HYUNDAI

DIESEL ENGINE MANUAL

Model DHY18KSEm

Maintenance Manual

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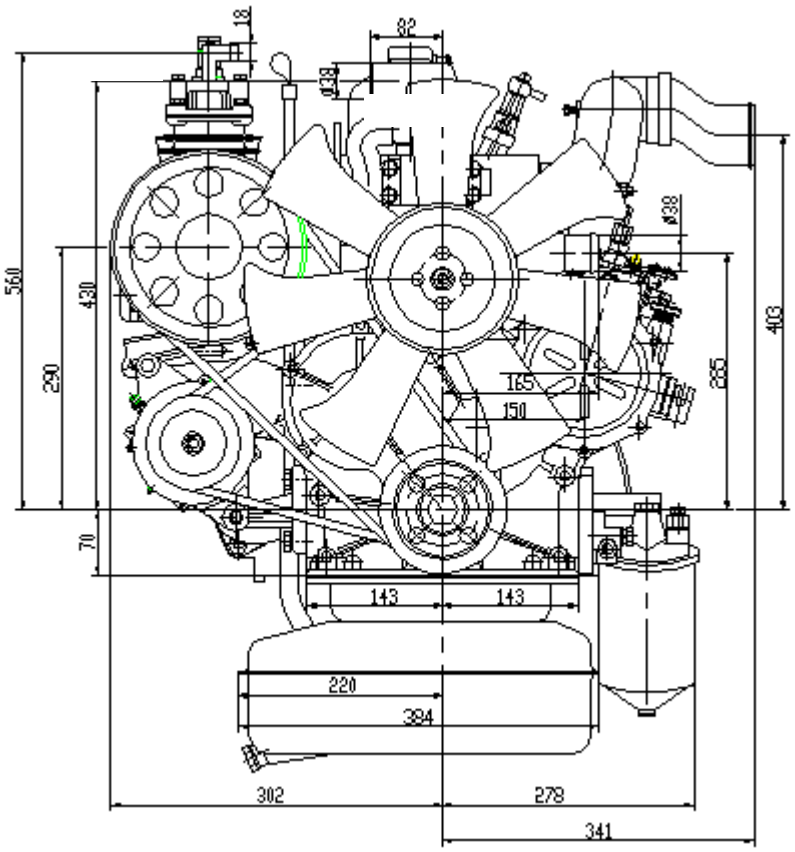
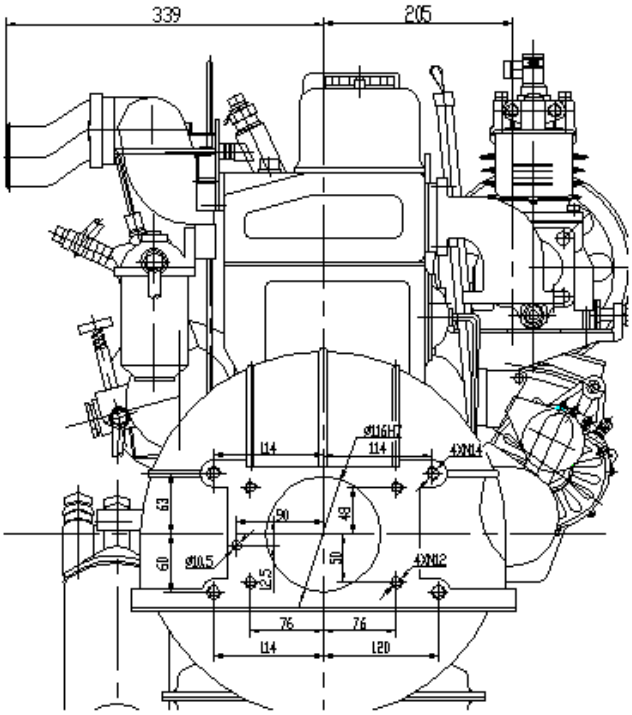
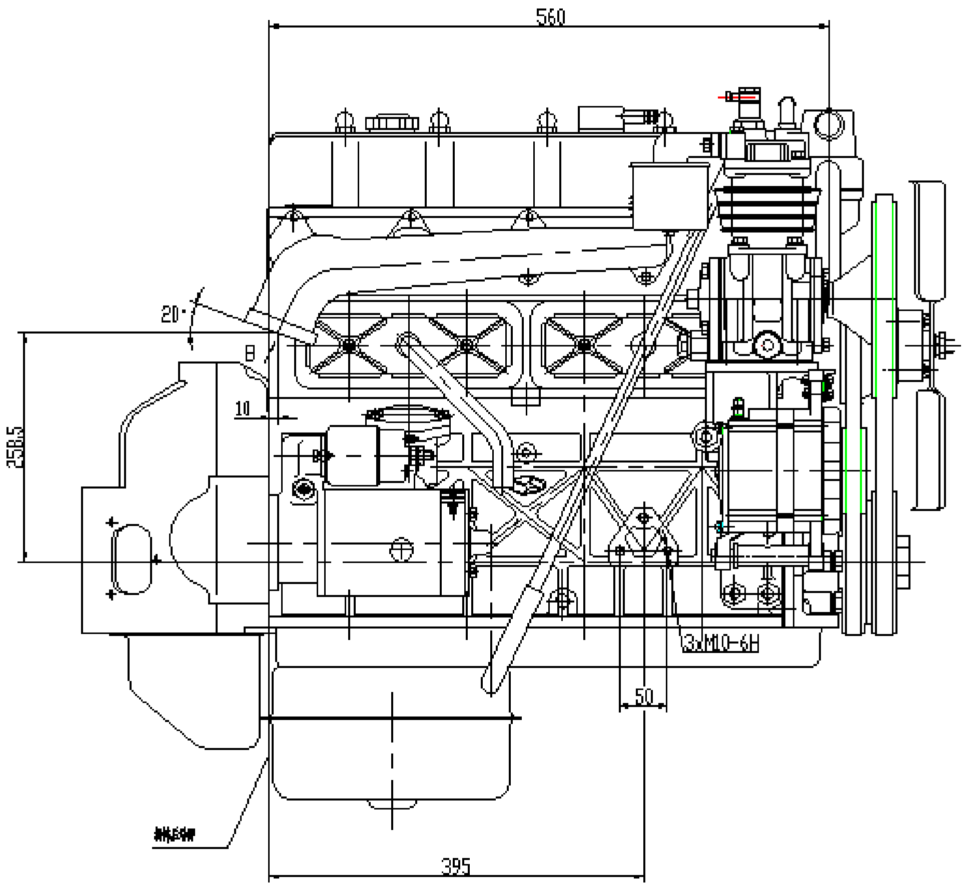
Main views of Diesel Engines



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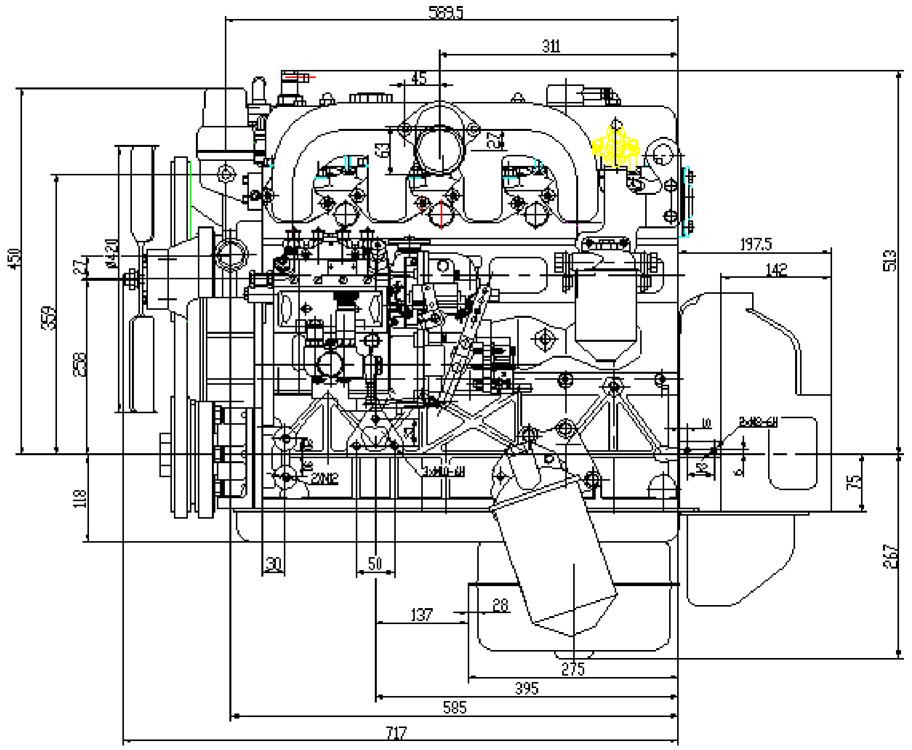
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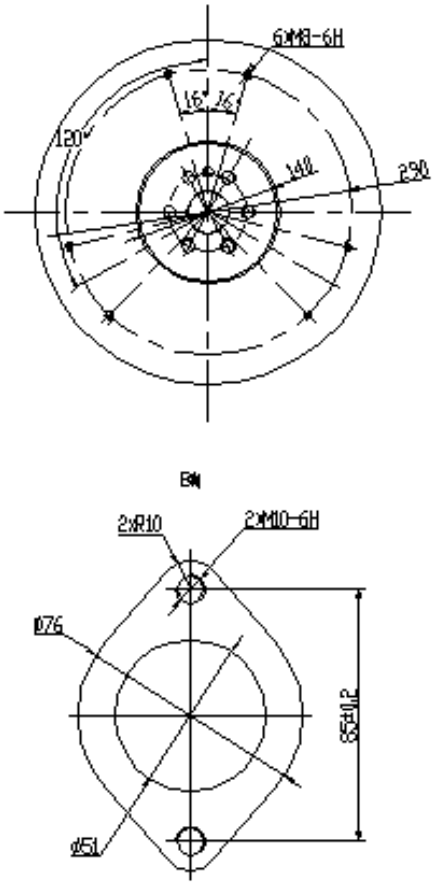
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1. Main specifications & data for diesel engines

1.1 Technical Performance Parameters of Diesel Engines

1	Model	HY490
2	Type	Inline, four stroke, water-cooled, direct injection combustion chamber
3	Number of cylinders	4
4	Bore(mm)×stroke(mm)	102×115
5	Total displacement(L)	3.76
6	Compression ratio	17:1
7	Rated power/rated speed	70/3200
8	Max. torque/speed(N・m/r/min)	≥230/1800~210
9	Min. fuel consumption at full load(g/kwh)	≤230
10	Oil, fuel consumption ratio (%)	≤0.8
11	Max. stable idling speed(r/min)	≤3520
12	Min. stable idling speed(r/min)	750±50
13	Free acceleration smoke density(Bosch)	≤3.5
14	Firing order	1-3-4-2
15	Lubrication	Forced splash
16	Cooling	Forced closed water cooling
17	Crankshaft rotation direction(viewing toward flywheel)	Counter-clockwise
18	Start mode	motor
19	Net mass(kg0	≤320
20	Length×width×height	892×622×733

Note: Rated power is the power that under the atmospheric pressure of 100 kPa (750mmHg), ambient temperature of 30%, without air filter and silencer. If the atmospheric condition in not the same as the standard one, it should be checked according to the standard GB1102.1-87<<performance test methods of internal combustion engine, standard ambient condition and declarations of power, fuel consumption and lubricating oil consumption>>

1.2 Main Technical Date of Diesel Engines

1. Temperature and pressure of diesel engine

Lube. oil temperature ℃	≤95℃
Outlet water temperature ℃	70~95℃
Exhaust temperature ℃	≤680℃
The oil pressure of main oil channel at rated working condition KPa	294~490kPA(3-5kgf/cm^2)
The oil pressure at idle speed	≥98kPa(1 kgf/cm^2)

2. Tighten torques of main bolts N・m (kgf・m)

Connecting rods bolt	100~140(10~14)
Cylinder head bolt	160~200(16-20)

Main bearing bolt	200~240(20-24)
Flywheel bolt	100~140(10-14)
Starting jaw	200~240(20-24)
Clutch bolt	70~110(7-11)

3. Main adjusted date

Type			HY490
Port timing	Intake valve open		24℃
	Intake valve close		48℃
	Exhaust valve open		65.3℃
	Exhaust valve close		29.3℃
Valve Clarence (cold condition)		Intake valve	0.30~0.35 mm
		Exhaust valve	0.35~0.40 mm
Advance angle of fuel supply			14±2°

2. Operation

2.1 Specifications of fuel

The sulfur content in fuel for diesel engines should be lower than 0.5%. If the weather is cold in winter, the fuel with low condensation point should be used. The choice of fuel type depends on the ambient temperature. Ex: fuel type –35 should be chosen at ambient temperature of –29℃.

Table 2-1 Relations between Fuel Type and Lowest Suitable Temperature

Fuel type	No. 10	No. 0	No. -10	No. -20	No. -35
Sulfur content (%)	0.2	02.	0.2	0.2	0.2
Cetane number	45	45	45	45	45
Condensation point (℃)	+10	0	-10	-20	-35
Lowest applicable temperature (ambient temperature) (℃)	+18	+4	-5	-14	-29

Fuel must be kept highly clean and away from dirt and impurities. Before being filled into the fuel tank, it should be kept still for over 27 hours and then the upper layer should be taken. This is quite important from early wear of the injection pump and the injection plunger.

2.2 Specifications of Oil

Correct choice of oil has a direct influence on the reliability of the engine and the ability of protecting the parts from abnormal wear. Grade CD should be chosen for HY490 diesel engines. Moreover, the choice of oil type should depend on the ambient temperature (see table 2-2). Ex: When the ambient temperature is –15C, Type 15W /40 should be chosen for Grade CD. The ambient temperature exceed the limits sporadically, it only influences the starting performance without damaging the engines. Oil must be kept clean and away from dirt and impurities. After filling the oil into the oil pan, the oil level should be checked in the following way: Draw out the oil dipstick, and wipe it with gauze, insert it into the oil. Then draw it out again, and see whether the oil level is between the upper and lower marks. The level must never be below the lower mark.

Table 2-2 Relations between Oil Type and Lowest Suitable Temperature

Type in Grade L-ECC		5W/ 30	10W/ 30		15W/ 40	20W/ 40	20/ 20W	30	40
Ambient Temperature (℃)		-25～ 25	-20～ 20		-10～ 35	-10～ 30	-10～ 10	5～ 30	>25

Type in Grade L-ECC	10W	5W/30	10W/30	15W/30	15W/0	20W/40	20/20W	30	40
Ambient Temperature (℃)	-20～-5	-25～25	-20～20	-10～25	-10～35	-10～30	-10～10	5～30	>25

2.3 Specifications of Coolant

Soft water (tap water, river water or rain water), instead of hard water (well water or spring water), should be filled into the cooling system of the engine for hard water contains CaCO3 and MgCO3. And after being precipitated on the water passage in cylinder block and the outer surface of the cylinder liner, it will increase of the restriction of water flow and therefore the heat dissipating of the cylinder liner. Hard water must be softened before being used. One method of softening is to add Na3PO4 into water (2g for 1 liter of water). Another one is to boil the water. Cooling water must be clean; otherwise, the impurities in the water may cause the wear of water pump or clogging in pipes of the coolant tank. When the ambient temperature is below 0℃, in case that the engine would be frozen, antifreeze fluid should be added to the cooling water, with its ingredients as displayed.

2.4 Preparations before Starting

2.4.1 Preparations before starting a new engine

Check the level of lubricating oil in the oil pan.

Check the stored fuel in the fuel tank.

Open the fuel switch so that the fuel could flow to the injection pump.

Deaerate the fuel system and the cooling system.

Add oil into the injection pump and turbocharger.

2.4.2 Deaerate the fuel system

Air in the fuel system may cause insufficient fuel supply of the injection pump resulting in difficulties in starting the engine, unstable running and even forcing the engine to stop. Therefore the fuel system must be deaerated when the fuel in the fuel tank runs out, it needs refilling or when the injection pump, the fuel filter and the fuel pipes have been disassembled and assembled.

Below are the procedures of deaerating the fuel system:

Unscrew the outlet screw on the fuel filter and the handle of fuel supply pump on the fuel injection pump (rotate several turns counter-clockwise), and then press the handle repeatedly until there is no bubble in the fuel released from the outlet screw. Then screw it again while keeping pressing the handle. Finally, screw the handle.

2.4.3 De-aerate the cooling system:

The cooling system must be deaerated when the coolant is added into the engine, otherwise, it may block the cooling system, making the engine overheat, and therefore

cause the serious fault of scuffing.
The procedures are as follows:
Unscrew the water temperature sensor (or the hexagon-headed plug) on the front end of the coolant outlet pipe and inject coolant into the cooling system, until there is no bubble in the coolant flowing from the coolant temperature sensor. Then screw the sensor again. If antifreeze fluid is used, it should be recollected for saving.

2.5 Starting

When starting, the gearbox should be free and unconnected with the clutch.
The procedures of starting are as following:
Loosen the air-bleed screw of fuel filter, press the fuel hand transfer pump to eliminate the air inside the fuel system. If the diesel engine is new or stop working for a long time, and the air inside the fuel system is more serious, then you can loosen the air-bleed screw of fuel injection pump, press the fuel hand transfer pump frequently to eliminate the air in side the system. If the diesel engine is often in use, then you can skip this procedure according to the actual conditions.
Unlock the switch to turn on the electrical power supply.
Press the starting button to start the engine. As soon as the engine starts, the button should be released, then put the switch to its original position. To protect the engine and batteries, the button should never be pressed for over 15 seconds at a time. If it fails to start, the engine should be restarted at intervals of 2~3min. If it fails three times in succession, it may be restarted only after the fault has been found and remedied.
The oil pressure should be checked soon after starting.
The oil pressure at idling running should never be lower than 98 kPa. After a newly assembled engine or the one changed oil is started, the oil level in the oil pan should be checked. If necessary, oil should be added so as to keep the oil level between the upper and lower marks.

2.6 Running and Monitoring

The engine must not run at full load condition as soon as it starts. It should run firstly for a period of time at low or medium speed. Only when the water temperature reaches 60℃ and the engine runs normally it can be operated at full load. It must be emphasized that it is harmful to warm up the engine at idling running in winter after starting.
Pay attention frequently to the oil pressure and the coolant temperature. The oil pressure at high or medium speed be within 294-490kPa while the coolant outlet temperature should be controlled below 95℃.
Check frequently after starting or before stopping whether there are any abnormal noises or faults. Stop the engine immediately if the abnormality occur, and restart after the fault has been remedied.
All limiting screws on the fuel injection pump have been sealed with the lead before sale. The customers themselves should not remove the lead to make adjustment.

2.7 Stopping

The engine should run at low speed for several minutes after its load is removed, and it should not be stopped until the coolant temperature drops lower than 60℃ If the cooling water contains no antifreeze fluid while the ambient temperature is below 5℃, the cooling water should be drained after stopping to protect the parts, such as the cylinder block, from cracking.

If the engine is to be shut down for a long period, cleaning should be carefully done. The cooling water must be drained and the necessary sealing with grease should be carried out to prevent the engine from rusting.

3. MAINTENANCE

Maintenance, which has a decisive influence on the life of the engine, is a necessity for a long-term reliability and economy of the engine. Therefore, the users should strictly abide by the following maintenance regulations.

3.1 Items of maintenance

Maintenance includes the maintenance in the run-in period and the technical maintenance in the running period.

Table 3-1 items of maintenance after the run-in period

Interval	No.	Items of maintenance
Run-in period (100hrs)	1	Clean the oil pan and change the oil
	2	Clean the strainer of the oil collector
	3	Tighten the nut (70-80N.m) for the drive gear of the oil pump
	4	Check the tighten torque of the bolts on the main bearing cap
	5	Check the tighten torque of the bolts on the connecting rod
	6	Check the tighten torque of the bolts on the cylinder head
	7	Check and adjust the valve clearance
	8	Clean the oil and fuel filters, remove dust on the air filter element, if necessary, change a new air filter element
	9	Check the fuel injection advance angle
	10	Check the tension of the fan belt
	11	Check the defects on the suspension pad or whether the nuts are loosen

Table 3-2 Items of technical maintenance

Interval	No.	Items of maintenance
Daily maintenance	1	Check the oil level in the oil pan and amount of coolant in the coolant tank
	2	Check tightness of the connections of water\oil and gas passage
	3	Clean the engine
	4	Remedy faults and abnormal defect
	5	Clean or change the oil filter element
	6	Clean the centrifugal oil filter
	7	Check the tension of the fan belt
	8	Remove the dust on the air filter element

	9	Charge grease to the water pump bearing
Second level main -tenance (100 hrs)	1-9	The same with the first level maintenance
	10	Change the oil in oil pan and injection pump, clean the oil pan and oil collector
	11	Change the fuel filter element
	12	Clean fuel tank, fuel supply pump strainer and fuel pipes
	13	Check and adjust the valve clearance
	14	Check and adjust the injection advance angle
	15	Check the opening pressure and the automation of the injector
	16	Change the oil coarse filter
Third level main -tenance (500 hrs)	1-16	The same with the second level maintenance
	17	Clean the oil cooler
	18	Check the tightness of cylinder head, connecting rod and main bearing bolts.
	19	Depending on the running conditions, decide if it is necessary to dismantle the cylinder head and grind the valve
	20	Depending on the running conditions, decide weather to have the injection pump checked and adjusted by the professional service agent

3.2 Description on maintenance

3.2.1 Check the oil level in the oil pan

Oil level should be checked with the engine shut down and kept horizontal, take out the oil dipstick, wipe it with clean cloth and insert it into the limit position. Take it out again and the normal oil level should be between the upper and lower marks. If the level is close to or below the lower marks, oil should be added immediately, and it is better to reach the upper marks. If the upper mark is surpassed, the redundant oil should be drained from the oil pan screw plug

The oil consumption of a new engine will be higher than the normal level during the run-in period, so oil level should be checked twice a day. But one time a day is enough thereafter.

3.2.2 Maintenance of the air filter

Meticulous and prompt maintenance of the air filter, together with protection of cylinder from dust, is of vital significance for the life the engine. The maintenance internal of the air filter depends on the quality of air in the running environments. In a severely dusty area, the interval should be shortened, and otherwise, prolonged. Black smoke or power drop might be caused by restriction in the air filter, and maintenance of the air filter should be taken into account. For an air filter with restriction indicator, when the indicator lights up, the air filter should be cleaned or changed. For an air filter with mechanical restriction indicator, the vehicle should be stopped and the rear cover should be opened, then, run the engine at a high speed to observe maintenance indicator.

To maintain the air filter, firstly open the filter cover by unscrewing the nut on it, and

then take out the filter element to remove the dust. Tap by hand or wooden stick at the two ends of the element while rotating it so that dust could be shaken off. It could be done to blow the element from the inner side with clean compressed air not higher than 600kPa, if the filter element is found blocked or damaged, the new air filter should be changed, and the quality of the new air filter should satisfy the relevant standards.

3.2.3 Check the tension of the belt

Tension of the fan belt should be checked frequently. Excessive tension may cause early damage of water pump bearing and alternator bearing, while inadequate tension may cause slipping of the belt and therefore shorten the belt life and overheat the engine.

Check according to the tension of the belt. Press a single belt with force of 39N, and see whether the belt deflection meets the standard of 10-15mm. If not, it should be adjusted by changing the position between the alternator and the adjusting arm. To guarantee the consistency in the tension of the two belts, it should be noted that the two belts must be replaced simultaneously, and the belts produced by different factories can't be used for the same engine.

3.2.4 Grease the water pump bearing

A grease fitting is fixed at top of the water pump housing. Grease should be regularly injected, to water pump bearing, with a grease gun.

3.2.5 Maintenance of the fuel filter

Fuel filter adopts paper filter element to ensure normal and enduring operation of the injection pump and injector. The paper filter elements should be replaced after 200hrs' running, instead of being used again after cleaning. Unfiltered fuel is not allowed to enter injection pump.

3.2.6 Check and adjust valve clearance

Proper valve clearance is a guarantee of normal power output of the engine as well as reliability and endurance of the valve train. Hence it is quite important to check and adjust the valve clearance.

Below are procedures of checking and adjusting of valve clearance:

Having confirmed that the piston in the first cylinder is at the top dead center, adjust primarily valve clearance of the first cylinder, and then others according to the firing order 1-3-4-2 each time a crankshaft travel of 180° is achieved. The valve clearance should be adjusted according to data in chapter 1.2, with the help of a feeler. After all the valve clearances have been adjusted, then start the engine, and check by observation or touch by hand in idling running to decide whether there is any mistake in adjustment.

3.2.7 Change oil for the engine and injection pump

Oil change should be carried out in a hot engine, because hot oil is apt to take away the impurities in it and be completely discharged. Unscrew the drain plug on the oil pan to drain out the oil. Tighten it (better to replace the washer) again after draining

out the oil, and then fill new oil.

3.2.8 Check fuel supply advance of the injection pump

There is no strict regulation for the interval of checking fuel supply advance angle. Under the condition of deterioration in performance of the engine, advance angle of the injection pump should be firstly checked. Checking is also necessary after the injection pump is reassembled.

The procedures of checking are as follows

① Remove the high-pressure fuel pipe of the first cylinder.

② Rotate the crankshaft counter-clockwise. At the same time, observe the fuel level in delivery valve fitting. At the beginning of a rise of the fuel level appears, stop crankshaft.

③ Check whether the pointer on the belt pulley end or on the flywheel observation window is pointing to an angle value as stipulated in 1.2.

Check once more if necessary, and adjust it.

The procedures of adjusting are as follows:

①Rotate the crankshaft counter-clockwise to an advance angle value before TDC of the first cylinder as specified by that type of engine. Confirm that it is the compression TDC of the first cylinder.

②Loosen the advance device coupling bolts, rotate the advance device, and observe the fuel level in delivery valve fitting of the first cylinder. Once a fluctuation appears, stop the rotation and tighten coupling blots.

③ Rotate the crankshaft to recheck the fuel supply advance angle in the same way as shown above.

3.2.9 Check the injection performance of the injector

The injector should be checked on a special test bed. While the fuel is being injected with the rate of 30 times per minute, under the pressure of 22-23Mpa, there should be even spray, clear cutoff of fuel, and a special clear sound.

In case of a poor spray performance of the injector, needle valve elements can be dismantled and cleaned (in clean diesel fuel) and adjusted to the standard pressure value. While checking the injector, pay attention not to confuse injectors from the cylinder, so as to ensure that the intrusion of the injector tip from the cylinder head bottom plane is within a permissible range. If a new injector is to be substituted, it should be adjusted with a copper gasket. The reassemble of the needle and the needle housing should accord to the original order.

4. MAIN CONSTRUCTION OF DIESEL ENGINES

4.1 Cylinder Block

4.1.1 Cylinder block

The cylinder block uses a typical gantry structure.

Beside cylinder lines holes and screw holes of cylinder head bolts, there are water

holes of the cylinder head, and there is a lubricating oil hole near the rear face to lubricate oil to the cylinder head.

There is a water inlet chamber of the water pump at front face of the cylinder block. Flywheel housing and rear oil sealing cover are mounted at the rear face. On the bottom surface of the cylinder block, there are screw holes for mounting main bearing bolts, lubrication oil inlet holes, oil pump holes and screw holes mounting the oil sump.

Oil filter, fuel filter and water drain valve are mounted at the right side of the cylinder block (view from the front face).

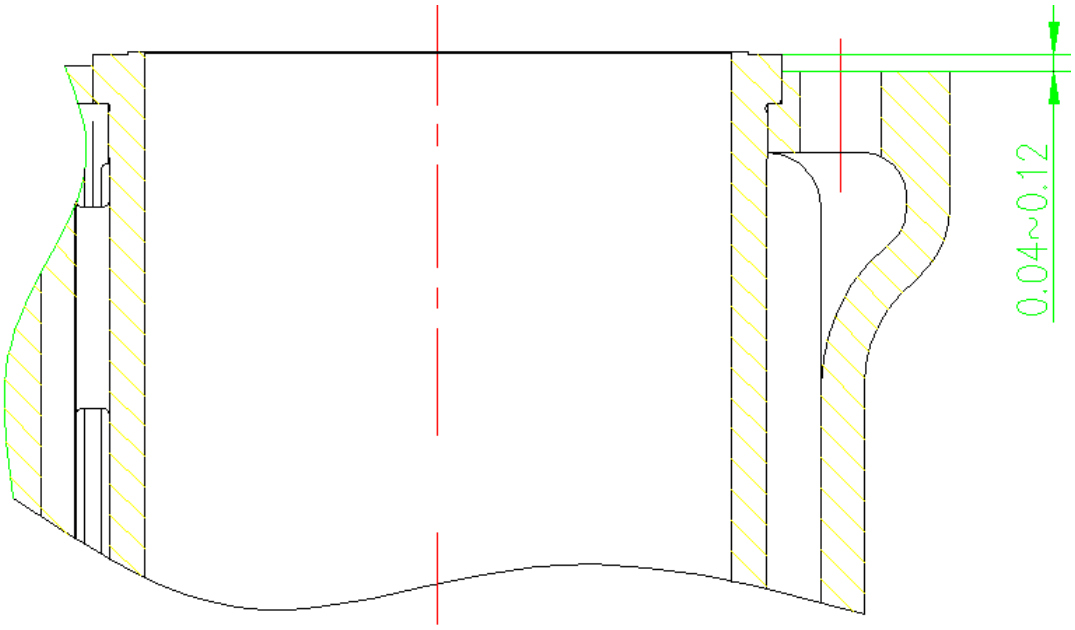
Main oil channel and branch oil channel cylinder block are arranged horizontally. When you dismantle the engine to repair, all oil channels shall be cleaned carefully, to ensure the oil ways keep clean and smooth. All the oil plugs of oil channel shall seal reliably, without oil leakage.

4.12 Main bearing

The main bearing uses a type of so called fully suspension bearing. The main bearing cap and the cylinder block is boring mate. And there are mating marks engraved on the cylinder block and main bearing cap, so as to avoid being changed at random and assembled on the wrong side. Pay more attention to aligning the front main bearing cap to the front face of the cylinder block, and on protrusion before assembling, to avoid affecting the tight pressing of timing gears chamber. Pay attention not to changing wrongly the upper and lower bearing after you dismantled them for checking and cleaning (this is an oil groove on the upper bearing). Thrust plates to the crankshaft are mounted on the rear main bearing, with each at the front and back, up and down. The thrust plates bear the axial thrust force coming from the crankshaft. There are oil grooves on the working face of the thrust plate, and the back face is a plane. When you assemble the thrust plate, the working face shall be put towards the thrust face of the crank arm, and mustn’t assemble oppositely. Knocking the thrust plates after tightening to keep the upper and lower at a same plane, then tight them one by one with specified torque. Turn the crankshaft with hand at the side of flywheel, it should be flexible after you have assembled it.

4.1.3 Cylinder liner

Cylinder liner is wet type. There are two ring-shape grooves assembled rubber o-ring at the bottom of the liner. O-ring mustn’t be distorted when assembled to the grooves, and then the cylinder liner is pressed into the cylinder liner holes, with the cylinder liner flange plane over the top surface of the cylinder block 0.04~0.12mm, to keep cylinder gasket tightened on this protruded surface and then ensure the sealing between cylinder liner and cylinder head. See figure 1.



1-Cylinder block 2-Cylinder liner

Figure 1: The distance that the cylinder liner flange is higher than the cylinder block top face

Oil sump is stretched by cast aluminum or steel plate. Be careful not to leave fibre like thread waste cloth on the wall, when you clean the inside of the oil sump, in order to avoid blockages in the copper wire net of the oil collector and oil filter core.

4.2 Cylinder Head

Intake/exhaust valves, valve seats, valve guide pipe, valve springs, rock arms and supports are assembled on the cylinder head.

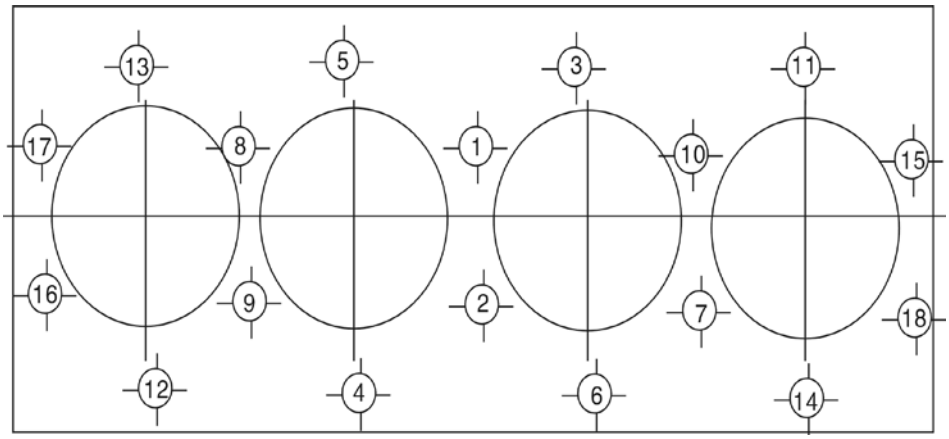


Figure 2: Tightening sequence of cylinder head bolts

Cylinder head is assembled on the cylinder block with cylinder head bolts. Torque wrench should be adopted to fasten the cylinder head bolts in turn according to the sequence of figure2 to achieve the required torque. Once the cylinder head has been dismantled, the cylinder head bolts torque shall be fastened according to the required value again after the engine runs hot for the first time and then stop it and get cool, and valve clearances shall be also adjusted.

Injectors are inclined on the top of cylinder head with an angle to the centerline of cylinder. When injectors are assembling holes, and the press plates shall be pressed evenly to avoid gas leakage, at the same time, slantwise face of the press plate shall face a down.

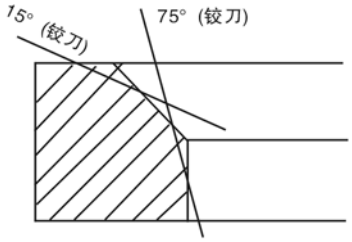
4.2.1 Intake/exhaust valves, valve seas and valve guide pipes

Intake/exhaust valves and valve seats shall be matched and ground to avoid leakage.

When burning, spot or wear occurs on the sealing area between valves and valve seats and causes gas leakage, grind should be done. Grinding cream as small valve sand should be applied on the sealing taped surface of valve. Then capping-in should be made to the valve and valve seat, till an even, continuous and unpolished sealing surface appears. Grinding cream must be strictly prevented from entering valve guide pipe. Cleaning the valve, valve seat and valve guide pipe carefully after grinding, for the wear of valve guide pipe will cause a partial wear to the valve sealing surface, thus leading to a poor sealing. Pour coal oil or diesel fuel into the gas way to check if there is a leakage at the sealing surface of valve after grinding.

The normal width of the sealing surface between valve and valve seat should be 1.2~1.7mm. After a long time use and many times of grinding, the sealing surface will get wider, causing a bad sealing result. Then reamers of 15° and 75° should be used to ream the sealing surface locating on the inner hole of the valve guide pipe. See figure 3. Lapping-in should be done to the valve after that.

A new engine's sinking distance between surface of intake exhaust valves and cylinder head shall be 0.8~1.0mm, see figure 4. After being used and reamed several times, the distance will enlarge and influence the compression ratio. So when the sinking distance augment over 2mm, you should consider replacing the valve seat.



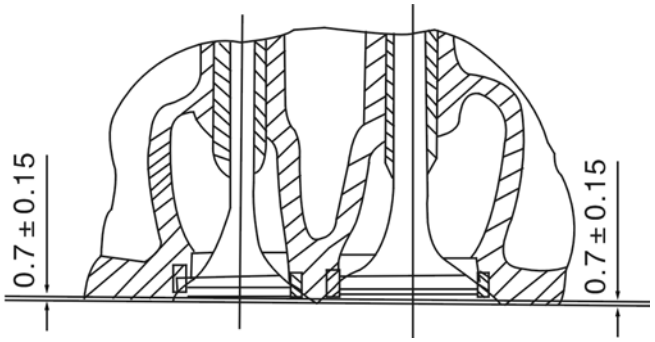


Figure 3: Valve seat reaming and repairing drawing Figure 4: Valve subsiding quantity

An assembled valve guide pipe should surpass the surface of cylinder head of about 12.5~13mm.

Constantly check the valve clearances, the incorrect clearance not only affect the correct timing and valve sealing. But also

Some other faults such as when the clearance gets larger, the noise coming from the transmission appliance of the valves will increase, and smaller, will lead to the valves' un-tightening dosing and valve burnt.

4.2.2 Cylinder head gasket

The gasket shall be even and smooth, if distorted or burned damages occur, it should be changed.

When the piston moves to the tope dead center, there should be a clearance of 0.66~1.27 between the top of the piston and the bottom surface of the cylinder head, in case influence the compression ratio or impact between the top of the piston and the bottom of the valve.

4. 3 Piston and Connecting Rod

Piston and connecting rods assembly consist of piston, piston ring, piston pin, retaining ring, connecting rod, connecting rod bolt, connecting rods bearing, and connecting rod bush and so on. Weight difference of the piston and connecting rod assembly shall not exceed 25g on the same diesel engine and that of the connecting rod assembly not exceed 15g.

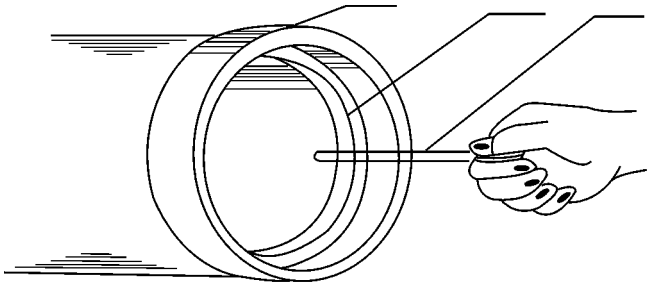
4.3.1 Piston

Combustion chamber on the top of the piston is ω type. Skirt of the piston is machined in a shape of barrel along the height direction and ellipse along the circumference. There are two gas ring grooves and an oil ring grooves machined in the piston.

4.3.2 Piston Ring

Porous chromium is plated on the external circle of the first ring to reduce the wear coming from cylinder liners and piston rings. Tapered ring is used in the second ring. When assembling the second ring, the face with the word "up" should be set toward the top surface of the piston, and be careful not to assemble it in the wrong direction.

Oil ring is designed to the style of internal expanding loop. When the elasticity of the oil ring reduces on account of wear, it can still keep a certain radial elasticity so to prolong its service life.



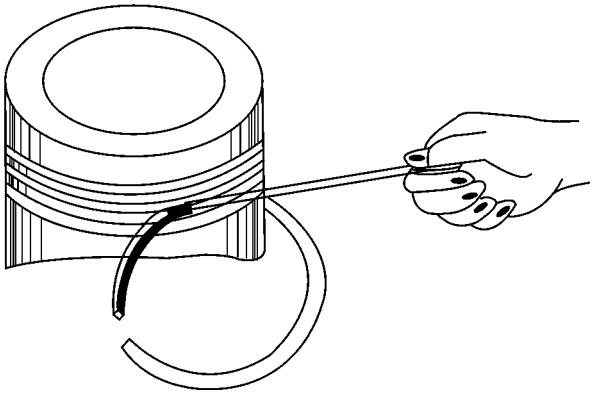


Figure 6: Measuring the piston ring end surface clearance

Figure 5: Measuring open clearance of piston ring

Check the gap clearance before assembling the piston ring. Put the piston ring in the place 15~20mm away from the top surface of the cylinder block. Using a feeler to check the gap clearance within a value between 0.3~0.4mm, see figure 5. Correct it with a file if the value is a little smaller. If it is larger, select another one. Moreover,

You shall also check the end clearance between the piston ring and the slot with a feeler. The end clearance of the first compression ring shall be within 0.05~0.082, and that of the second within 0.03~0.062, see figure 6.

Special toll shall be used to assemble or dismantle the piston rings. The gaps of the piston rings should be staggered 120° in successively, and also avoid being set in the direction of piston pin.

During inspection if the piston is found sticky and can not move, then dip it into the diesel fuel(coal oil or gasoline fuel), for 24h or longer, and then knock the piston ring slightly, to make it loose by itself and take it out and clean it with diesel fuel or carbon tetrachloride.

Check whether the piston has cracks and damages in it. Change the piston if any defects are found and also change the piston ring.

4.3.3 Piston Pin

When assemble or dismantle the piston pin, firstly assemble a retaining ring at one end of the piston (or dismantle retaining rings on both ends). Put the piston into the oil (or boiled water) and heat it to a degree of 100~120℃, gently knock the piston out or push it in with a suitable punch. Apply clean oil on the piston pinhole and the connecting rod bush. Assemble another retaining ring after assembling the piston pin.

4.3.4 Connecting rods and connecting rods bearing shell

The cross section of connecting rods body is designed in H-shape. Connecting rods and cap are matched pair and bored. And there are matching marks on them both for assembling. You shall not assemble them wrongly.

There is a bronze sleeve pressed in the hole of the connecting rods small end. Align the oil hole in the sleeve to the hole at the top of the connecting rod small end so as to ensure the splash lubrication of the piston pin and sleeve.

Change the connecting rods bearing shell in couples when the clearance exceeds the limit on account of wear or serious flakiness, burned damages occur on the surface.

When the engine is overhaul or renew the connecting rods, check the depth of parallelism of no more than 0.03mm per 100mm in the vertical direction of 100mm, no more than 0.06mm per 100mm in the horizontal direction. Otherwise, you shall align the connecting rod.

Scrape out carbon dust and oil spot on the upper of the cylinder liner before you assemble (or dismantle) the assembly of piston and connecting rods in/out. Apply cleansing oil on surfaces of cylinder liner holes, piston exterior face, piston rings, connecting rod bearing shells and connecting rod journals of crankshaft before assembling, then put the guide sleeve of the piston on the cylinder liner, rotate the crankshaft, assemble the piston and connecting rod assembly cautiously into the cylinder liner, tighten the connecting rods bolts several times in turn according to the specified torque, rotate the crankshaft with hand after tightening, it can move freely.

4. 4 Crankshaft and Flywheel

4.4.1. Crankshaft

Timing gear, oil pump drive gear and crankshaft pulley are assembled at the front end of crankshaft, and bearing and flywheel at the rear end. Position the flywheel with a stop dowel, and tighten it with six flywheel bolts according to the specified torque. Three safety plates are used to prevent the bolts' from loosening. An E60203 bearing is assembled at the center of the flange, which support the transfer shaft of the gearbox. There is a making line engraved on the crankshaft pulley to the timing gear cover to indicate the degrees of the advance angle.

4.4.2 Flywheel

Flywheel gear ring shall be covered on the external circle of the flywheel. A mark line is engraved on the flywheel to check the advance angle of fuel supply.

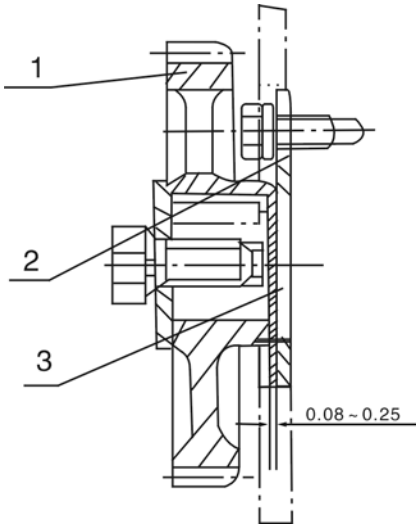
Pulley is prohibited to assemble directly on the flywheel to pull the machine horizontally, or you will cause the damage to the main bearing. If you need pull the implements horizontally, you should ad bearing seats at both ends of the pulley.

4. 5 Camshaft

4.5.1 Camshaft

Cam outline is symmetrical, the inlet and exhaust cam outline are different. When the camshaft is rotating, cam pushes valve tappet, push rod, rock arm and valve to control the air inlet and outlet of each cylinder separately.

There is a thrust flange at the front end of the camshaft, and a camshaft thrust plate is assembled at the front face of the cylinder block. The camshaft thrust flange exceeds the thrust plate 0.08~0.25mm in length to control the axial float of the camshaft. See figure 7.



1-Camshaft timing gear 2-Thrust plate 3-Camshaft

Figure 7: Camshaft timing gear and thrust plate

All the camshaft bearing are lubricated separately by high-pressure oil, which guides from the main oil channel. When assembling camshaft bush, you should check whether the oil hole on the camshaft bush is aligned to that on the cylinder block.

4.5.2 Valve tappet

There is an offset of 2mm between the valve tappet axis and the centre line of symmetry to the cam's width. The tappet shall rotate at work so as to make an even wear to the bottom and cylindrical surface.

4. 6 Timing Gears

4.6.1 Timing gears

Gear transmission consists of crankshaft timing gear, timing idle gear, camshaft timing gear, fuel injection pump timing gear and fuel injection pump timing gear seat and so on.

There are timing mark engraved on each timing gears. You must align the mark at the mesh position when assemble the gears to ensure a correct movement relation between moving parts.

4.6.2 Dismantling and assembling of timing gears

Special tools are needed when you dismantle or assemble the crankshaft timing gears. Camshaft timing gear can be pulled out by puller or pushed out by press device. Clearance fit is adopted between the timing idle gear and the cylinder block, and they shall be tightened with bolts. The assembling construction of fuel injection pump timing gear is as follows：Fuel injection pump timing gear is mounted on its connecting disk. You shall fist dismantle the cover of injection-advance device, then loosen the nut on the fuel injection pump shaft with sockets wrench, next fix the fuel injection pump in the pad to make it rotate and the pad is press-assembled on the gear chamber. The connecting disk drives the fuel injection pump through a woodruff key, see figure 8. Loosen the three fixing nut on the fuel injection pump gasket, then you can withdraw the fuel injection pump.

Make sure to align the Φ7 hole with dimension of R34.5 to the hole of M6 on the connecting disk of fuel injection pump with dimension of 34.5, and connect them with a M6 bolt when assembling the fuel injection pump timing gear.

Three long kidney holes on the fuel injection pump seat are used to adjust the advance angle of fuel supply. Loosen the three nuts of the kidney holes when adjusting the angle. Turning the fuel injection pump in the direction of outside of the cylinder block will enlarge that angle, and the opposite direction will reduce that angle.

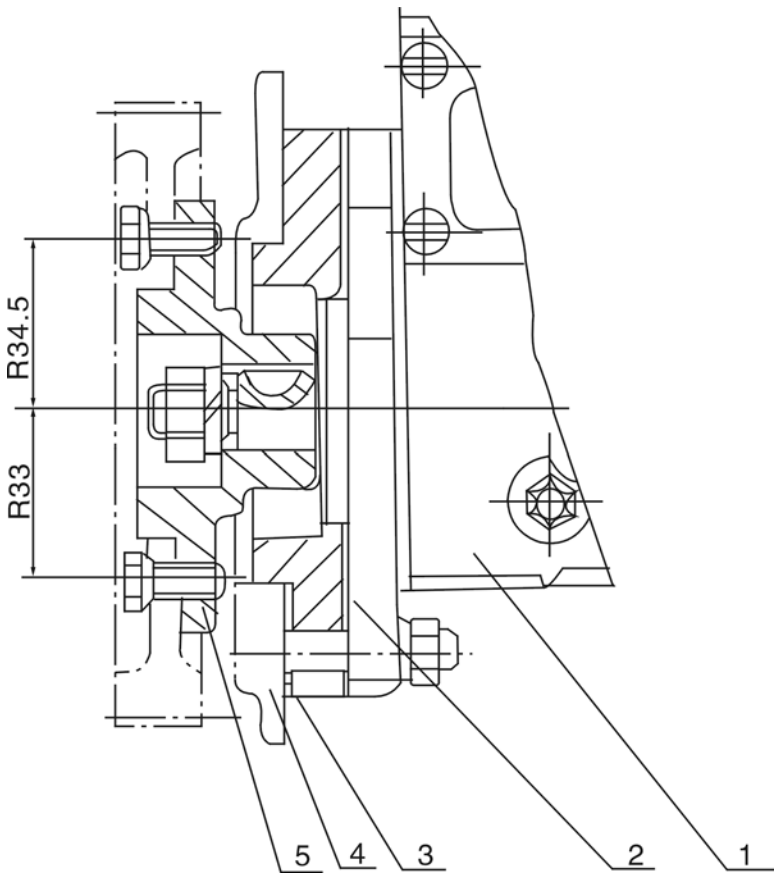


Figure 8: Injection pump transfer motion connecting disk.
1-Injection, 2-Flauge washer, 3-seat pad, 4-connecting disk washer, 5-Gear box, 6-Timing gear.

4.7Fuel system and speed governing system

Fuel and speed governing system is the main operating part of diesel engine. It consists of fuel transfer pump, fuel filter, fuel injection pump, and governor, high and low pressure pipes, injectors and so on. See figure 9.

The fuel transfer pump transfer the fuel with low pressure to the fuel filter and then to the fuel injection pump. The fuel shall get high pressure in the fuel injection pump and spray into the combustion chamber from the injector through high-pressure pipe.

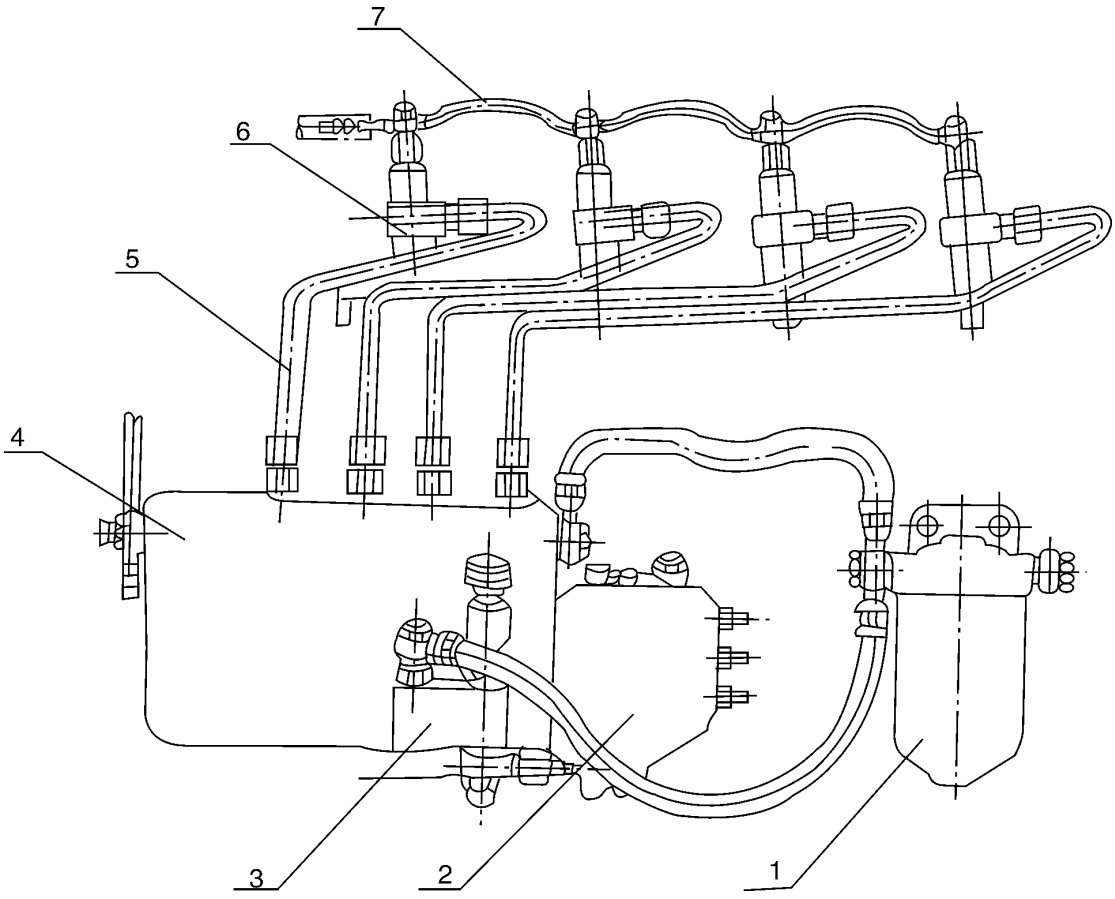


Figure 9: Fuel and governing system.
1-Diesel fuel filter, 2-Governor, 3-oil supply pump, 4-Injection pump,
5-High pressure oil pipe, 6-Injector, 7-Oil return pipe.

4.7.1 Fuel transfer pump

The fuel transfer pump uses a construction of single-acting roller wheel. It consists of

hand transfer pump, roller wheel parts, piston, piston spring, fuel transfer pump body, inlet and outlet check-valves and joints of inlet and outlet fuel pipes, etc.

The fuel transfer pump is driven by an eccentric wheel on the fuel injection pump camshaft, the eccentric wheel pushes the tappet and the tappet pushes the piston, then press transferred the fuel to the fuel injection pump chamber.

A filter net is assembled in the fuel transfer pump inlet pipe joint to filter foreign material in the fuel. Clean the filter net if it is blocked when checking, change it if it is worn out or it will cause severe wear to the matching friction elements of the fuel transfer pump and lack of fuel supply because of the failed sealing of the fuel inlet and outlet check valves.

4.7.2Injector

Before assembly, the injector must be cleaned. At 45℃ inclination, the needle should be able to slip freely into the needle housing. The tighten cap on in injector should be tightened with torque of 70 ± 20N .m. If the torque is too big, the needle housing may deform to be clamped. The number of injection hole with the diameter of 0.29mm is 5. The opening pressure of injector may be adjusted by an adjusting screw on special test bed. See figure 10.

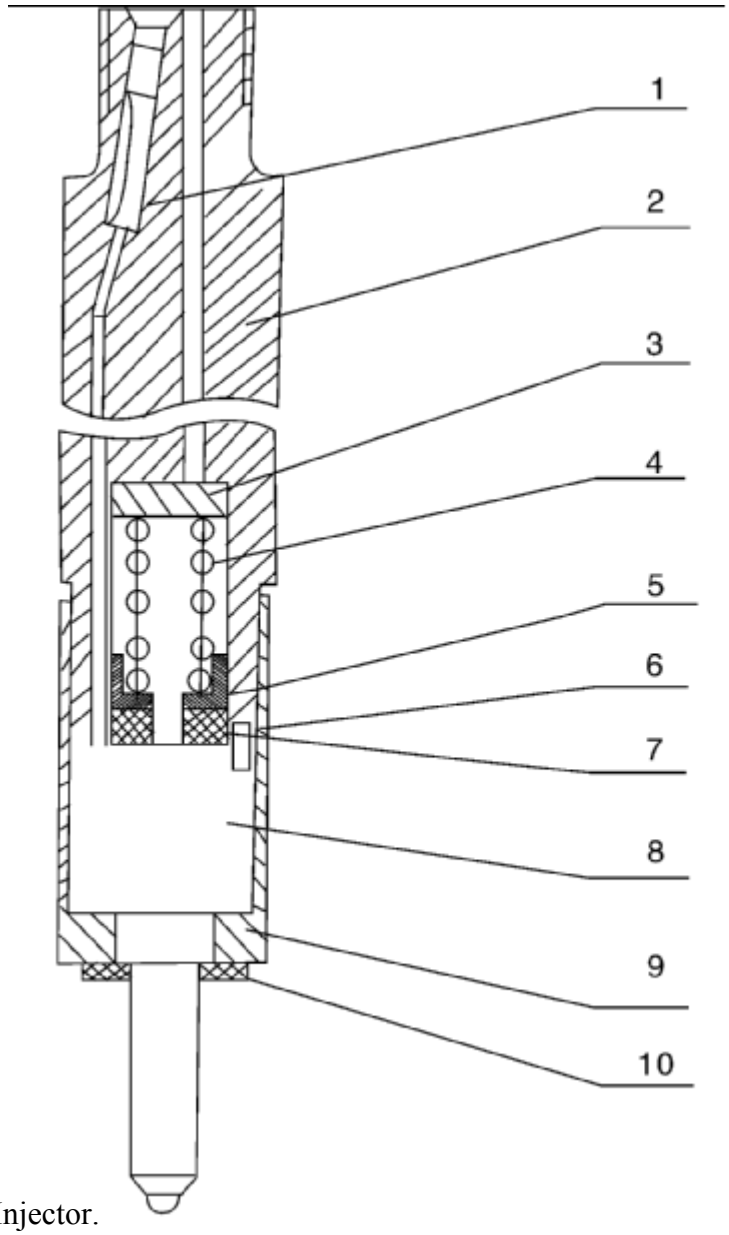


Figure 10: Injector.
1-Nut 2-Gasget 3-Pressure regulating 4-Tappet 5-Injector lock nut
6-Gasket 7-Needle valve couple.

.7.3 Fuel supply pump

Plunger type fuel supply pump (See Fig.11) is mounted on the side of injection pump, sucking fuel from fuel tank via fuel filter to supply fuel to injection pump.

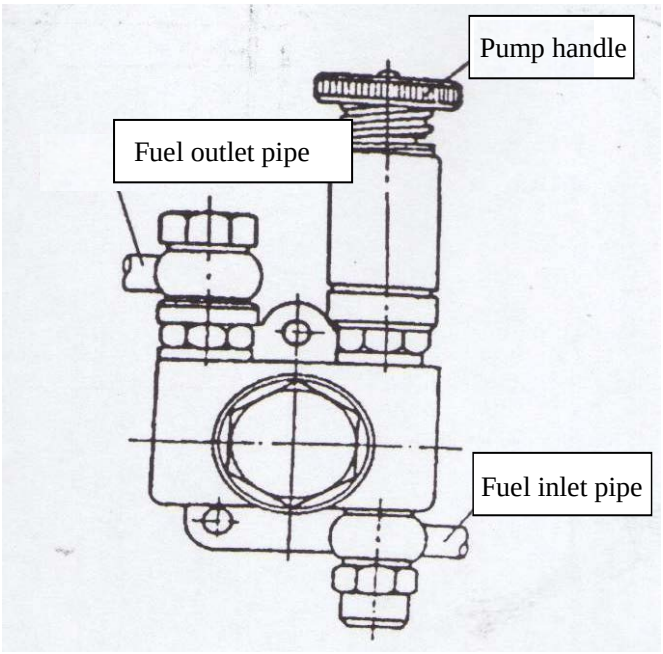


Fig. 11 Fuel supply pump

4.7.4 Governor

Governor adopts T7B or T110 type, full-scale mechanical centrifugal governor, mainly consists of driving parts, sliding disk parts, and sliding bush, governing spring and governing controlling shaft etc. see figure 12. (Speed sensing unit of T7B is a steel ball, T110 fly hammer).

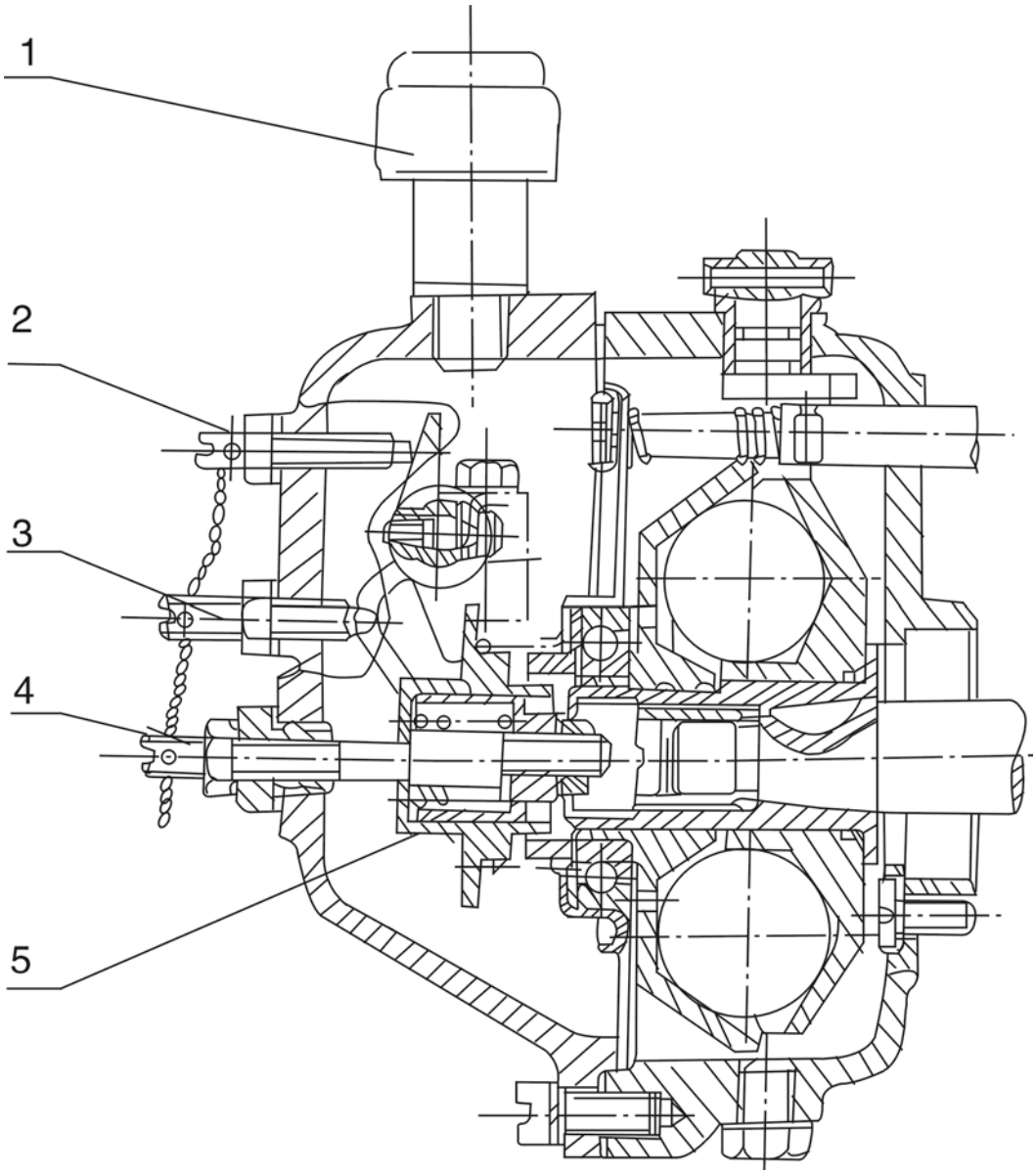


Figure 12: Governor.
1-Inspirator and oil filler, 2-High speed limit screw, 3-Idle speed limit screw,
4-Limit screw of max. Oil volume, 5-Sliding bush

4.8 Intake and exhaust system

Intake and exhaust system consists of intake connection pipe, air heater, strainer, intake pipe, exhaust pipe, etc. Most of the engine adopt dry paper filter element, and oil bath type filter are used in humid areas. Some engines is equipped with the indicating light for monitoring the block of the air filter, if the lamp lights, the users should clean or change the air filter in time.

4.9 Lubricating System

Lubricating system consists of oil collector, oil pump, oil filter and pipe lines, etc. see figure 13.

The diesel engine adopts forced lubrication and splash lubrication. Crankshaft main bearings, connecting rod bearing, camshaft bushes, fuel injection pump seat bearing and rocker arm shaft bushes etc. adopt forced lubrication, cylinder liners, piston pins, connecting rod bushes, cams and valve guide pipes adopt splash lubrication. Others such as rolling tappets, valve bearings which are used in water pump and generator are lubricated by adding grease termly.

Oil stored in the oil sump is sucked into the oil pump through oil collector and oil pump inlet pipe and pressurized, and then sent to the oil filter. The filtered oil afterwards enters the main oil channel of cylinder block. Next the oil in the main channel is divided into three ways, one is to the main bearing, then to the connecting rod bearing, then to the cylinder head to lubricate the rocker arm bearing. The last one is to the timing idle gear bearing, and pass through sub-oil duct of timing gear chamber, finally to the fuel injection pump timing gear seat bearing.

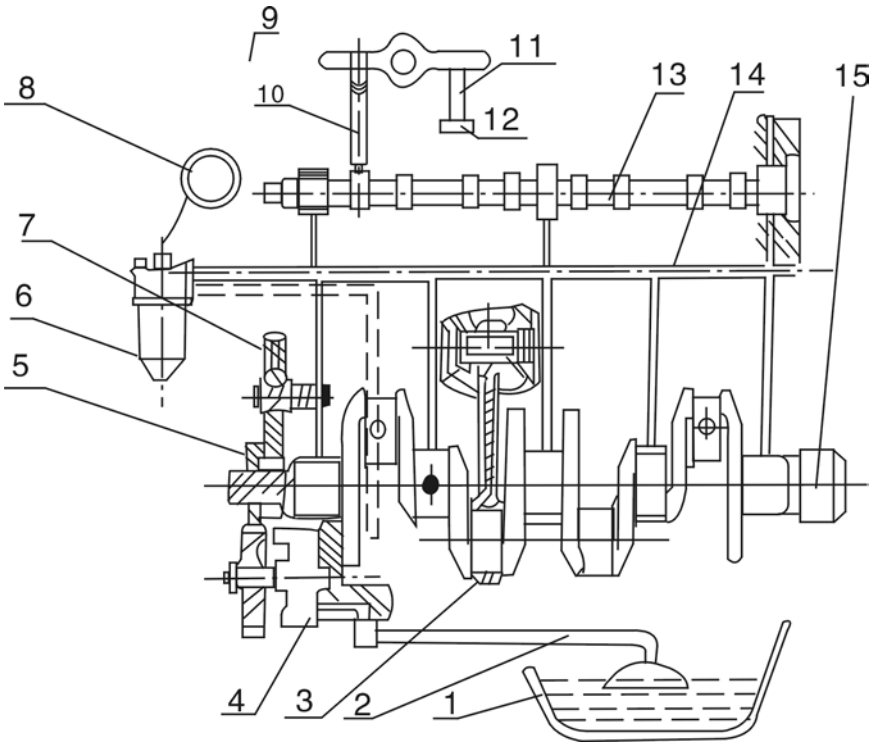


Figure 13: Lubrication system.

1-Oil sump, 2-Lube. Oil filter, 3-Piston connecting rod assembly and cylinder liner, 4-Lube Oil pump, 5-Lube Oil pump drive gear, 6-Lube. Oil filter, 7-gear system, 8-Lub Oil pressure meter, 9-Valve rocker arm, 10-Valve tappet, push rod and cylinder block valve push rod hole, 11-Valve rocker arm shaft, 12-Valve and valve guide pipe, 13-Camshaft and bush, 14-Oil channel in cylinder block, 15-Crankshaft and bearing.

4.9.1 Lubricating oil pump

Rotor type oil pump is adopted. The rotor in the oil pump is fixed on the shaft by a pin. The drive gear assembled on the crankshaft drives the oil pump gear. Pressure limiting valve is fixed on oil pump body to adjust the oil volume and pressure. On the oil pump cover body oil inlet and outlet holes are cast, which are connected to the cylinder block. Oil pump body and cover body are fastened on the cylinder block. Oil pump body and cover body are fastened on the cylinder block with blots. In operating when the oil temperature is 80℃, the oil pressure shall be 200~400kPa (1kgf/cm^2) at idling speed.

4.9.2 Oil filter

Oil filter adopts paper element and can be changed at regular intervals. Safety valve is mounted on the oil filter, when the filter is blocked, the safety valve will open and the oil flows to the main channel without being filtered, so you must clean and change the filter element termly according to the requirements of “technical maintenance”.

4.9.3 Oil drain plug

The oil drain plug is mounted at the right lower bottom of the oil sump. When the oil needs to be changed, you shall dismantle the plug and drain away the oil, the clean up the scrap iron impurity. Check the sealing function of the plug before you add oil.

4.10 Cooling System

Cooling system is a closed and forcing water cooling system. Cooling system consists of radiator, water pump, fan, thermostat and air guide cover.

4.10.1Cooling water way (see figure 14)

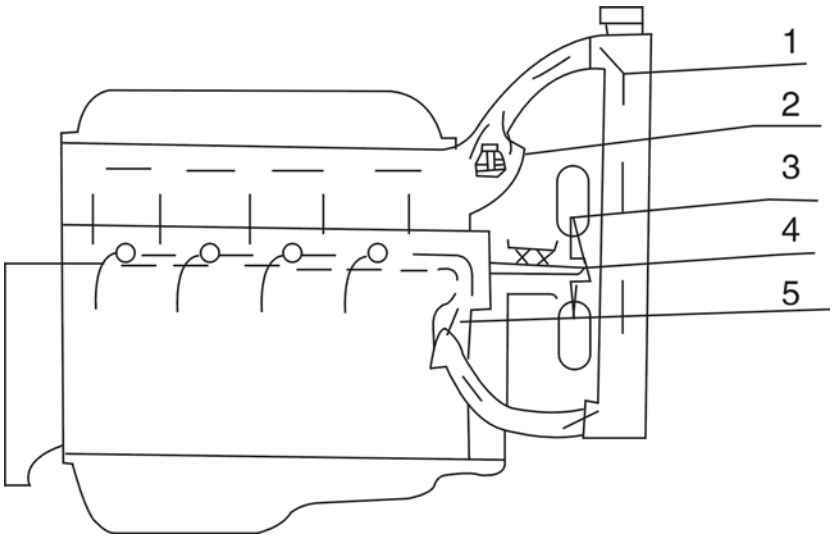


Figure 14: Cooling system.
1-Radiator, 2-Thermostat, 3-Fan, 4-Water pump, 5-Water inlet pipe.

The cooling water in the radiator is pumped into general water channel of the cylinder block by water pump. One way flows directly into the cylinder head, and first cools the valves and triangle area of combustion chamber through water inlet guide sleeves, the other way enters the outside of the cylinder liners tangentially, then circles the cylinder liner and flows to the cylinder head. The used cooling water flows back to the radiator through the thermostat and water outlet pipe on the front face of cylinder head. When the water outlet temperature is lower than 70℃, the thermostat will close and the cooling water flows through the small circulation water pipe and doesn't pass through radiator, until it enters the water pump directly, thus lesser circulation is realized when the temperature is higher than 70℃～80℃, the thermostat will fully open, and the cooling water flows into the upper water chamber of radiator through the thermostat ,then flows downwards along flat copper pipe to the air sucked or exhausted by the fan, greater circulation is realized. It's better to select BJ130 type radiating area is 10.62m^2.

While in torrid area or in summer, when the water temperature is too high, you can dismantle the thermostat to improve the radiator efficiency by enlarging the cooling water fluidity.

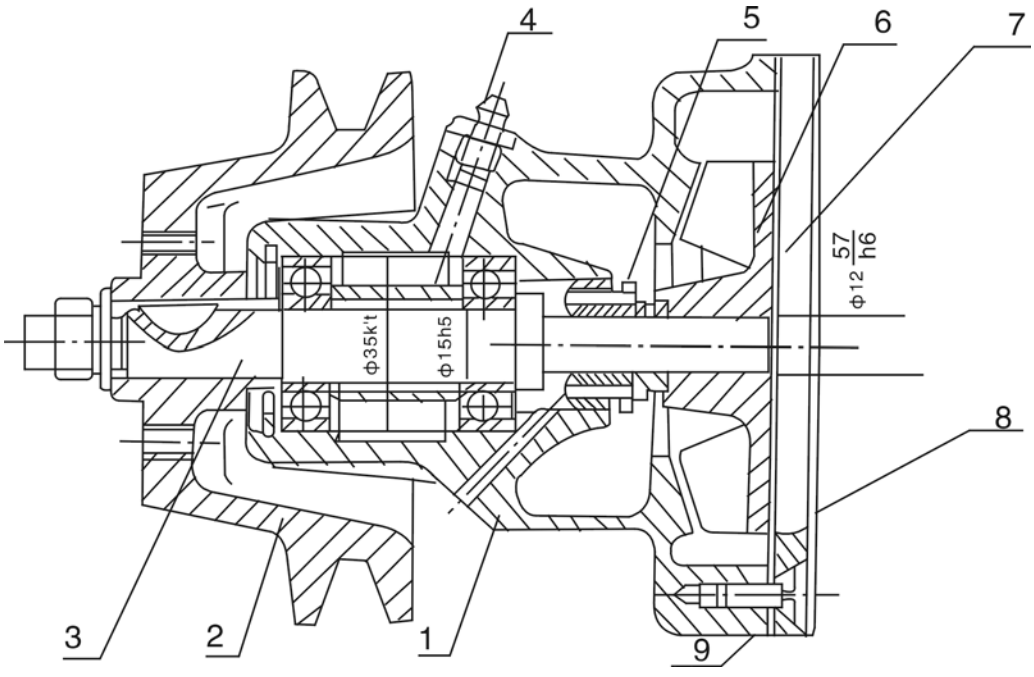


Figure 15: Water pump.
1- Water pump housing, 2-Belt pulley, 3-Water pump shaft, 4-Oil cup M8 1, 5-Water sealing F-12, 6-water pump impeller, 7-Water pump gusset plate, 8-Gusset plate gasket, 9-Gasket.

4.10.2 Water pump

Water pump is centrifugal type. The water inlet chamber is set at the front end face of the cylinder block. Two E60202 bearing is adopted as holder by the water pump. Water seal is of ceramic and graphite structure. The water pump is driven by the crankshaft pulley and fan belt. Main parts of water pump are water pump body, water pump, impeller, water pump pulley, water pump shaft, bearings and water seal. See figure 15.

Change water seal when the water seal is broken and water drips seriously from the drain hole at the bottom of water pump in operation. Plugging the drain hole is prohibited while dripping, or water will enter the bearing and cause quick wear.

You shall consider replacing bearing when it has abnormal noise running.

No.4 calcium base grease shall be added into water pump oil cup termly according to "Technical Maintenance". Grease shall not been added too much, just about 1/2～1/3 of the bearings cavity, or it will cause the overheat of bearings.

4.10.3Thermostat

Thermostat is of wax pattern and pipe shaped, assembled in the thermostat shell which is at the water outlet in the front of cylinder head, it can control the opening and closing of valve automatically.

It shows the thermostat has broken down and shall been dismantled to check in the following two cases. One case is after the engine has been started at cold condition, the water temperature has not reached 70but there is water flows out from the water outlet pipe. Second is that the water temperature exceeds 70℃ after the engine has been running hot, there is no water flows out from the water outlet pipe. To check the thermostat, you can put it into the water and heat it slowly, when the water temperature reaches 70℃, the valve of thermostat shall begin to open, when the temperature reaches 85℃, it shall open fully. Change a new one if the thermostat does not meet the requirements.

Don't take away the thermostat at random. It's harmful to the engine's normal running if the cooling water temperature is too low.

4.10.4 Fan

Check and adjust the fan's tension at regular intervals according to "Technical Maintenance".

To check the fan belt's tension, you can press the belt between the fan and the alternator pulley, it's better to keep the pressing distance 10～20mm. you can loosen the regulating arm bolt of the generator to adjust the tension if necessary.

4.11 Electrical System

Electrical system consists of starter, generator, starting button and meters. The connection mode is showing in figure 16.

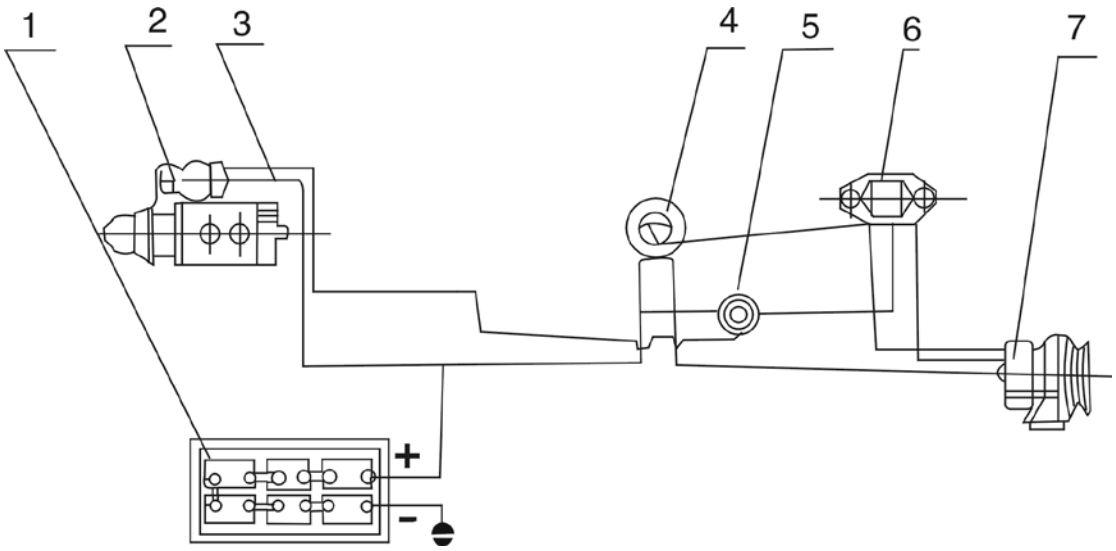


Figure 16: Electrical system.
1-Accumulator, 2-Starter, 3-Wire, 4-Ammeter, 5-Ignition, 6-Regulator, 7-Charging generator.

TROUBLE SHOOTING

In this part, the symptoms, causes and remedies of the common faults are described as follows for reference.

5.1 Difficult to Start or Failure of Engine to Start

Table 5-1

Causes	Remedies
1.no fuel in fuel tank	1.refill it
2.air in fuel system	2.deaerate the fuel system by supply pump and check for leakage
3.blocked in fuel system	3.dismentle and clean
4.no fuel supply or intermittent fuel supply	4.check for the sealing of plunger and check valve of fuel supply pump, and the efficiency of spring
5.incorrect advance angle of fuel supply	5.check and adjust
6.poor spray quality or the injection pressure too low	6.clean the injector nozzle couple parts, adjust injection pressure, check the wear of injector plunger and delivery valve and integrity of delivery valve spring
7.excessive wear of piston rings and Liner, high blow-by	7.replace piston rings and liners

8.poor tightness caused by sticking, loss of elasticity, break of piston rings	8.clean or replace piston rings
9.valve leakage	9. Check for the sealing between valves and valve seats. Repair and grind the sealing surface of valve, readjust the valve clearance
10.too cold in winter	10.use heater to warm up the engine
11.the voltage of batteries too low to enable the engine to reach the required min. starting speed	11.recharge the batteries
12.loose connection in electric wiring	12.check and reconnect the loose ones
13.starter gear cannot mesh with flywheel	13.check and repair the starter

5.2 Failure of the Engine to Develop Full Power

Table 5-2

Cause	Remedies
1.air filter blocked, insufficient air intake	1.clean or replace air filter element
2.clogging in fuel pipe or fuel filter, insufficient fuel injection	2.clean fuel line or replace fuel filter element
3.incorrenct advance angle of fuel supply	3.readjust
Cause	Remedies
4.inconrrect valve clearance	4.readjust
5.poor atomization, blocked in injection holes, needle valve sticks	5.check, clean or replace the injector nozzle couple parts and readjust injection pressure
6. insufficiency of fuel supply of injection pump	6. Check wear of plunger and delivery valve. Replace the worn parts if necessary
7.overheating of engine	7.check cooling system and remove the scale deposits in cooling system
8.excessive carbon deposits in exhaust manifold or muffler	8.remove the carbon deposits
9.insufficient compression pressure in cylinder	9. Check for the sealing between valve and valve seat, check for the worn parts of piston ring, acyl. Liner and piston. Grind the sealing surface of valve or replace cylinder. Liner, piston ring and piston, if necessary
10.poor quality of fuel	10.use the fuel in accordance with the specifications
11. Too high the ambient temp. or running at altitudes	11.running under these conditions, the engine will decrease the power, so the customers should reduce the load

5.3 Sudden Stopping of Engine.

Table 5-3

Cause	Remedies
1.air entrapped into fuel system	1.deaerate the fuel system
2.blocked in fuel lines or fuel or fuel fitter	2.clean the blocked parts or replace filter element
3.fuel supply pump inefficient	3.repair or replace the fuel supply pump
4.crankshaft seizure	4. Caused by too low oil pressure or no pressure. Repair the journal and bearing shells of crankshaft. Replace crankshaft if necessary.
5.piston seizure	5. Check water pump and belt, change piston, piston rings and liners. Check and re-adjust the injection pump and injector.

5.4 overspending of the engine

Table 5-4

1. Governor invalid	1. Check governor
2. Governor spring broken	2. Change the broken spring
3. control rack and ring gear stick	3. Check and repair injection pump Note: in this case, the engine must be shut down at once, cut off fuel supply, stop the air inlet. If the engine is equipped with exhaust brake valve, shut it down to force the engine at once.

5.5 Abnormal noises in operation

Table 5-5

Causes	Remedies
1. Excessive clearance between valves and rocker arms, metallic knocking sound from valve train	1. Check and readjust the valve clearance
2.valve spring broken or push rod bent	2. Check and change
3. Fuel supply too early, resulting in rhythmic metallic knocking sound in cylinder	3. Check and readjust timing
4. Deep and unclear sound in cylinder resulting from too late fuel supply	4. Check and readjust timing
5. Excessive clearance between piston and cylinder. Knocking sound in cylinder weakens with the warming up of engine	5. Change the worn piston, piston rings and liners.
6. Excessive clearance between piston pin and bearing of the connecting rod small end. Light and sharp sound, specially in idling	6. Change piston pin and conrod small end bush to ensure the correct clearance
7. Excessive clearance of main bearing shell and connecting rod big end bearing. Knocking sound may be heard when the engine speed suddenly reduced and the sound would be deep and strong in low speed.	7. Change main bearing shells, connecting rod bearing shell and ensures correct clearance.

8. Excessive clearances due to badly worn gear, knocking sound may be heard from gear housing	8...Change the all of gears.
9. Excessive axial clearance of crankshaft. knocking sound in idling operation	9 change the thrust plate of crankshaft or camshaft, ensure the correct clearance
10. Damage of water pump shaft and alternator shaft resulting in continuous noise	10. Change shaft or assemblies of water pump or alternator
11.friction between turbine scroll and impeller of turbocharger	11. Check and replace

5.6 Unstable running

Table5-6

Causes	Remedies
1. Air entrapped in fuel system	1. De-aerate by pressing the handle of fuel supply pump
2.excessive water mixed in diesel fuel	2. Check the water content in the fuel and change with correct fuel
3.inefficiency of injectors	3. Check and clean , or replace injectors
4.el line leaks	4. Check for the tightness of the lines
5. Uneven fuel supply to each cylinder	5. Check and adjust injector pump(carried out on test bench by qualified personal)
Causes	Remedies
6. Spring of injection pump plunger broken	6. Replace (carried out by qualified personal
7. Governor hunting	7.check and repair governor

5.7 Abnormal color of smoke

Table 5-7

1. Black smoke	
1.1 Individual cylinder doesn't work	1.1 Find out the faulty cylinder and the reasons and repair
1.2 Overload	1.2 Unload the excessive load
1.3 Injection pressure too low or insufficient injection pressure	1.3 Clean or replace injector nozzle couple parts; readjust the injector pressure
1.4 Incorrect advance angle of fuel supply	1.4 Readjust advance angle of injector pump
1.5 Poor quality of fuel	1.5 Replace with the fuel in accordance with specifications
1.6 blocked in air filter, insufficient air intake	1.6 Clean air filter or replace filter element
1.7 Incorrect valve clearance, valve stem sticks in valve guide or	1.7 Check the valve clearance; clean valve and valve guide; check and

valve conic sealing surface leaks	grind valve conic sealing surface
2 Blue smoke	
2.1 Piston ring gaps located at the same side	2.1 relocate in 120° spacing
2.2 Piston ring seizure or badly worn	2.2 check and remove
2.3 Drop or damage of oil seal if valve stem	2.3 replace the oil seal of valve guide
2.4 Inefficiency of oil seal of turbocharger	2.4 repair turbocharger; ensure proper tightness
3 White smoke	
3.1 Water is leaked to the chamber	3.1 check for tightness of cylinder head gasket, cracking of cylinder head, cavitation, cracking of cylinder liner
3.2 Excessive water in fuel	3.2 replace with specified fuel

5.8 Overheating of the engine

Table 5-8

causes	Remedies
1. too high oil temperature	1.1 reduce the excessive load
1.1 overload	1.2 clean or replace oil cooler; check by-pass valve; clean oil channel
1.2 inefficiency of by-pass valve due to clogging of oil cooler core and oil gallery	
2. coolant temperature too high	
2.1 dirty radiator element	2.1 clean the radiator
2.2 insufficient coolant	2.2 add coolant
2.3 insufficient thermostat	2.3 replace the thermostat
2.4 insufficient water pump or loose pump belt	2.4 dismantle and repair water pump; adjust the tension of water pump belt
2.5 cooling water channel clogged by dirt	2.5 clean the clogged portion
2.6 overload in hot weather	2.6 reduce load and speed

5.9 Dilution of oil

Table 5-9

causes	Remedies
1. piston ring gumming or badly worn out of the limits	1 clean the gummed up piston rings; replace the worn rings
2. oil or fuel not in accordance with specifications	2 replace with the right fuel or oil
3 fuel coming into oil pan; injection pressure too low, or needle couples stick, poor atomization of fuel	3 check, adjust injection pressure or replace needle couples

5.10 Oil pressure too low

Table 5-10

causes	Remedies
1. insufficient oil in oil pan	1. refill oil
2. oil pressure gauge or sensor inaccuracy	2. replace oil pressure gauge or sensor
3. excessive clearance between crankshaft journal and main bearing shell	3. replace worn main bearing shell or crankshaft
4. wear of gear, bearing and body of oil pump	Replace the pump
5 pressure regulating spring broken	Clean the pressure regulating valve or replace spring
6. viscosity of oil is too low	Use the correct oil
7. clogging in oil filter or oil cooler	Clean or replace oil filter element or oil cooler
8.clogging in oil collector	Clean
9. rotor of centrifugal oil filter broken	Replace rotor assembly

5.11 Mixing of oil and water

Table 5-11

Causes	Remedies
1. Oil level in oil pan rising	
water seals of cylinder liner broken	Replace
cracking in cylinder liners or cylinder head	Replace cylinder block or cylinder head
cylinder head gasket broken	Replace cylinder head gasket
2 oil in water tank	
element of oil cooler broken	Replace oil cooler element
sealing gasket of oil cooler broken	Replace the gasket

5.12 Starter Faults

Table 5.12

Causes	Remedies
1. Starter does not rotate	
(1) Short circuit in evicting coil	(1) Repair
(2) Short circuit in armature	(2) Repair
(3) Brush broken or burnt	(3) Repair or replace
(4) Loose electromagnetic switch	(4) Repair
(5) Electromagnetic switch of starter broken	(5) Repair
2. Rotation of starter inefficient	
(1) Bushing of bearing worn	(1) Replace the new bushes
(2) Poor contact of brush	(2) Clean the contact surface of inverter
(3) Inverter dirty	(3) Clean the contact surface of inverter, and polish it with abrasive cloth
(4) Loose terminal connection	(4) Re-weld
(5) Slipping of frictional clutch	(5) Adjust the frictional torque of clutch
(6) Insufficient charging or capacity of batteries	(6) Charge or replace batteries
3.difficult retraction of gear; switch contact disk burnt	3.repair the switch

5.13 Injector Faults

Table 5.13

Causes	Remedies
1. Little or no fuel injected	
(1) Needle sticks with barrel	(1) Clean, lap or replace
(2) Needle and barrel badly worn	(2) Replace
Causes	Remedies
2. Injection pressure too low	
(1) Loose adjusting screw	(1) Adjust to the required pressure
(2) Deformation or break of the spring	(2) Replace the spring
3. Injection pressure too high	
(1) Needle valve sticks	(1) Clean or replace
(2) Clogging of injection holes	(2) Clean
(3) Pressure of adjusting spring too high	(3) Readjust
4. Heavy leakage	
(1) Adjusting spring broken	(1) Replace
(2) Needle and valve seat surface damaged	(2) Replace
(3) Deformed cap	(3) Replace

5.14 Failure Of Injection Pump

Table 5.14

Causes	Remedies
1. Insufficient or no fuel supply	
(1) Air in fuel system	(1) Desecrate the fuel system
(2) Check the valve of supply pump for sticking or spring broken	(2) Clean or replace spring
(3) Delivery valve stuck or spring broken	(3) Clean or replace spring
(4) Valve stem of delivery and sealing surface worn	(4) Replace
(5) Plunger worn or spring broken	(5) Replace
(6) Fuel inlet pressure too low	(6) Replace oil filter element
(7) Ring gear screw of plunger loosen	(7) Readjust fuel volume and tighten the screw
2.leakage between plunger and barrel; fuel level in oil pan rising	Check injection pump, replace plunger together with barrel

5.15 Failure of Governor

Table 5.15

Causes	Remedies
1. Idling unstable or too high	
(1) Control arm not been put to the end	(1) Check and adjust
(2) Ring gear and regulating rack stick	(2) Check and adjust
2. Hunting	
(1) Permanent deformation of governing spring	(1) Replace spring
(2) Distance of weights flying out different from that of retracting back	(2)Check and adjust
(3) Floating lever worn	(3) Check and repair
3. Over speeding	
(1) Speed is too high	(1) Loosen and readjust the high speed limiting screw
(2) Governor spring broken	(2) Replace spring
(3) Adjusting rack and ring gear stick	(3) Check and repair

Note: Repair and adjustment of injection pump should be carried out by professional department.

5.16 Failure of Air Compressor

Table 5.16

Causes	Remedies
1.inefficient compression due to scale on exhaust valve, broken valve spring and piston ring, worn cylinder liner	1remove scale and replace the faulty parts
2.piston ring sticks, broken, worn cylinder liner, clogging of oil return line	2.check and the faulty parts
3.worn crankshaft and bearing; piston hits cylinder head	3. Check and the faulty parts

5.17 Increase Of Fuel Consumption

Table 5.17

Causes	Remedies
1.increase of restriction of air intake system	1.check air filter element
2.serious leakage in fuel system	2.check and adjust the advance angle of fuel supply
3.incorrect fuel supply advance angle of injection pump	3.chack and adjust the advance angle of fuel supply
4.injector fault	4.check injector, repair or replace
5.incorrect adjustment of injection pump	5. Check and adjust injection pump on test bench
6. some parts are heavily worn	6.check worn cylinder liner, piston, piston ring; check tightness of valve, valve seat; check worn moving parts and repair

5.18 Increase Of Oil Consumption

Table 5.18

Causes	Remedies
1.serious external leakage of oil	1.check leaks outside of engine, crankshaft oil seal, and replace the broken parts
2.clogging in air filter	2.clean or replace air filter element
Causes	Remedies
3.block in crankcase ventilation inlet	3.clean crankcase breather
4.worn valve guide	4.replace valve guide
5.excessive oil leakage of air compressor	5.repair air compressor
6.inefficient seal ring of turbocharger	6.replace seal ring
7.worn cylinder liner, piston, piston ring and valve conic sealing surface, etc.	7.repair engine; replace worn part

5.19 Failure of the Fire Pre-heating Device

Table 5.19

If the starting fails, please check the temperature of the pre-heater	Causes	Remedies
Cold	No power	Check the circuit, controller, plug in connector, the pre-heater connecting wire
	Pre-heater circuit broken	Change the pre-heater
	Engine faults	Check fuel system, oil density and battery volume
Hot	Electromagnetic valve does not work	Check the electromagnetic valve and the wire
	No fuel coming into pre-heater	Clean the strainer and nozzle hole
Very hot	Short-circuit of the pre-heater	Change the new pre-heater

Appendix: Table of Fit Clearance

NO	Description	Standard dimension	Fitting mode	Clearance of new engine
1	Connecting rod small end bush / Connecting rod small end hole	shaft $\Phi\ 39s9^{+0.105}_{+0.043}$ / hole $\Phi\ 32^{+0.025}_{0}$	interference	-0.105~-0.1018
2	Piston pin / Connecting rod small end bush	shaft $\Phi\ 35H4^{0}_{-0.07}$ / hole $\Phi\ 35F7^{+0.050}_{+0.025}$	Clearance	0.025~0.057

3	Piston pin / Piston pin hole	shaft $\Phi\ 35h4^{0}_{-0.07}$ / hole $\Phi\ 35H4^{0}_{-0.007}$	Clearance	0~0.014
4	1st compression ring / Piston ring groove	$2.605^{-0.01}_{-0.03}$ / $2.685^{+0.03}_{0}$	End clearance	0.09~0.14
5	2nd compression ring / Piston ring groove	$2.35^{-0.01}_{-0.03}$ / $2.35^{+0.07}_{+0.05}$	End clearance	0.06~0.10
6	Oil ring / Piston ring groove	$4.0^{-0.01}_{-0.025}$ / $4.0^{+0.06}_{+0.04}$	End clearance	0.05~0.085
7	1st compression ring		Split clearance	0.30~0.45
8	2nd compression ring		Split clearance	0.25~0.45
9	Width of the crankshaft thrust face / Gap of crankshaft thrust journal	$43.5^{-0.018}_{-0.032}$ / $43.5^{+0.05}_{0}$	Axial clearance	0.018~0.082
10	Front and rear bushes of camshaft / Bush hole of cylinder block	shaft $\Phi\ 62^{+0.06}_{+0.041}$ / hole $\Phi\ 62^{+0.03}_{0}$	Interference fit	-0.011~-0.06
11	Camshaft journal / Front and rear bushes of camshaft	shaft $\Phi\ 56^{-0.1}_{-0.13}$ / hole $\Phi\ 56^{+0.03}_{0}$	Clearance fit	0.1~0.16
12	Valve tappet / Valve tappet hole	shaft $\Phi\ 16^{-0.095}_{-0.205}$ / hole $\Phi\ 16^{+0.018}_{0}$	Clearance fit	0.016~0.052
13	Press plate of camshaft / Gap of camshaft thrust journal	$12^{-0.095}_{-0.205}$ / $12^{+0.11}_{0}$	Axial Clearance fit	0.095~0.315
14	Valve guiding pipe / Cylinder head	shaft $\Phi\ 17^{+0.046}_{+0.028}$ / hole $\Phi\ 17^{+0.018}_{0}$	interference	-0.046~-0.01
15	Timing idle gear shaft / Bush of gear shaft	shaft $\Phi\ 26^{-0.020}_{-0.041}$ / hole $\Phi\ 26^{+0.021}_{0}$	Clearance	0.020~0.062
16	Idle gear shaft / Idle gear shaft hole of cylinder block	shaft $\Phi\ 26^{+0.056}_{+0.034}$ / hole $\Phi\ 26^{+0.021}_{0}$	Clearance	-0.056~-0.014
17	Back lash of meshing timing gears		Clearance	0.13~0.17
18	Intake valve seat / Cylinder head	shaft $\Phi\ 46^{+0.125}_{+0.01}$ / hole $\Phi\ 46^{+0.025}_{0}$	interference	-0.075~-0.125

19	Exhaust valve seat / Cylinder head	shaft $\Phi\ 39_{0}^{+0.125}$ / hole $\Phi\ 39_{0}^{+0.025}$	interference	-0.025~-0.125
20	Intake valve / Valve guiding pipe	shaft $\Phi\ 9_{-0.040}^{-0.025}$ / hole $\Phi\ 9_{0}^{+0.022}$	Clearance	0.025~0.062
21	Exhaust valve / Valve guiding pipe	shaft $\Phi\ 9_{-0.065}^{-0.050}$ / hole $\Phi\ 9_{0}^{+0.022}$	Clearance	0.050~0.085
22	Rocker arm shaft / Rocker arm bush	shaft $\Phi\ 20_{-0.020}^{0}$ / hole $\Phi\ 20_{+0.020}^{+0.050}$	Clearance	0.020~0.071
23	Rocker arm bush / Rocker arm	shaft $\Phi\ 23_{+0.035}^{+0.056}$ / hole $\Phi\ 23_{0}^{+0.021}$	Clearance	-0.056~0.014
24	Oil pump shaft hole / Oil pump shaft bush	shaft $\Phi\ 32_{0}^{+0.025}$ / hole $\Phi\ 32_{-0.029}^{-0.045}$	Clearance	0.029~0.07
25	Fuel injection pump pad / Timing gear chamber	shaft $\Phi\ 78f7_{-0.076}^{-0.030}$ / hole $\Phi\ 78H7_{0}^{+0.030}$	Transition	0.030~0.106
26	Connecting rod journal / Connecting rod bearing shell	shaft $\Phi\ 65_{-0.019}^{0}$ / hole $\Phi\ 65_{+0.050}^{+0.099}$	Clearance	0.050~0.118
27	Main journal of crankshaft / Main bearing shell Of crankshaft	shaft $\Phi\ 80_{-0.0190}^{0}$ / hole $\Phi\ 80_{+0.07}^{+0.122}$	Clearance	0.07~0.141
28	Piston skirt section / Cylinder liner	shaft $\Phi\ 99.86_{-0.03}^{0}$ / hole $\Phi\ 100_{0}^{+0.035}$	Clearance	Two Groups 0.011~0.145
29	Oil pump shaft bush / Oil pump bear shaft	shaft $\Phi\ 16H7_{0}^{+0.016}$ / hole $\Phi\ 16f7_{-0.034}^{-0.016}$	Clearance	0.016~0.050

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