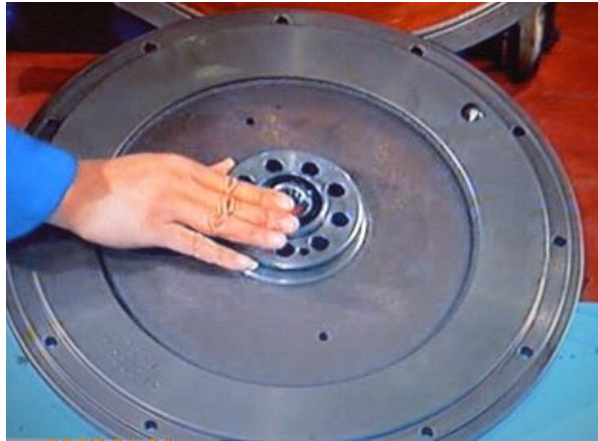


5. Wipe the seven main bearing holes, install the main bearing shells, and daub some cleaning oil on the round face inside the shells. Attention: do not install the shells mistakenly; the one with the oil groove and oil hole is the upper one.



6. Daub some butter on the two pairs (upper and lower) of thrust plates, and install them on the either side of the second main bearing hole respectively. Attention: the oil groove shall face outwards. Sleeve two O-shaped rubber seal rings respectively at the ports of oil duct hole of the second and third main bearings.

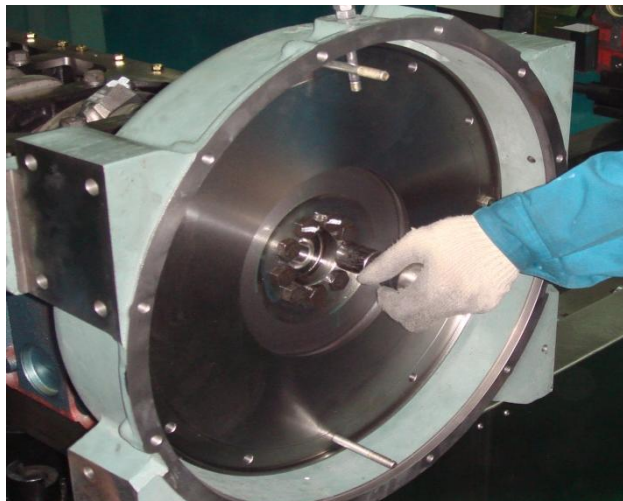




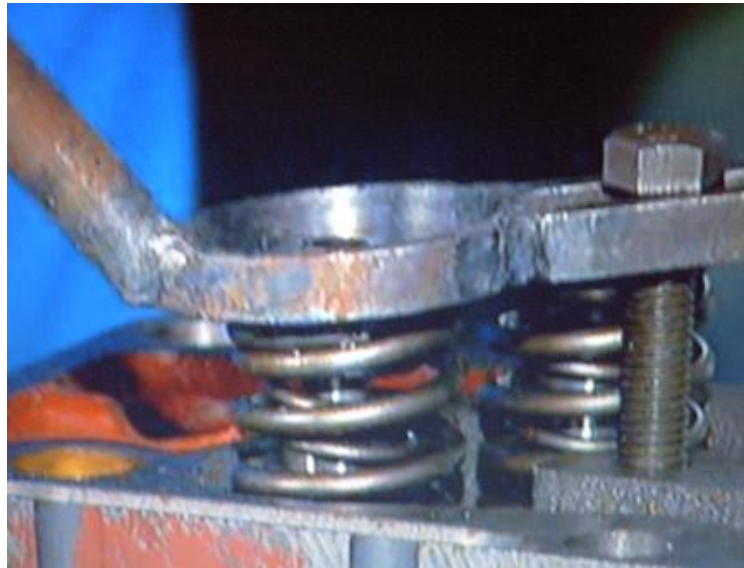
Fit the 2 M10×90 double-ended bolts into the flywheel ring gear, install the flywheel ring gear onto the flywheel, hoist the flywheel to align the positioning pin hole of flywheel with the positioning pin of crankshaft, and then install the flywheel onto the crankshaft.



Dip the flywheel bolts with oil, and fit two ones first. Lay the technological positioning pin into the upper hole of flywheel, and then tighten the flywheel bolts as required diagonally and twice: the first time, 60 N·m; the second time, rotary angle 180°. The after-tightening torque should lie in the range of 230~280 N·m.



Press the inner and outer springs down with special tools, install the valve lock between the lower seat of cylinder valve spring and the cylinder valve spindle, and then slowly release the spring. Check to see whether the valve lock has been installed properly.



27. Fit the 6 cylinder beds, wipe the bottom land of the assembled cylinder head subassemblies and fit them in. Knock those not reaching the proper position with a mallet. Fit the clamping blocks and compressing blocks into the auxiliary bolts of the cylinder head. Daub the threaded parts of the 21 auxiliary nuts and the 24 king bolts of the cylinder head with oil and screw them in. After that, tighten the king bolts and auxiliary nuts of the cylinder head based on the sequence as shown in the figure:

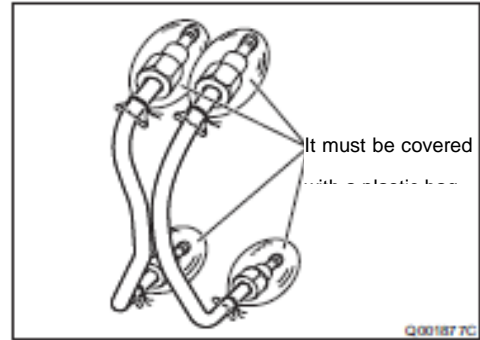


Sequence to tighten the king bolts of cylinder head:

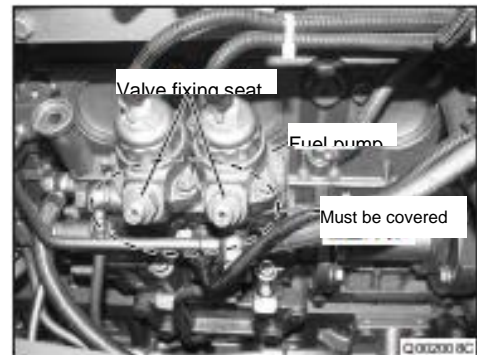
(5) Remove the high pressure pipe.

Attention

- Wrap the high pressure pipe with a plastic bag to protect it from dust or foreign matters.



- Wrap the fuel pump valve fixing seat with a plastic bag to protect it from dust or foreign matters.

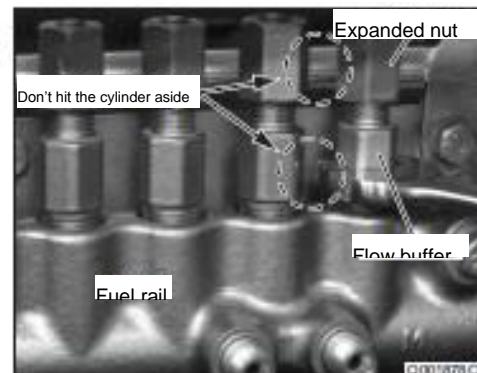


(6) Fix the flow buffer of fuel rail with a wrench as shown in the right figure.

(7) Loosen the expanded nut completely and get ready to remove the fuel rail from the high pressure pipe. It needs to loosen 6 expanded nuts here.

Attention

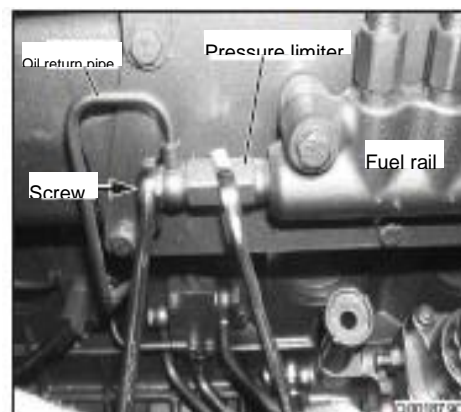
- **Make sure the tool does not hit the cylinder aside.**



(8) Remove the screw of pressure limiter; and first remove the oil return pipe from the pressure limiter.

Attention


- No washer is allowed to be reused.
- Fix the pressure limiter and then loosen the screw as shown in the right figure



Appendix II Flash code List for Malfunctions of High-pressure Common Rail Diesel Engine

Flash Code	Malfunction Code	Meanings of Code	Action of ECU	Malfunction Point	Malfunction Phenomenon
1	P1683	Short-circuit to ground of exhaust brake auxiliary output	Light off	Short-circuit to GND of 37 OUT6	The gassing brake function of engine works abnormally.
1	P1684	Short-circuit to battery of exhaust brake auxiliary output	Light on	Short-circuit to +B of 37 OUT6	The gassing brake function of engine works abnormally.
2	P1602	The data of QR code have not been put in.	Light on	The data of QR code have not been put in (all for zero).	Deterioration of output power and exhaust performance, and increase of engine noise and white smokes
2	P0602	The data of QR code is wrong.	Light on	The data of QR code is wrong (EEPROM) KQRSW reads 0,1,2	Deterioration of output power and exhaust performance, and increase of engine noise and white smokes
2	P1601	The data definition of QR code is wrong (The modification for definition of QR code is not right).	Light off , the system has no action.	The data definition of QR code is wrong (such as wrong order of 40, 80, 120, 140) This will not happen in batch production.	Deterioration of output power and exhaust performance, and increase of engine noise and white smokes
3	P0607	Malfunction of CPU. Monitor the malfunction of integrated circuit.	Light on, cruise stops, PTO stops, and fuel limitation 70%	Malfunction of auxiliary CPU (monitoring the computer of main ECU)	Insufficient output power, deterioration of exhaust performance, increase of noise, and engine stall
3	P0606	CPU malfunction, malfunction of main CPU	Light on, cruise stops, PTO stops, and fuel limitation 70%	Malfunction of main CPU (getting malfunction signal from auxiliary ECU)	Insufficient output power, deterioration of exhaust performance, increase of noise, and engine stall



Click  and choose parameters,

信号	单位
冷却水温度	degC
发动机转速	Rpm
最终燃油喷射数量	mm3/
最终燃油喷射正时	CA
进气歧管压力	kpa
燃油喷射量	mm3/
燃油喷射间隔	usec
进气温度	degC
钥匙开关	on/off
启动开关	on/off
发动机转速活动标志	on/off
凸轮活动标志	on/off
发动机停止开关	on/off
诊断开关	on/off
预热继电器	on/off
补偿后踏板位置	%

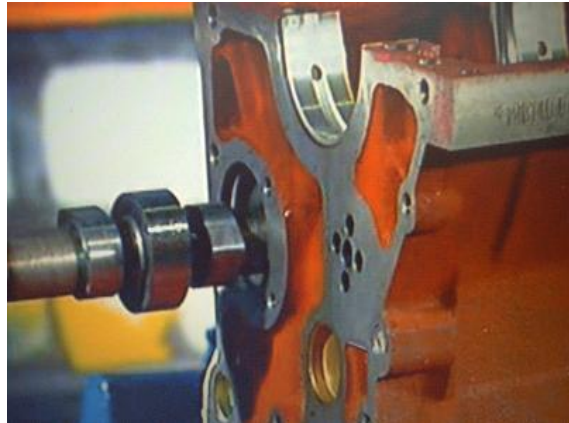
Select the items individually, including rotation speed of engine, final quantity of fuel oil injection,

Troubleshooting: Check and repair.

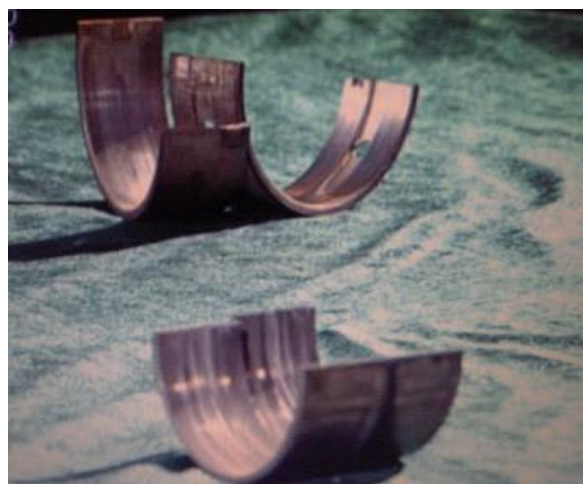


Cause X: The running-off of seized camshaft bearing leads to leakage of engine oil and reduction of engine oil pressure.

Troubleshooting: Replace camshaft bearing and bushing.



Cause XI: Too wide gap of bearing shell due to serious abrasion of main bearing shell and connecting-rod bearing shell, burning of bearing shell due to shortage of engine oil as well as scoring of bearing shell due to dirty engine oil will bring about difficulty in forming of lubricating oil film, which leads to leakage of engine oil and reduction of engine oil pressure;



Cause XII: Sealant used on joint surfaces of upper engine body and lower engine body is excessively thick or the sealant is not the special sealant, which leads to too wide gap between main bearing shells.

Troubleshooting: Check and repair.

replaced had better be the one that can be meshed and driven with others.

(2) Clear meshing sound exists in the gear pair of the engine, and with rhythmmed clash. The clash becomes louder as the increase of rotation speed of engine. This phenomenon shows that the gear meshing does not match. The engine gear from the same manufacturer is recommended.

(3) Appearance of long time “hoot” sound means that the meshing is too tight when the gear pair is running, and it is also caused by using unqualified gears or gears from different manufacturer.

(4) If rhythm “clatter” sound appears in the gear chamber when the engine is running and the sound is louder as the increase of the rotation speed, it must be the damage of timing mid-gear bearing 6206C3. The machine must be stopped and repaired. Using common 206 bearing for replacement is forbidden.

(5) Because of the damage of drive shaft bearing 6306C3 of injection pump and NU206BC3 bearings, the abnormal sound can also be sent out from gear chamber. This abnormal sound is caused by the damage of bearing and the change of meshing clearance between drive gear of injection pump and timing mid-gear, and sounds like “clatter”. The machine must be stopped and repaired immediately to prevent the accident from expansion when encountering this situation.

Cause:

(1) The gear system of the engine is completely lubricated through splashing. If the speed is accelerated immediately after starting the engine, the lubrication of gear system and bearing will be insufficient. After a long time, they will be damaged because of wear. In particular, accelerating after starting may cause dry wear of the bearing, so that the bearing can be easily damaged. The correct operation method is that the engine runs by the driving of the starter in idle speed for several circles to make the oil pressure arise, but the engine should not be started. Restart it after stopping 3~5 minutes. After the engine starts, run about 5 minutes in idle speed, and then accelerate it slowly.

(2) After repairing the engine, especially for the grinding of camshaft and crankshaft, the distance between the central lines of camshaft and crankshaft has changed, which can easily cause the change of meshing clearance, so as to damage the gear.

(3) Improper replacement method of crankshaft gear. For example, baking with oxyacetylene and excessive heat leads to distortion as well as the distortion of ring flange, which cause the displacement of crankshaft gear installation and improper meshing, so as to damage the gear.

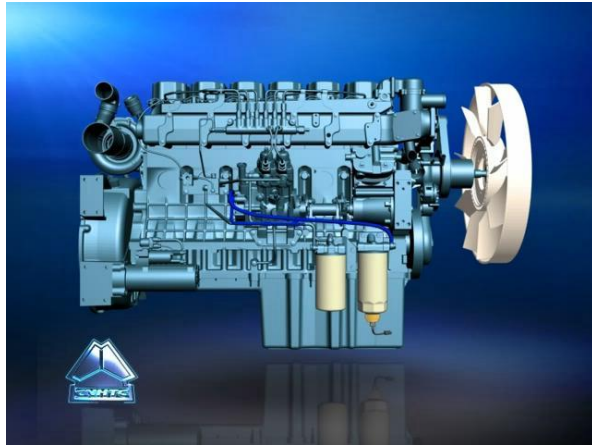
(4) The looseness of fixing bolt of timing mid-gear bearing leads to the change of meshing clearance and damage of bearing and gear.

(5) Abnormal sound may appear due to improper meshing because of excessive running-out of gear journal end surface when installing the gear caused by the burning of bearing shell of engine and camshaft and deviation of grinding process.

Judgment of malfunction and troubleshooting:

VI. Abnormal Sound from Damaged Mid-gear Bearing

Malfunction phenomenon:



4. Malfunction phenomenon: Failure of starting, normal operation of starter, small quantity of oil out of high-pressure oil circuit, without smoothness.

Cause: The diesel cleaner is blocked. Clean or replace the cleaner core;

Troubleshooting: Clean or replace diesel cleaner.



5. Malfunction phenomenon: Failure of starting, normal operation of starter, oil exists in high-pressure oil circuit, and black smoke exists in exhaust pipe.

Cause: Seriously bad atomization of oil ejector. Make experiment on the experimental bench.

Troubleshooting: Clean or replace diesel injector.

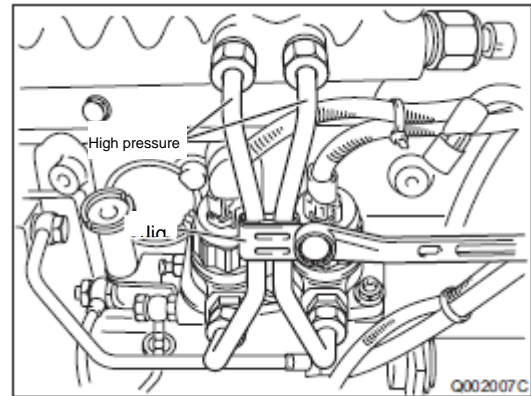


Tightening torque: 40 N·m (407.9 kgf·cm, 29.5 ft·lbf)

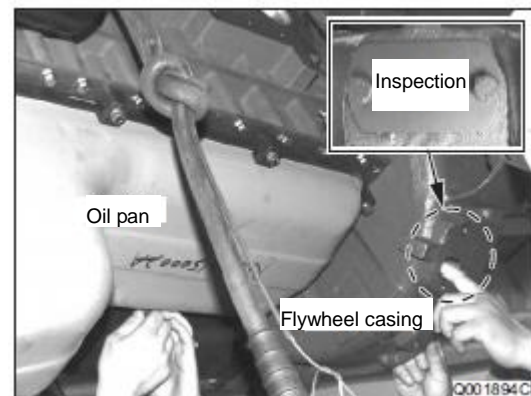
□ **Attention** □

Fix and screw down the fuel pump valve fixing seat as shown in the right figure.

(16) Install the high pressure pipe jig.



(17) Install the timing inspection cap.

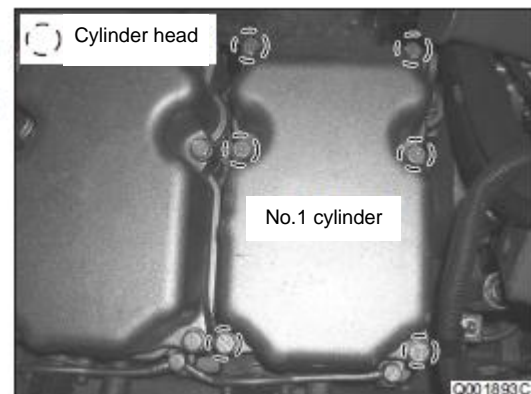


(18) Install the cylinder head cover of the NO.1 cylinder, and screw down the head cover bolt.

Tightening torque: 23 N·m (234.5 kgf·cm, 17.0 ft·lbf)

□ **Attention** □

Replace the rubber seal ring with a new one and paint the surface with engine oil; moreover, check the cylinder head cover for breakage in installation.



(19) Install the air cleaner, and connect the air intake hoses (2 pieces), then screw down the hose clamps.

