

ZN485T ZN490BT

DIESEL ENGINES.
OPERATION MANUAL

—changchai—



CHANGCHAI BRAND



CHANGCHAI CO., LTD., CHINA

FOREWORD

Thanks a lot for your purchase and use of CHANGCHAI brand ZN485T ZN490BT diesel engine.

ZN485T ZN490BT Diesel,new products recently developed and manufactured by our company,are multi-cylinder,vertical type,water cooled,four-stroke and high speed engines. They are suitable for tractor application.With slight modifications,they can be used as a prime mover for combine harvester,engineering machinery,ship propulsion,electrical generators,etc.

This operation manual gives a brief description on performances,structure,operation and maintenance of the engine.It is recommended that the operators read the instructions carefully and master correctly the procedures of service and maintenance of the engine in a shortest period of time in order to ensure the normal and reliable running of the engine,make full use of the engine power and give a good service.

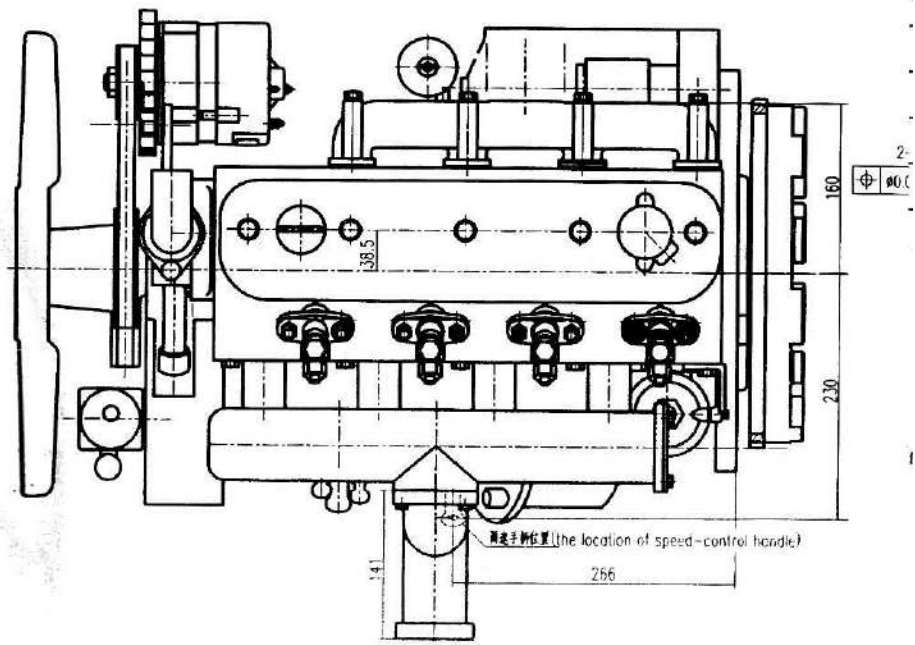
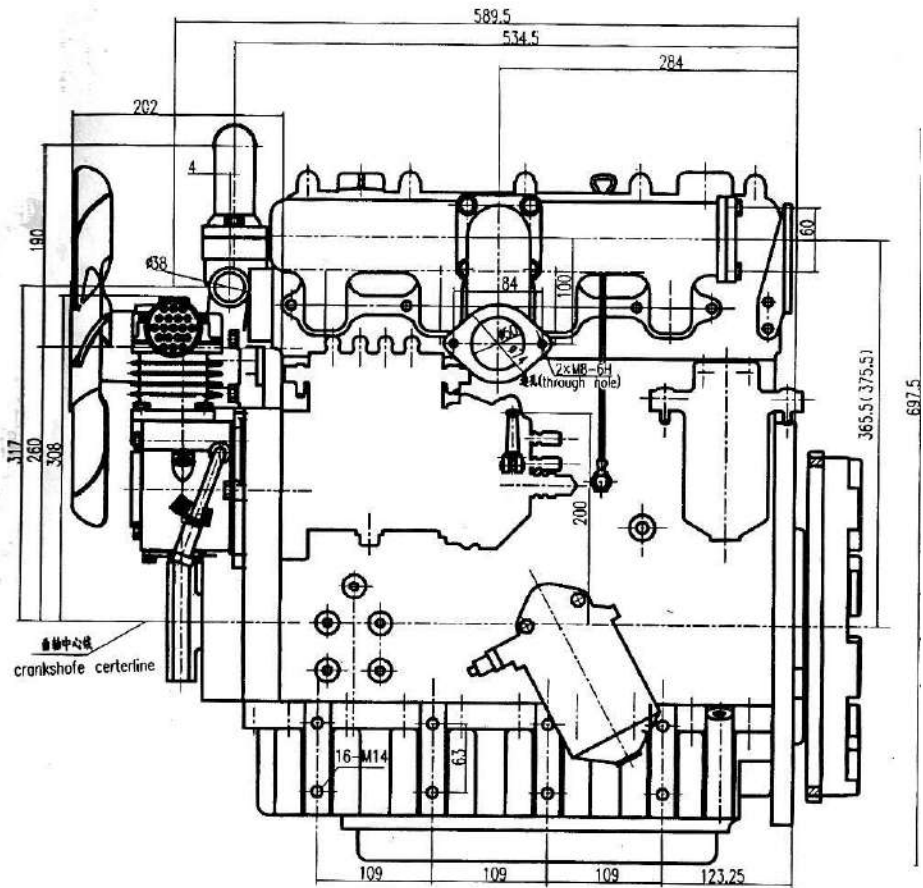
Since improvements on products and broadening of applications are made from time to time,your engine may be slightly different from instructions and statements contained within this manual.They won't be altered until the new revised edition is published.The operators are requested to pay attention to this.

For further improvements on quality of products and better service to the users,your suggestions are welcome.

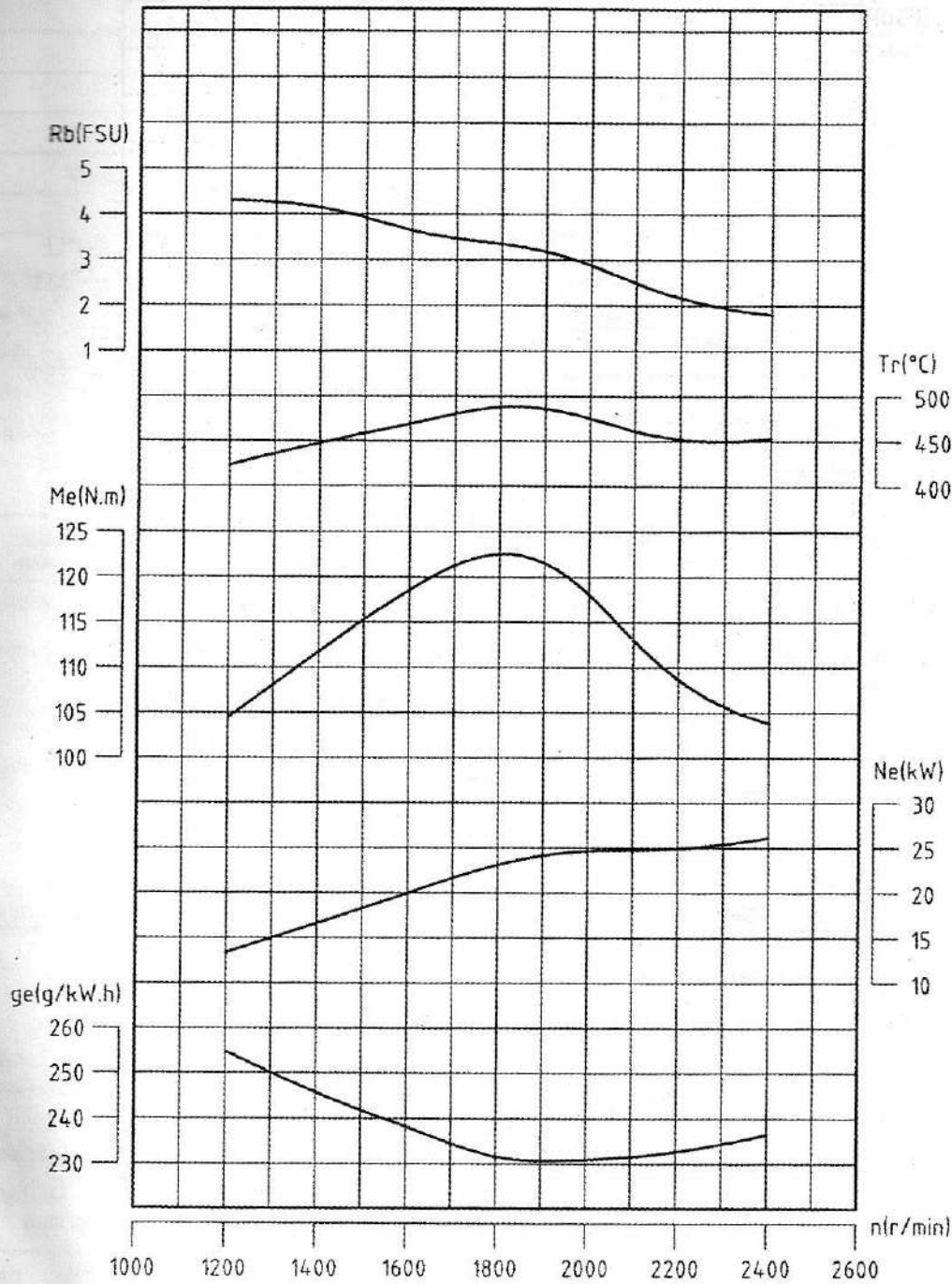
Contents

Overall Section of ZN485T/ZN490BT Diesel Engine

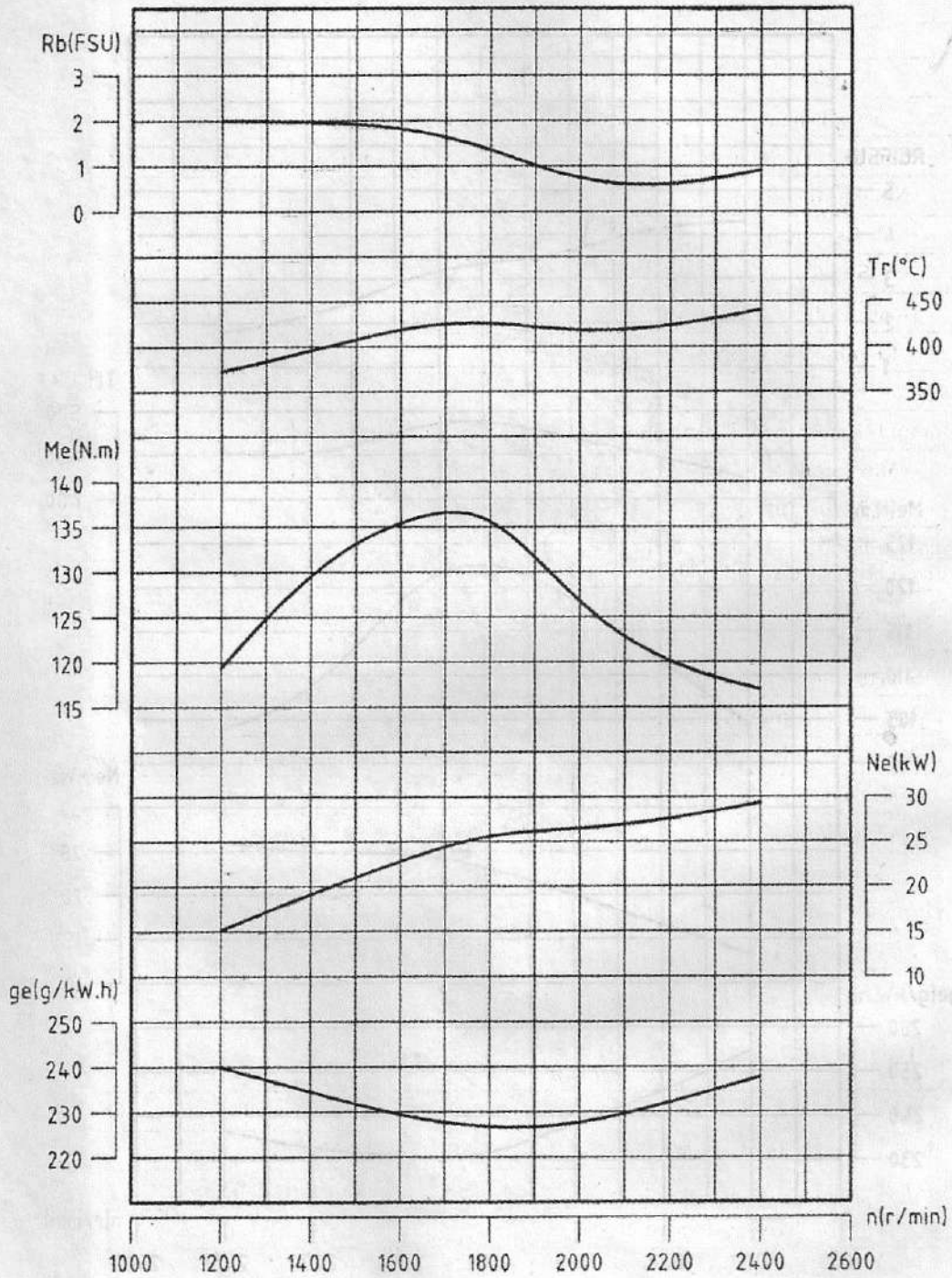
SECTION I ENGINE DATA	(1)
A.Specificaitons of the Engine	(1)
B.Engine Data	(1)
C.Accessories	(2)
SECTION II MAIN STRUCTURE AND ASSEMBLY OF THE ENGINE	(4)
A.Cylinder Block	(4)
B.Cylinder Head	(5)
C.Piston and Connecting Rod	(7)
D.Crankshaft and Flywheel	(8)
E.Camshaft System	(9)
F.Drive System	(10)
G.Fuel System	(11)
H.Lubrication System	(12)
I.Cooling System	(14)
J.Electrical System	(15)
SECTION III OPERATION OF THE ENGINE	(17)
A.Precautions	(17)
B.Operation	(17)
SECTION IV ADJUSTMENT OF THE ENGINE	(20)
A.Adjustment of Valve Clearance	(20)
B.Adjustment of Injection Timing	(20)
C.Adjustment of Fuel Injector	(20)
D.Adjustment of Fuel Injection Pump	(21)
E.Adjustment of Fan Belt Tension	(22)
SECTION V MAINTENANCE	(23)
A.Routine Maintenance	(23)
B.Maintenance after Every 100 Hours of Operation (First Class Maintenance)	(23)
C.Maintenance after Every 500 Hours of Operation (Second Class Maintenance)	(24)
D.Storage of the Engine	(25)
SECTION VI TROUBLE SHOOTING	(26)
A.Failure to Start	(26)
B.Abnormal Lubricating Oil Pressure	(27)
C.Smoke Exhaust	(27)
D.Insufficient Output	(28)
E.Unordinary Noise	(28)
F.Serious Vibration	(29)
G.Overheating	(29)
H.Excessive Lube Oil Consumption	(29)
I.Overspeeding	(30)
J.Engine Stalls	(30)
K.Uneven Running	(30)
L.Rising of Oil Level in the Sump	(30)



Speed Performance Curves of ZN485T Diesel Engine



Speed Performance Curves of ZN490BT Diesel Engine



SECTION I ENGINE DATA

A.Specifications of the Engine

Model	ZN485T	ZN490BT
Type	Vertical,water cooled,four-stroke	
Combustion chamber	Direct injection	
Number of cylinders	4	
Bore(mm)	85	90
Stroke(mm)	95	100
Total displacement(L)	2.156	2.545
Compression ratio	18:1	
Firing order	1-3-4-2	
Rated output/Rated speed(kW/r/min)	25.7/2300~2400	29.4/2300~2400
Max.torque/speed (N·m/r/min)	≥123/1725~1800	≥141/1725~1800
Min.specific fuel consumption of external characteristics[g/kw·h]	240	
Lubricating oil consumption at rated output/ rated speed[g/kw·h]	2.72	
Smoke intensity(FSU)	≤4	
Direction of rotation of crankshaft	Counter-clockwise(View from flywheel end)	
Method of lubrication	Combination of pressure with splash	
Method of cooling	Forced water cooling	
Method of starting	Electric	
Net weight(kg)	≤205	≤215
Overall dimensions(L×W×H)(mm)	769.5×516×697.5	

B.Engine Data

1.Engine Data

Valve timing (Deg.CA)	Intake valve opens	12° before T.D.C.	
	Intake valve closes	38° after B.D.C.	
	Exhaust valve opens	50° before B.D.C.	
	Exhaust valve closes	14° after T.D.C.	
Valve clearances in cold state	Intake valve(mm)	0.25~0.30	
	Exhaust valve(mm)	0.25~0.30	
Max idle speed(r/min)		≤2484(2300)	≤2592(2400)
idle speed(r/min)		≤750	

Fuel injection timing(°Degree)(In case with advancer)		20±1(ZN485T)	21~22(ZN490BT)
Injection pressure[MPa(kgf/cm ²)]		19.6(200)	
Exhaust temperature(°C)		≤600	
Lubricating oil temperature(°C)		≤105	
ideal outlet water temperature(°C)		80~90	
Lube oil pressure	at rated speed(kPa)	0.2~0.4	
	at idle speed(kPa)	≥0.05	
Capacity of oil sump(L)		5.5	

2.Torque limits of main bolts

Cylinder head bolts(N·m)	118~137
Main bearing cap bolts(N·m)	118~137
Connecting rod bolts(N·m)	59~69
Flywheel bolts(N·m)	98~118
Pulley bolts(N·m)	98~118

C.Accessories

Fuel injector	Model	PF68S23(ZN490BT)	PF75Sa(ZN485T)
	Nozzle	CN-DLLA155S255(ZN490BT)	ZCK154S425(ZN485T)
Fuel injection pump	Type	I pump with four cylinder	
	Plunger diameter	Ø9.0(ZN490BT)	Ø8.0(ZN485T)
Lube oil pump	Type	JZX1420 Rotor type	
Cooling water pump	Type	Centrifugal	
	Speed	2600	
	Flow	70	
	Discharge head(mW·G)	6	
Starting motor	Model	QD139(ZN490BT)	QD138(ZN485T)
	Capacity(kW)	3.0	
	Voltage(V)	12	
Generator	Model	JF11A	
	Power(W)	350	
	Voltage(V)	14	
Model of fuel filter		C0708A1	

Model of lube oil filter		J0810A1	
Model of air filter		KW1329 or K1317A	
Thermostat	Type	Wax element thermostatB52A3	
	Opening temperature(°C)	75	
	Full opening temperature(°C)	84	
Battery	Capacity(A·h)	105(ZN485T)	120(ZN490BT)
	Voltage(V)	12	

SECTION II MAIN STRUCTURE AND ASSEMBLY OF THE ENGINE

A. Cylinder Block

The block is made of high-strength cast iron HT250 and is of arch structure, and cylinder liner of wet type is used.

On the front side of the block is the water pump and gearcase which acts as drive mechanism and on the rear side are assembled an oil seal cover and the flywheel housing. There are cooling water passages and lube oil ducts within the block. Viewing from the front side on the left side of the block are assembled a generator, a starting motor and a breather, and on the right side are assembled a fuel injection pump, a fuel filter, a lube oil filter and a water drain valve. On the bottom is the oil sump. On the top of the block, besides the holes for cylinders and tapped holes for cylinder head bolts, there are water holes to the cylinder head. Near the front end of the block, there are also oil holes connected with the oil holes of the cylinder head.

The main bearing are of full support type. The main bearing cap and the engine block are bored in couples. On the main bearing cap there are a cast arrow and a mating number. While assembling, the arrow should point to the front side of the block and mating number should be the same as that on the block. They shouldn't be mixed up. The main bearing shell is separated into two sections, and the one with oil groove is the upper. While fitting, don't mix up them. The crankshaft thrust plates are located on the main bearing, one upper and one lower at both front and rear ends. While fitting, the working surface with oil groove on it should face crankshaft side.

While tightening the main bearing bolts, the two bolts for the same bearing cap should be tightened in turn several times to reach a specified-tightening torque of $118\sim 137\text{N}\cdot\text{m}$ ($12\sim 14\text{kgf}\cdot\text{m}$). During tightening the cap, knock from time to time the cap and both the front and rear ends of the crankshaft with a wooden hammer to keep the bearing and crankshaft in good fitting condition. After completion of the assembling of the crankshaft, turn the crankshaft by hand to make sure it turns freely.

The rear oil seal cover is provided with oil seal $\text{SC}85\times 110\times 12$ for sealing the rear end of the crankshaft. While assembling, attention should be paid not to damage the edge of the oil seal. The rear oil seal cover is positioned by two dowel pins and fixed on the rear end surface of the cylinder block by bolts.

The flywheel housing is provided with ring and positioned by two dowel pins and fixed on cylinder block by bolts.

The camshaft bushings are pressed smoothly into the cylinder block by means of a special tool. While pressing, the oil hole of the bushing should coincide with that in the camshaft bore of the cylinder block.

The cylinder liner is of wet type. On the lower part of the cylinder, there're two circular grooves in which rubber rings are fitted for prevention of water leakage. While fitting of the rubber rings, they should not be twisted. Then the cylinder liner is pressed in to the cylinder block.

While fitting the cylinder liner on to the cylinder block, the pressure should perpendicularly apply to the end of the cylinder liner, with its shoulder being $0.02\sim 0.10\text{mm}$ higher than the block end. The

differences of the height of the cylinder liners on one block should be not more than 0.05mm, otherwise, another selection of cylinder liners should be made.

B. Cylinder Head

The cylinder head is made of high-strength cast iron HT200, on which, the intake and exhaust ports and cooling water jacket space are cast. On the cylinder head are installed the parts of valve mechanism, including rocker arm supports, rocker arms, rocker arm shafts, intake and exhaust valves, valve guides, valve seats and valve springs and installed some parts of cooling system, including thermostat housing, thermostat cap, thermostat and also cylinder head cover and fuel injector.

The cylinder head is pressed against the cylinder block by 6 bolts of M12 for each cylinder, which are evenly spaced around the cylinder. Between the cylinder head and block, a piece of cylinder head gasket is fitted. While locating the cylinder gasket, attention should be paid to the positions of oil holes, water holes and tapped holes, no mispositioning shall be made. The cylinder head is positioned on the block by 2 dowel pins with a diameter of 16mm. While mounting the cylinder head on to the block, a torque wrench should be used. The sequence of tightening of cylinder head bolts should be done according to Fig.2-1 and the operation of tightening should be made several times to gradually reach the torque limit of 118~137N·m. After remounting the cylinder head, let the engine run hot for a while, then tighten the cylinder head bolts again according to the required torque limit and readjust the valve clearance.

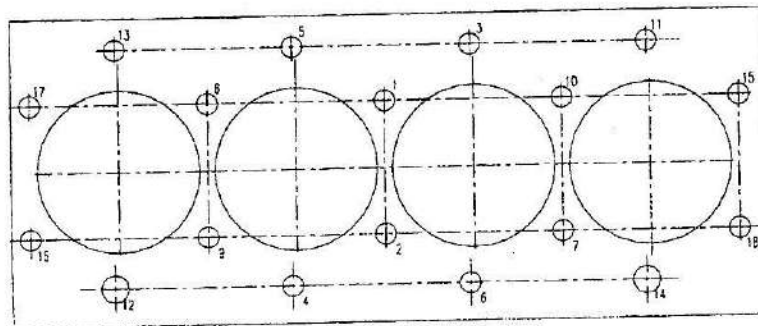


Fig.2-1 Sequence of tightening the bolts of the cylinder head

1. Intake & exhaust valves, valve seats and valve guides

The intake and exhaust valves are lapped in their respective valve seats to guarantee their airtightness. When the seat is worn or eroded by burning gases and results in leakage, it should be relapped. The lapping procedure should be done as follows: Take the valve out of its seat, smear some lapping abrasives, on its taper sealing surface, then lap it in its respective seat, until an evenly, cautious, lightless sealing surface appeared. The valve guide should be strictly prevented from being got into abrasives. After lapping, the valve seats and guides should be thoroughly cleaned of lapping abrasives and checked for leakage by pouring kerosene or diesel oil into intake & exhaust ports.

When the valves and the valve seats are heavily worn, they should be renewed. While renewing the valve seat, the chamfered end should be pressed into the cylinder head and the valve seat

tapered angle is 90° , then put the valve back to seat and lap to form a seating line of about 1.5mm wide (1.2~1.7mm).

The valves and valve seats should be replaced on the following conditions:

- ① The width of the seating line is over 2.5mm;
- ② The valve is 1.5mm more below the surface of the cylinder head as shown in Fig.2.2 (For a new engine, it should be 0.55~0.85mm).

In case one of the conditions occurs, the valve and the valve seat should be replaced according to the circumstances.

The valve clearance in cold state should be 0.25~0.30mm. After a period of operation, the engine should be stopped and the valve clearance should be checked and adjusted according to the method in section IV.

Water jacket space of the cylinder head should be tested for three minutes for leakage under water pressure of 400kPa. After being pressed into the cylinder head, the guide should be $14_{-0.50}^0$ mm above the valve spring seating surface.

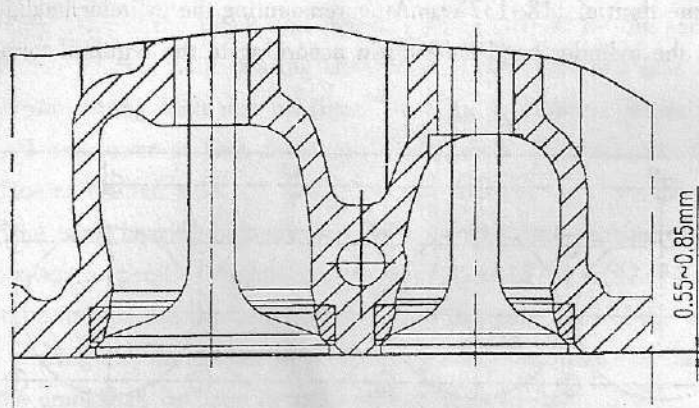


Fig.2-2 Depth of valve surface below the surface of the cylinder head

2. Rocker arm, rocker arm shaft and rocker arm support

The rocker arm is assembled on the rocker arm support by rocker arm shaft, and the rocker arm support is fixed on the cylinder head. After being assembled, the rocker arm should act freely without getting stuck. The front rocker arm support has a oil hole connected with the oil duct of the cylinder head. It shouldn't be missed while assembling.

3. The cylinder head gasket is made of asbestos metal compound plate, the whole surface of the gasket should be smooth and even. No crinkles, scars, folds and rust should be found on it except the wrapped edges. Otherwise, it should be renewed.

C.Piston and Connecting Rod

The piston and connecting rod is composed of piston,piston rings,piston pin,circlip,connecting rod small end bushing,large end bearing shell,connecting rod bolts,connecting rod and connecting rod cap.For the same engine,the weight difference among the connecting rod component including rod,connecting rod small end bushing,connecting rod bearing shells,connecting rod bolts and connecting rod cap should be less than or equal to 15 grams.The weight difference among the piston connecting rod assemblies should be less than or equal to 25 grams.

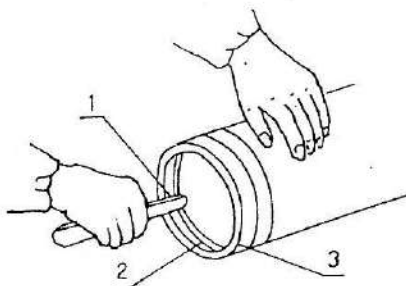
1.Piston

On the top of the piston,there is a combustion chamber.On the piston,there are two compression ring grooves and one oil scraping ring groove.

2.Piston ring

Piston rings are made of alloy cast iron.The first compression ring is of trapezoidal type and both are porous chrome plated on outside surface.The second compression ring is of tapered surface type.While fitting,make sure the surface marked with "上" of the ring should face the top of the piston.No mistake is permitted.The oil scraping ring is of spiral spring backed type,its inner cylindrical surface,inner round surface and outer cylindrical blade surface are all chrome plated.While assembling,make sure the connection of the spring should be opposite to the opening of the oil scraping ring.The assembling of the piston ring should be done by means of special expander and the applied force should be proper to prevent the piston ring from being broken.The piston rings should be free to turn and shall seat on the support face inside the groove due to its gravity.While assembling,the openings of the piston rings should be spaced 120° apart from one another.The opening of the piston rings should be avoided in the axial direction of the piston pin.

Before installing the rings,their gap clearances should be checked as shown in Fig.2-3.



1.Feeler gauge 2.Piston ring 3.Cylinder liner

Fig.2-3 Checking the opening gaps of the piston rings

Place the ring into the liner 15~20mm from the top of the liner.Measure its gap clearance by means of a feeler gauge.The gap clearance for the first ring should be 0.30~0.45mm,the gap clearance for the second ring should be 0.25~0.40mm,the gap clearance for third ring should be 0.20~0.40mm.If the gap clearance is not sufficient,it could be enlarged by filing.If the gap clearance is too much,a new one could be selected.

Besides, the end clearance between the ring and its groove should also be checked by means of a feeler gauge as shown in Fig.2-4.

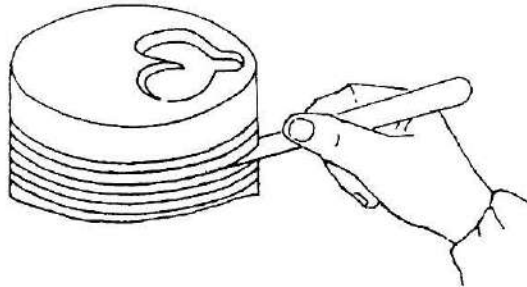


Fig.2-4 Checking the end clearance of the ring

For the second and the third ring, the end clearance should be 0.03~0.062mm. After a long period of operation, the ring may be stuck within the groove. Soak the entire piston in fuel oil, kerosene or gasoline for a period of about 24 hours, knock the ring slightly, and it would free itself and can be dismantled easily. Then clean the groove and the ring. Check the piston for damage or cracks, if any damage is found, renew the piston and also the rings.

3. Piston pin

While assembling the piston pin, first put one circlip into the piston pin bore. Heat the piston in oil until it reaches a temperature of 100°C. Then smear lube oil on the piston pin and push it into the bore by hand or by means of a pin punch. After this, install the other circlip. While assembling, attention should be paid to that the cavity on piston crown should be in the same side with the match marks on the connecting rod. The front end mark on the piston crown should face the front end of the engine. All the moving parts should be lubricating.

4. Connecting rod and large end bearing shell

The connecting rod is made of steel 40Cr. The body and the cap are marked so that they would not be mixed up during assembly. The connecting rod bolts should be tightened 2 or 3 times until the tightening torque of the connecting rod bolts is 60~70N·m. While re-assembling, attention should be paid to make sure the convex locating pin of the bearing shells keep on the same side. Don't mix up them. The weight of large end and small end are strictly distributed for the same engine, the weight difference among the piston-connecting rod assemblies should not be more than 25 grams. If the clearance exceeds the limit due to the wear of bearing shell and crank pin, change the bearing shells. If any damage or crack is found, renew them.

D. Crankshaft and Flywheel

The crankshaft is of full support and entirely balance block structure. Between the main journal and rod journal are drilled oil holes through which lube oil goes to the rod journal from the main journal.

On the front end of the crankshaft is the timing gear and pulley for driving the camshaft, fuel injection pump, lube oil pump and water pump. And on the rear end is the flywheel which is located by locating pin and is fixed by six flywheel bolts. All the bolts should be tightened evenly with a torque wrench until the torque reaches $98\sim 118\text{N}\cdot\text{m}$. And they are to be tightened by turns in a diagonal order.

When the 6 bolts are tightened, the flywheel should be locked with 3 locking plates. At the center of the flywheel, a bearing model 203 is assembled to support the driving shaft of the gearcase.

On the pulley there are mark-lines for checking fuel injection timing and top dead center of piston.

On the peripheral of the flywheel, the flywheel ring gear is installed. On the periphery of the flywheel there is mark line for checking the injection timing.

The crankshaft, flywheel and pulley have been balanced, so attention should be paid to their balance when they are replaced.

E. Valve System

The camshaft is made of steel No.45 and has three supports. Its journals and surfaces of its cams have been high frequency hardened. On the front end of the camshaft, there is a timing gear. When the camshaft is turning, the valve tappets, push rods, valve rocker arms and valves follow the movement of the cam to control the air intake and exhaust of the cylinders respectively.

On the front end of the camshaft there is a thrust collar. On the front end of the cylinder block there is a camshaft thrust plate. The clearance between the thrust plate and the timing gear is $0.08\sim 0.25\text{mm}$ for controlling the axial movement (please refer to Fig.2-5).

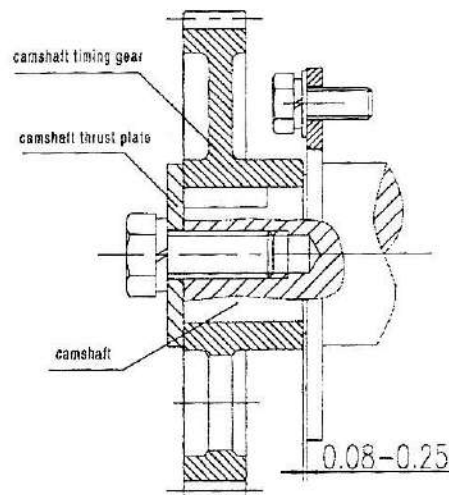


Fig.2-5 Camshaft timing gear and thrust plate

The camshaft has a long drilled hole which carries oil to lubricate the camshaft bearings. In the first bearing section there is an oil passage leading to the cylinder head and rocker arms. While assembling the camshaft bushings, check the oil holes in the bushings to make sure that they coincide with those in the cylinder block. And attention should be paid to the installation of the front and rear bushings. They should not be mixed up.

The tappets are made of chilled cast iron. There is a deviation of 2mm between the center lines of the tappet and camshaft. Therefore the tappet rotates uninterruptedly during operation of the engine, resulting in even wear and prevention of sticking.

The push rod is of steel No.45 and both of its round ends have been high frequency hardened.

The rocker arm shaft is of all-support with high stiffness. The pressed oil coming from the cylinder head lubricates the rocker arm and rocker arm shafts.

The valves and valve seats are made of alloy steel and alloy cast iron, and they are mated by lapping. Checking the valve for tightness may be done by pouring into the intake and exhaust ports a small quantity of fuel, and observe for two minutes to see whether it leaks out around the valve seat.

The valve clearance would have an effect on technical condition of the engine. Therefore the valve clearance should be adjusted to a specified value of 0.25~0.30mm both intake and exhaust in cold state.

The air filter is of paper element type. It should be correctly, rationally and firmly fixed on the chassis or on the cab in proper location and should not be fixed in dusty location. A flexible rubber pipe should be used to connect the air filter to the opening of the intake manifold. The rubber pipe may be long or short and bent, according to the requirement. Both ends of the rubber pipe should be fixed with a clip and the dust outlet of the air filter should be kept downwards.

F. Drive System

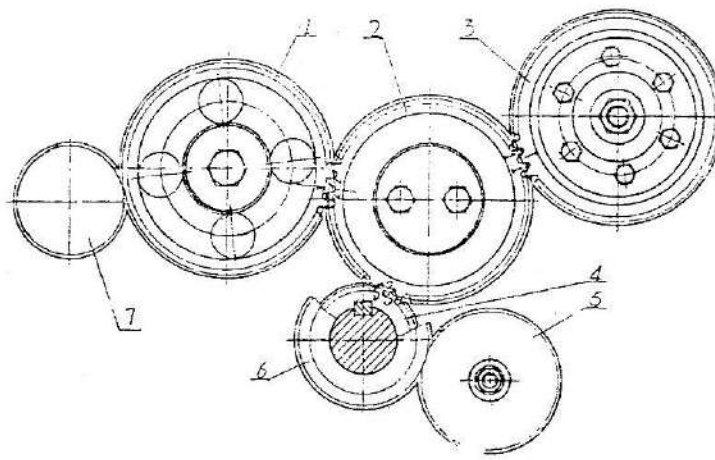
The gear case section consists of gear case, gear case cover and timing gear train system. The whole section is installed in the front end of the cylinder block.

The gear case is positioned on the cylinder block with dowel sleeves and sealed by gaskets. On the right rear end of the gear case, the injection pump and its connecting plate are fixed. On the front end of the injection pump driving shaft there is an advancer, connecting the timing gear of the injection pump by means of six M6 bolts.

The gear case cover and the gear case are also positioned with dowel sleeves and sealed with gaskets. The SG52x72x12 gaskets are fixed between the gear case cover and crankshaft journal.

The timing gear system plays the role of driving and timing, which is composed of crankshaft timing gear, idle timing gear, camshaft timing gear, injection pump timing gear and oil pump gear. When the engine works, the crankshaft timing gear drives the idle timing gear, which drives the camshaft timing gear and the injection pump timing gear. And the oil pump driving gear drives the oil pump gear.

All the timing gears have marks. While assembling, all these marks should be correctly placed in order to obtain exact timing relative to each other as shown in Fig.2-6. After assembly of the idle gear, its axial clearance should be checked. The gears should be free to rotate without being stuck.



1.Camshaft gear 2.Idle gear 3.Fuel injection pump gear
4.Crankshaft gear 5.oil pump gear 6.oil pump drive gear 7.hydraulic pump gear

Fig.2-6 Relative positions of gears during assembling

G.Fuel System

Fuel system is composed of supply pump,injection pump,governor,fuel filter,injector,and high and low pressure pipings.

The supply pump is of piston type,which is located on the side of the injection pump.During normal operation,it is driven by the eccentric cam of the injection pump.During the engine is not in operation,the hand pump may be used for removing of air in fuel system.

The fuel filter is of folded paper element cross flow type,which is composed of the housing,filter seat and filtering element,no by-pass due to leakage is permitted caused by bad sealing.Renew the filter element after every 100 hours of operation of the engine in order to obtain clean fuel.

Injection pump is of series No.1 or of BQ type.The pump consists of pump body,camshaft,plunger couple,delivery valve couple and fuel quantity control mechanism.The injection pump is also provided with the feed pump and the governor.

The injection pump is stalled on the gear case.The fuel injection timing depends on its relative position,which has been set at the factory and shouldn't be changed unless absolutely necessary.After dismantling,the fuel injection timing should be readjusted.

The injection pump is driven by the injection pump timing gear.As the camshaft rotates,the roller and tappet follow the movement of the cam thus causing the plunger to have a reciprocating motion to deliver the fuel.

The fuel quantity control mechanism is made up of a speed control lever,governor fork,regulation arm which is close fitted into the plunger.The speed control is controlled by the governor. When the lever moves to or opposite the direction of the governor,the quantity of fuel delivered decreases or increases.The injection pump has been calibrated at the factory.Be sure not to

dismantle it. If it is necessary to dismantle, repair or adjust it, it should be kept clean. The plunger couple and delivery valve couple are not interchangeable.

The governor is of mechanical full-speed type, which is located on the rear end of the injection pump and consists of driving parts and fuel control mechanism. The governor has been adjusted and sealed at the factory and shouldn't be changed unless absolutely necessary. If any problem is found, it should be adjusted on the fuel injection pump tester.

The injector is composed of the injector body, lock nut, needle valve couple, spindle, adjusting spring and adjusting screw. The needle valve and barrel of the nozzle are precisely mated. Therefore they are not interchangeable. They should be changed in pair if any of bad atomization, fuel dribbling and sticking is found.

H. Lubrication System

The main moving parts are lubricated by combination of pressure and splashing. The main bearing journals, connecting rod journals, camshaft journals, idle gear shaft, and rocker arm shaft, etc. are all lubricated by pressure oil. And some of other parts including the cylinder liner, piston, piston pin and cam surface are splash-lubricated. The schematic drawing of the lubrication system is shown in Fig. 2-7.

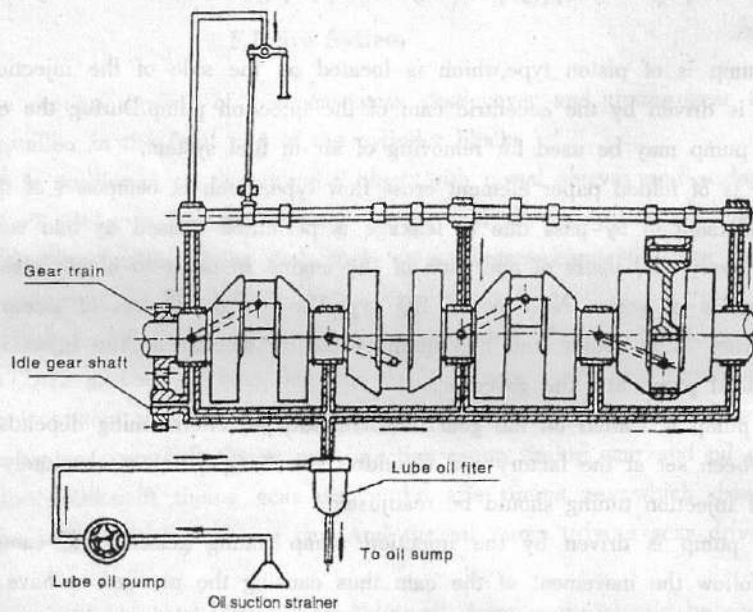


Fig. 2-7 Schematic drawing of lubrication system

The lube oil pump is of rotor type, which is installed in the gear case. Oil is drawn from the sump into the oil pump through a suction pipe. The oil pump delivers the oil to the oil filter. The filtered oil passes through the main oil passage and then respectively goes into the main bearings, crankshaft bearings and idle gear shaft hole. On the rear end of the main bearings, there is another oil passage leading to the rocker arm supports for lubrication of rocker arm bushings.

The lubricating oil should be added properly. If it is added too much, it would be burning, if it is added too less, the bearing shells would be burnt. It is ideal to add oil until its lever reaches between the upper and lower marks on the dipstick. Before starting the engine, the oil lever should be checked.

The suction strainer is used to filter out coarse particles to prevent them from getting into the main oil passage. After a long period of operation, the screen wire shall be dogged. Therefore, the suction strainer should be cleaned regularly or renewed.

The oil filter and the cylinder block are sealed with gasket. While dismantling and reinstalling the oil filter, attention should be paid to the installation direction of the gasket. Otherwise the oil in the main oil passage shall leak into the sump. The oil pressure shall be shown as "0".

The pressure regulator is fixed in the oil filter, which consists of pressure adjusting screw, nut, spring, valve and valve body as shown in Fig. 2-8.

The working principle of the pressure regulator is as follows: When the lubricating oil pressure is too high, the oil will overcome the spring force and push the valve down until the oil pressure cavity is connected with the oil return hole. Then, a portion of the oil returns to the sump and the oil pressure in the oil pressure cavity shall be reduced. The pressure regulating valve has been adjusted at the factory. It shouldn't be adjusted unless necessary. After a long period of operation, when the moving parts of the engine are worn, the oil leakage will increase, which will decrease the oil pressure. When the pressure decreases to lower than 100kPa, the adjusting screw should be readjusted in time to press the spring and bring the pressure back to specified limits. If the pressure can't be increased, it may be that ① The oil pump is worn. ② The moving parts of the engine are heavily worn. For condition ①, the oil pump should be repaired or renewed. For condition ②, the moving parts should be renewed.

During rated working of the engine, the oil pressure is 200~400kPa. And during idle speed working, oil pressure shouldn't be less than 50kPa.

A specified lube oil is recommended for lubrication of the engine. Because of high heat load and high mechanical load of diesel engine parts, higher sulphur and acidic content of diesel fuel than gasoline, the requirement of lubrication oil for diesel engine in which various additions are added is higher than that for machines. So it should not be replaced by lubrication oil for machines.

The normal operation of diesel engine depends upon the correct use and maintenance of the lubrication system, to which special attention should be paid by operators.

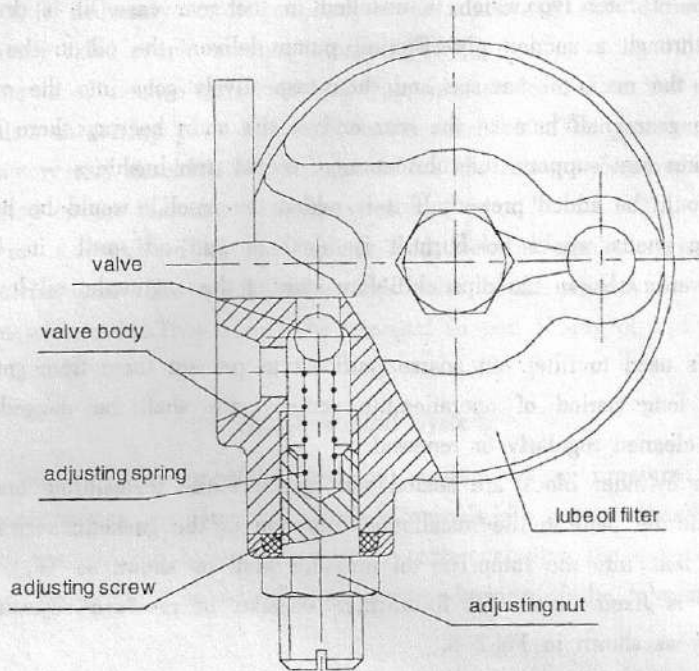
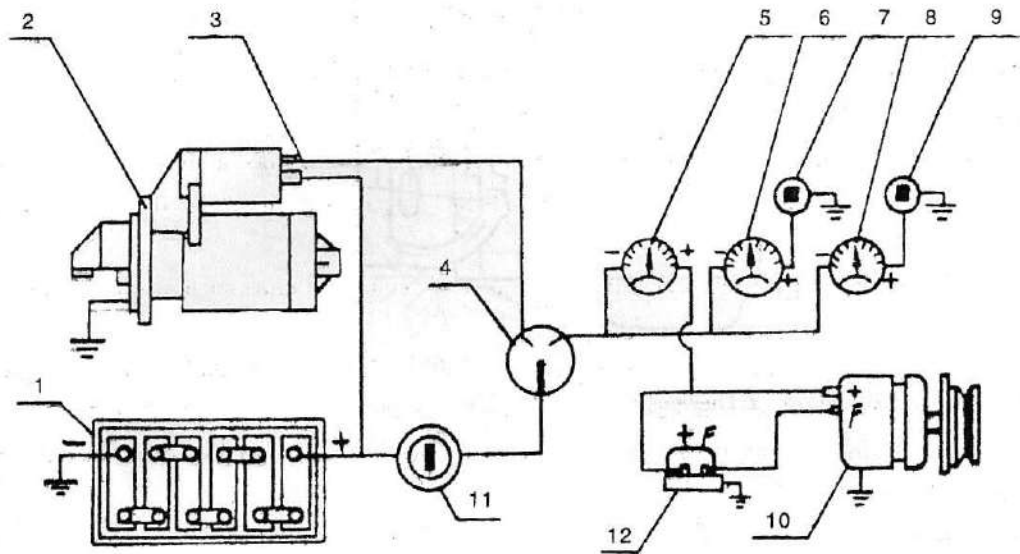


Fig.2-8 Pressure regulating valve assembly

I.Cooling System

The cooling system is of water cooled,forced and closed circulation,which consists of water pump, thermostat,fan,and radiator,etc.

The water pump press the cooling water into the water jacket space of the cylinder block to cool cylinder liner,cylinder block and cylinder head,then into the thermostat.When the water temperature is lower than 75°C ,the thermostat closes and the cooling water can't go into water tank. It will go directly into the water pump,realizing small circulation in the cylinder block.When the water temperature is higher than 75°C ,the thermostat opens and the cooling water goes through the thermostat into the water tank and is cooled down by the atmosphere and pressed again by the water pump into the cylinder block,realizing great circulation.For guaranteeing the water temperature not more than 95°C ,the heat radiating area of the water tank should be guaranteed,but not too big, because the over lower temperature of the cooling water is harmful to the normal operation of the engine.The cooling system is shown in Fig.2-9.



1.battery 2.starting motor 3.wire 4.preheater starting switch 5.ammeter 6.oil pressure gauge 7.oil pressure sensor 8.water temperature gauge 9.water temperature sensor 10.generator 11.circuit key switch 12.voltage regulator

Fig.2-10 Electrical system

SECTION III OPERATION OF THE ENGINE

A. Precautions

1. Adjustment and maintenance should be made according to the procedure specified in this manual during operation of the engine.

2. Running the engine at high speed or with high load immediately after start is strictly forbidden. It is recommended to run the engine at low speed with no load first then gradually increase to high speed and full load.

3. Diesel fuel and lube oil should be clean and conform with specifications. Before use, fuel should be thoroughly precipitated and filtered.

4. Keep water at normal temperature of 75°C ~95°C. Normal lubricating oil pressure during operation at medium speed should be 200~400kPa.

5. Load of engine should be strictly controlled, no overload is permitted. Otherwise, the reliability and service life of the engine would be affected.

6. Run in the engine at medium speed and with low load for 30 minutes at least after renewing or replacement of injector. Before fitting, the nozzle couple should be cleaned in kerosene or light diesel fuel to remove the coating of rust-resistance.

7. During operation, if any of abnormal phenomena is found, stop the engine for check.

8. A new engine or a overhauled engine should be running in gradually.

B. Operation

1. Fuel, lubricating oil and cooling water

(1) Fuel: Grade of fuel is to be chosen according to local seasons and temperature. In most areas of China, light diesel fuel of grade No.0 is used in summer, grade No.-10 in winter. In cold northeast areas, No.-20 or NO.-35 light diesel fuel is used.

(2) Lube oil should conform to Chinese standard GB11122《L-ECC Lube oil for diesel engine》. In summer season, No.40 is used when weather temperature is above 20°C and No.30 or 20w/40 is used when temperature is 0°C~20°C. In winter, when -10°C~10°C, grade 20/20w is used, when -20°C~0°C, grade 10w/30 is used, when below -20°C, grade 5w/30 is used.

(3) Cooling water: It is recommended to use rain water, tap water or clean river water. Hard water (well or spring, etc.) should be softened, if they are used. Otherwise, scale, rust and sludge will form and this will affect the performance of the cooling system. Boiling up is a common practice to soften the hard water. After precipitation and removal of impurities, the softened water may be used as cooling water. When the engine operates in cold weather the cooling water is liable to freeze, antifreezer should be added to the cooling water. Common antifreezers are glycol or alcohol. If the engine has difficulty in starting under weather temperature below 0°C, heat the cooling water to a temperature of 40~50°C.

After a long period of operation, scale deposits will form on surfaces of water jacket space, which will affect heat radiation of the engine, so periodic removal of scale deposits should be made as follows:

① Smear machined surfaces with grease to prevent any corrosion. Fill water jacket space with a solution of hydrochloric acid (HCl) of 25% concentration, keep it for about 10 minutes and then drain it off. Then blow-wash with fresh water. Repeat it again if not thoroughly cleaned.

② Fill water jacket space with a solution of caustic soda (NaOH) in a ratio of 1 liter of water to 75~80 grams of caustic soda. Then start the engine and run it at medium speed for about 10 minutes. Keep the solution in the water jacket space for 10~12 hours. Finally start and run the engine at medium speed for 10 minutes, then drain it off, blow-wash with fresh water. If not thoroughly cleaned, repeat it again.

2. Preparation before operation

(1) Check the mounting of engine for reliability. Be sure that all control handle such as throttle control lever and stop handle, are in good order.

(2) Rotate the crankshaft for several revolutions to check whether all moving parts move freely.

(3) Check to see whether oil level in the oil sump and injection pump is as specified.

(4) Check the cooling system to see whether the cooling water is full and whether there is any leakage.

(5) Check the fuel system. Make sure that the fuel tank has sufficient fuel, and fuel line is through and no leakage is found. Open the fuel tank cock.

(6) Check if the battery is fully charged, and the connections of the electric system are correct and tight.

(7) Check if accessories of the engine are in good connection (injection pump, injector, fuel filter, water pump, fan, charging generator and its bracket, fan belt pulley, starting motor, lubricating oil filter, radiator, etc.).

(8) Check the engine. Be sure it is unloaded when starting (If clutch is attached, it should be disconnected with the engine).

3. Starting

(1) Set the speed control lever at medium speed position.

(2) Loosen the pipe connecting bolt of fuel filter to vent air, if any, in the fuel system. In case there is a lot of air in the fuel system, it is necessary to loosen the vent bolt on the injection pump and repeatedly press hand-operated fuel feed pump in order to let air get out of the system.

(3) Turn the starting switch to start position, the engine will start running. The operating duration of the starting motor should not be more than five seconds. If the engine fails to start for the first time, it is necessary to release the starting switch and wait for 1~2 minutes, then try the second time. If the engine still fails to start after three consecutive starting operation, it is necessary to check causes. After remedy has been done, start the engine again.

(4) After the engine has been started, immediately release the starting switch. Then turn the starting switch to charging position for charging operation of generator. Meanwhile, adjust the throttle to let the engine run at idle speed and check whether the engine is in normal operation and if there is any abnormal noise. Special attention should be paid to make sure that lubricating oil pressure is normal. Then gradually shift the speed control lever to ensure the engine to run at medium speed for warming up of the engine.

4. Operation of the engine

(1) Only when temperature of cooling water reaches 50°C and temperature of lubricating oil reaches over 40°C , the engine may be loaded. However, when the engine is running at rated output, outlet water temperature should be $80 \pm 5^{\circ}\text{C}$.

(2) Increase the speed and load gradually. Except in special instances, don't increase or decrease load the engine suddenly.

(3) During operation, observe the gauges and check the operating conditions of the engine from time to time. If any abnormal exhaust smoke color and noise are noted, stop the engine for check.

(4) During operation, the charging generator should be in charge operation for charge of the battery and the pointer of amperemeter should point to "+".

5. Stopping

(1) Before stopping, reduce the load and speed gradually and let the engine run at idle speed for about 3-5 minutes.

(2) After stopping, turn the starting switch to "0" position.

(3) When the weather temperature is below 5°C , after the engine has stopped, it is necessary to drain out the cooling water completely in order to prevent subsequent cracking of cylinder block because of freezing. However, if anti-freezer has been added in the cooling water, it is unnecessary to drain out cooling water.

SECTION IV ADJUSTMENT OF THE ENGINE

A. Adjustment of Valve Clearance

When maintaining the engine, it is necessary to check and adjust the valve clearance. The procedure of adjustment of valve clearance and valve mechanism is as follows:

1. Remove the cylinder cover to check and tighten the bolts on the rocker arm supports.
2. Rotate the flywheel to locate the top dead center of the compression stroke of the first cylinder, which may be checked in the following way. Align the marked line at the marked 0 on the crankshaft pulley with the point on the gear case, then turn the flywheel back and forth nearby this position. In the meantime, check to see whether the two valve push rods of the first cylinder move up and down. If the two valve push rods fail to move up and down, it indicates the first cylinder is at the top dead center of compression stroke. If the two valve push rods move up and down, it indicates the first cylinder is at the top dead center of exhaust stroke. In this case, taking one turn of the flywheel is needed for top dead center of compression stroke.
3. Check and adjust the valve clearances of intake valve and exhaust valve by means of a feeler gauge inserted between the valve stems and the rocker arms of the first cylinder. Then according to the firing order of cylinders (1-3-4-2), rotate the crankshaft in turn through an angle of 180° in order to adjust the valve clearances of other cylinders.

B. Adjustment of Injection Timing

For best specific fuel consumption and operating performance, injection timing should be adjusted to its specified value of $20 \pm 1^\circ$ (ZN485T), $21 \sim 22^\circ$ (ZN490BT).

The procedure of adjustment of injection timing is as follows:

1. Vent any air in the fuel system, and repeatedly rotate the crankshaft to make the fuel pump filled with fuel. Then disconnect the high pressure fuel pipe of first cylinder and blow off the remaining fuel in the open end of delivery valve holder. And slowly rotate the crankshaft in its operation direction and at the same time closely observe the fuel level in the open end of delivery valve holder until the fuel just begin to flow out of it.
2. Check the point on the gear case to see whether it coincides with the marked line on the pulley within the specified optimum value.
3. If injection timing is too advanced or too lagging behind, it is necessary to loosen the three nuts on the triangle-shaped flange of the injection pump for adjustment. Viewing from the front end, turning clockwise of the injection pump will set the injection timing earlier and turning anticlockwise will set the injection timing later. After the adjustment has been done, tighten the three nuts on the flange and check the injection timing again until it meets the requirement.

C. Adjustment of Injector

The test and adjustment of the injector should be done on the injector test bench for checking and adjusting of injecting pressure and atomization quality to remedy the trouble in time.

Some troubles such as black smoke emission, decrease of output and speed, increase of exhaust temperature and serious piston knock during operation of the engine may be caused by too high or too low injecting pressure, abnormal fuel injection or damaged parts.

1. Procedure of adjustment of the injector

(1) Operate the hand pump until the reading of pressure gauge reaches 18MPa, then continue to slowly and gently operate the hand pump until the pressure is up to 20MPa, at the same time check to see whether fuel dribbling or leaking is found at the injection orifice of the injector. Fuel dribbling won't be found in normal case. If fuel dribbling still occurs, it is necessary to dismantle the nozzle for cleaning, checking or lapping before next testing.

(2) Adjustment of injecting pressure

Remove the injector, and adjust the thickness of pressure adjusting gasket to make the injection pressure to 20MPa.

(3) Checking the atomization quality

The atomization quality is tested at a spraying rate of about one time per second. The atomized fuel should be homogeneous. Abnormal phenomena such as fuel splashing, partly uneven density and single-side injecting are not acceptable. And obvious clear sound should be heard when cutting off the fuel. In common cases, abnormal fuel injection is caused by the trouble of the movement of the needle valve. And fuel dribbling from the injection orifice is caused by the failure of sealing.

2. Maintenance of injector

(1) Before maintaining the injector, clean its outer surface. Then clamp it upwards on the bench clamp with copper lining. Screw off its nut then remove the nozzle and draw out the needle valve, immerse them in fresh fuel. In the meantime, remove the pressure adjusting spring, spindle and pressure adjusting gasket.

(2) In case the needle is stuck with its body or bad atomization is found, it should be cleanly washed. Immerse the sticky needle valve and its body into fresh fuel for a while, then clamp the needle valve by means of a pair of pliers lined with cloth and gently turn and draw it out from its body. Care should be taken during this operation for prevention of scratching. The needle valve and its body may be scraped clean by means of a piece of wood dipped in gasoline or diesel fuel. Never use metal sheet for cleaning. If the needle valve and its body are not so smooth and the movement is not so free, lapping is needed. Fresh fuel should be used for lapping. When match lapping, the needle valve must not strike against its body seat. After lapping, it is necessary to cleanly wash the needle valve and its body, be sure no metal lapping dust and dirt remain on them.

D. Adjustment of Fuel Injection Pump

The fuel pump is already carefully adjusted and checked by the engine manufacturer. In case the readjustment is needed, it should be done on a special fuel pump testing bench equipped with standard injectors and high pressure fuel pipes of standard length according to the related instructions in "operation manual" edited by Fuel Injection Factory.

E. Adjustment of Fan Belt Tension

When a new fan belt is used, it is necessary to adjust its tension after running a period of 2~1 hour in the following way as shown in Fig.4-1. Press the belt with a force of 50~60N at the midpoint between the generator pulley and the crankshaft pulley, the belt would be pressed down 10~15 below its original position.

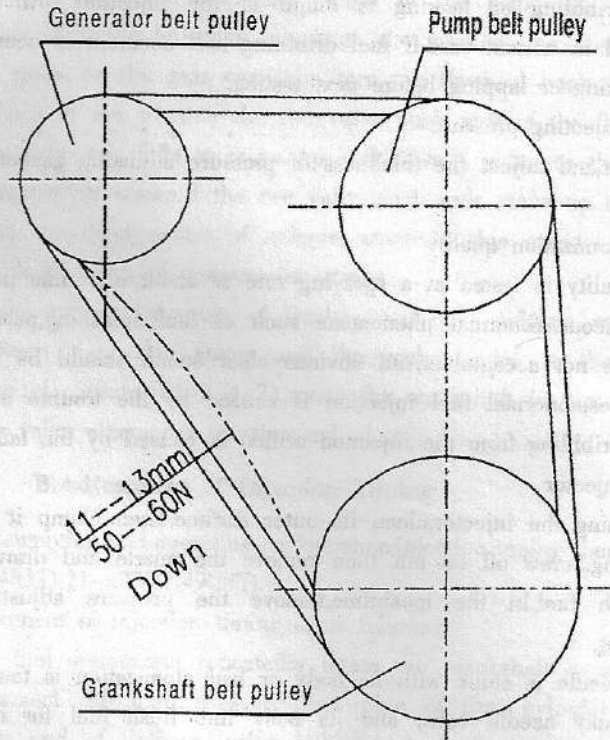


Fig.4-1 Adjustment of the fan belt pulley

SECTION V MAINTENANCE

To ensure the normal and reliable operation and prolong service life, end users must execute the regulation of engine maintenance as follows:

A. Routine Maintenance

1. Check the oil level in the sump to see whether it lies between upper and lower mark lines on the dipstick but near the upper one. As for a new engine or the engine which has been put out of service for a long time, after refilling oil up to the upper mark line, run the engine at low speed for 5-10 minutes then stop the engine. And then measure the oil level again by means of the dipstick.
2. Check quantity of cooling water in the radiator.
3. Check the oil level inside the governor of fuel injection pump, refill it if insufficient.
4. Check for leakage of oil, water and air.
5. Check all the components attached to the engine for correctness and rigidity.
6. Check the installation of the engine. Make sure all foundation bolts are tight and connection with the driven machine is in good order.
7. Be sure to keep the engine clean. Remove oil sludge, and dust from all parts of the engine, using dry rags or rags soaked with a little gasoline. Take special care not to foul the electrical equipment.
8. After the first 50 hours of underload running of a new engine, change lubricating oil in the oil sump and injection pump, and clean the element of oil filter, oil sump and oil suction strainer.
9. Remedy troubles and abnormalities found.

B. Maintenance after Every 100 Hours of Operation (First Class Maintenance)

In addition to "Routine maintenance", the following should be performed:

1. Replace lubricating oil in the oil sump. Draining off lubricating oil should be done while the engine has been warmed up after running.
2. Clean or replace the lubricating oil filter element.
3. Clean or replace fuel filter element after every 150 hours of operation and air filter element (or accumulated 200 hours of operation).
4. Check the cylinder head bolts for tightness.
5. Check the valve clearance and adjust it to the specified value.
6. Check the belt tension. Adjust it if necessary.
7. Add grease to the components with oil cup.
8. Clean intake and exhaust manifolds and silencer as well.

9. Check injection pressure and atomization quality of the injector, clean it if necessary after accumulated 200 hours of operation.

10. Check the batteries. At room temperature of 15°C, the specific gravity of the battery acid should be 1.28~1.29. Ordinarily it should not be less than 1.27. The level of the acid should be kept 10~15mm above the lead plates. When it is too low, add distilled water, the voltage should not be below 10V.

11. Renew cooling water after every 200 hours or according to the turbidness of water. Remove the thermostat and then start the engine and change its speed frequently to stir the cooling water and thus wash away the sediment in the cooling system. Then drain water by opening cocks on the radiator and cylinder block. Then continuously refill the radiator with clean water after stopping of the engine. Start the engine again and run it at idle speed to make the water flow. Timely check the draining water until it is clean. Then close the draining cock and stop the engine, install back the thermostat.

12. Those parts removed for maintenance must be cleaned and located correctly while reassembling.

C. Maintenance after Every 500 Hours of Operation (Second Class Maintenance)

In addition to "First Class Maintenance", proceed as follows:

1. Check the injection pressure of the injector and the atomization of fuel spray. Clean the nozzle couple and readjust the pressure if necessary.

2. Check the injection timing, adjust it if necessary.

3. Check both intake and exhaust valves and valve seats for leakage. If necessary, lap them.

4. Check the connecting rod bolts, main bearing bolts and flywheel bolts for tightness.

5. Retighten the cylinder head bolts, adjust the valve clearance as specified.

6. Clean or renew the air filter element. According to the quantity of dust in the operation condition, this may be performed in advance after every 100 hours or shorter of operation.

7. Renew lubricating oil in the injection pump governor.

8. Clean the cooling system. (Refer to Section III)

9. Check the working condition of the thermostat.

10. Check the wiring connections of the electrical system. All contacts should be tight and without any traces of burn-out.

11. Generally check all the components of engine, repair or adjust them if necessary.

12. Check the wear on the end plane of lubricating oil pump, adjust the clearance between the rotor and pump cover, and adjust oil pressure.

13. Check the opening gaps of piston rings and remove carbon deposits from the piston crown and ring grooves of piston.

14. Check both the front oil seal and rear oil seal of the crankshaft, renew them if any hardening and damage is found.

In addition to periodic maintenance, end users may proceed more detailed maintenance according to actual conditions.

D.Storage of the Engine

1.If the engine is to be put out of service for a long period of time,it is necessary to drain out lubricating oil,cooling water and fuel when engine is still warm after stopping the engine.

2.Perform maintenance accordingly.

3.Dismount both intake and exhaust manifolds and pour into the cylinder liner from the air ports about 0.2kg of clean dehydrated oil (By heating the lubricating oil to 110~120°C,until all air bubbles on surface of oil disappear).And rotate the crankshaft so that the valves,cylinder liners and pistons etc. are all covered with a layer of this oil.Then remount the intake and exhaust manifolds.

4.Remove sludge and dust from outer surfaces of the engine.Smear anti-rust oil on to exposed machined surfaces of parts of the engine.Rubber plastic components are prohibited to be smeared with oil.

5.Block the intake and exhaust manifolds with wooden plug,or wrap up them properly with plastic cloth in order to prevent any dust from getting in.

6.The engine so preserved should be stored in room of good ventilation and low humidity but without any dust.It is strictly forbidden to store the engine wherever there are chemicals.

The preservation according to the above procedure may be good for three months.Over this period,repeat this procedure.

SECTION VI TROUBLE SHOOTING

A.Failure to Start

Cause	Remedy
1.Low starting speed	
(1)Battery not fully charged or loose wiring connections	(1)Charged voltage should be more than 10V. Tighten the connections.Repair the connectors if necessary.
(2)Bad contact between the carbon brush and the commutator	(2)Repair or renew the carbon brush.
(3)Starting motor pinion fails to engage with ring gear of flywheel	(3)Turn the flywheel to another position.If necessary,check the mounting of starting motor and correct the unparallel center lines of starting motor and ring gear.
2.Faults in the fuel system	
(1)Fuel tank empty or cock in fuel supply line not open	(1)Fill and open.
(2)Air in the fuel pipe line,water in fuel,leakage in connections	(2)Vent the fuel pipe line,renew fuel and tighten connections.
(3)Blockage in fuel pipes	(3)Clean fuel pipe lines,renew fuel filter element. Clean inlet pipe of feed pump.
(4)Feed pump fails to supply fuel	(4)Check inlet pipe of feed pump for leakage. Repair feed pump.
(5)Injector doesn't work or insufficient fuel spary. Injection pressure too low and bad atomization. Spray holes choked.Adjusting spring of the injector broken.	(5)Repair the injector and test it on the test bench.Check injection pump for densified starting.
(6)Leakage in delivery valve of injection pump, spring broken.Pump element worn	(6)Lap,repair or renew.
3.Insufficient compression	
(1)Valve clearance incorrect	(1)Adjust as specified.
(2)Leakage in valves	(2)Lap them.
(3)Leakage in cylinder head gasket	(3)Renew the cylinder head gasket and tighten the cylinder head bolts.
(4)Piston rings worn	(4)Renew,clean,adjust.
4.Weather temperature too low	Pour hot water into cooling system.

B. Abnormal Lubricating Oil Pressure

Cause	Remedy
1.No oil pressure or pressure too low	
(1)Oil level too low.Oil deteriorated or too thin	(1)Refill or renew.
(2)Oil pipes broken.Leakage due to untightened connections.Damaged pressure gauge.	(2)Weld,tighten or renew.
(3)Adjusting spring of oil filter deformed,broken	(3)Renew.
(4)Excessive clearance of oil pump	(4)Repair or renew.
(5)Oil pump shims damaged	(5)Renew.
(6)Excessive fitting clearance of bearings	(6)Check,renew.
2.Oil pressure too high	
(1)Relief valve of oil pump or pressure adjusting valve of oil pump out of order,unsteady flow of oil	(1)Check and adjust it.
(2)Weather temperature too low.High viscosity of oil	(2)Use specified oil.Viscosity gets lower after warming up of engine.
3.No oil on rocker arm shaft	
(1)Blockage of oil passage of upper cylinder head and oil hole at the bottom of rocker arm shaft support	(1)Clean and make it through.
(2)Incorrect fitting of camshaft bushing	(2)Check and adjust it.

C. Smoke Exhaust

Cause	Remedy
1.Engine exhaust dense black smoke	
(1)Injector choked and needle valve stuck due to carbon deposits	(1)Check,repair or renew.
(2)Engine overloaded	(2)Reduce load.
(3)Injection timing too late,a portion of fuel burns in the process of exhaust	(3)Adjust injection timing.
(4)Incorrect valve clearance,bad sealing of valve	(4)Check valve clearance, valve sealing and valve spring and remedy the troubles.
(5)Fuel quantity delivered by each individual pump element uneven	(5)Adjust fuel quantity delivered by each individual pump element.
(6)Intake manifold and air filter choked,intake not smooth	(6)Remove and clean air filter
2.Engine exhausts white smoke	
(1)Low injection pressure,bad atomization,oil leakage	(1)Check,adjust,repair or renew the nozzle.
(2)Cooling water temperature too low	(2)Raise cooling water temperature.
(3)Water gets into cylinder liner	(3)Check cylinder head gasket.
3.Engine exhausts blue smoke	
(1)Oil get into combustion chamber due to excessive wear of piston rings or insufficient elasticity due to carbon deposits of piston rings	(1)Clean or renew piston rings.
(2)Oil level too high	(2)Drain excessive oil.
(3)Upside-down of the second taper ring	(3)The end with mark "L" upward.
(4)Fuel injection timing too small	(4)Increase the injection timing.

D. Insufficient Output

Cause	Remedy
1. Fuel filter or inlet pipe connection of feed pump and fuel screen clogged	1. Clean or renew.
2. Incorrect injection pressure or bad atomization of injector	2. Check the injector or renew nozzle.
3. Excessive wear of plunger couple of injection pump	3. Adjust the quantity of fuel delivered. Renew plunger element and delivery valve.
4. Low engine speed due to distorted and loose governor spring	4. Adjust high speed limiting screw and renew governor spring.
5. Air in fuel system	5. Vent fuel system.
6. Incorrect injection timing	6. Adjust it as specified.
7. Fuel quantity delivered by each individual pump element uneven	7. Adjust fuel quantity delivered.
8. Air filter choked	8. Clean or renew element.
9. Leakage of valve	9. Check valve clearance, elasticity of valve spring, wear of valve guide, sticking of valve and sealing of
10. Insufficient compression	10. Refer to A.3 in this section.
11. Incorrect valve timing	11. Excessive wear of cam. If necessary, renew camshaft.
12. Leakage of the holder of injector	12. Renew copper ring, clean surface of holder, evenly tighten the injector clamping plate.
13. Loose cylinder head bolts	13. Tighten them as specified tightening torque.

E. Unordinary Noise

Cause	Remedy
1. Injection timing too early. Engine detonates with a clear metallic knock	1. Readjust injection timing.
2. Suddenly clatter is heard due to fuel dribbling of nozzle and seized needle valve	2. Clean, repair or renew nozzle.
3. Engine runs with a clear knocking noise due to excessive valve clearance	3. Adjust valve clearance.
4. Engine runs with a heavy and rhythmical noise due to the striking of piston and valve (This may be felt by touching your hand on the cylinder head cover nut.)	4. Properly enlarge valve clearance, correct clearance of connecting rod bearing shell, or renew connecting rod bushing, connecting rod bearing shell, renew cylinder head gasket.
5. Engine runs with a heavy knocking noise due to the striking of piston against the bottom of cylinder	5. Renew cylinder head gasket.
6. Valve mechanism emits slight knocking noise due to broken valve spring, detored valve push rod, wear of valve tappet	6. Renew valve spring, push rod or tappet and adjust valve clearance.
7. Noise due to excessive clearance between piston and cylinder liner	7. If necessary, renew cylinder liner and piston pin.
8. When engine speed suddenly drops, a heavy and powerful noise is heard, because of excessive clearance of connecting rod bearing shell	8. Renew connecting rod bearing shell.
9. A slight and sharp noise is heard which is particularly clear at idle speed. This due to excessive clearance between connecting rod bushing and piston pin.	9. Renew connecting rod bushing or piston pin.
10. Noise from crankshaft pounding against the thrust during idle running of the engine due to worn thrust plate and excessive axial clearance	10. Renew crankshaft thrust plate.

F. Serious Vibration

Cause	Remedy
1. Uneven fuel quantity delivered by individual elements of injection pump. Bad atomization of injector. Serious leakage in cylinder. Too much compression differences of cylinders.	1. Check and adjust fuel quantity delivered by injection pump. Repair nozzle. Remedy leakage. Check and adjust compression of difference cylinders.
2. Water and air in fuel	2. Vent. Precipitate fuel. Renew.
3. Bad alignment of installation of engine. Loose foundation bolts	3. Correct installation. Tighten.
4. Knocking of piston and rough running of engine	4. Check injection timing. Load the engine after engine has been warmed up.

G. Overheating

Cause	Remedy
1. Fuel gets into crankcase or water in lubricating oil. Diluted or deteriorated oil. Insufficient or excessive oil. Low lubricating oil flow and low oil pressure. Fitting clearance of bearings too less.	1. Check and renew piston rings. Renew oil. Check level oil. Check cylinder head gasket. Check wear of inner and outer rotors. Check and adjust fitting clearance of bearings.
2. Water pump impeller damaged. Fan mounting incorrect. Thermostat out of order. Passage of cooling system blocked. Scale deposit in the water jacket too thick. Displacement of water pump insufficient. Insufficient water quantity. Cylinder head gasket damaged. Fuel gets into water passage.	2. Check and renew water pump impeller. Check tension of fan belt or renew. Check the mounting of radiator. Check thermostat. Clean cooling system and water jacket. Check clearance of water pump impeller. Refill water. Renew cylinder head gasket.

H. Excessive Lube Oil Consumption

Cause	Remedy
1. Viscosity of oil too low, its grade incorrect	1. Use oil as specified grade.
2. The wear of piston and cylinder liner too much. Return holes of piston ring groove choked.	2. Renew. Clean the return holes.
3. Piston rings stuck. Upside-down compression rings. Wear too much.	3. Clean, adjust or renew.
4. Leakage of front and rear oil seals of crankshaft and on the mounting surface of oil sump	4. Check and renew related parts.
5. Steam splashes due to high oil temperature and high pressure	5. Lower temperature. Check and adjust pressure-limiting valve of oil pump and pressure-regulating valve of oil filter.

I.Overspeeding

Cause	Remedy
1.Governor out of order,speed control lever seized in full speed position	1.Repair governor and speed control lever.
2.Sliding disk bushing of governor seized	2.Repair.
3.Adjusting arm gets out of fork	3.Repair.
4.Oil gets into cylinder too much	4.Remedy as mentioned above.

J.Engine Stalls

Cause	Remedy
1.Air in fuel pipes.Fuel feed pump doesn't work. Fuel filter element choked.	1.Vent.Repair fuel feed pump.Clean fuel filter.
2.Piston seized.Journals seized by bearing shell.	2.Incorrect fitting clearance,repair or renew.Oil interrupted or oil pressure too low.Check lubricating oil lines.
3.Fuel delivery valve of injection pump seized. Plunger spring broken,sliding drive disk bushing of governor seized.	3.Repair or renew.

K.Uneven Running

Cause	Remedy
1.Fuel quantity delivered to different cylinder uneven.Fuel dribbling of injector.Loose screw of speed control fork	1.Adjust fuel quantity delivered to different cylinder.Repair or renew nozzle.Tighten screw of speed control fork.
2.Clearance between fork and adjusting arm too much.Serious wear of steel ball and sliding drive disk results in depression on disk	2.Renew parts.
3.Axial clearance of camshaft of injection pump too much	3.Adjust with copper washer.
4.Sliding drive disk bushing stuck	4.Clean repair or renew.

L.Rising of Oil Level in the Sump

Cause	Remedy
1.Leakage on cylinder head gasket	1.Renew gasket.
2.Leakage in cylinder head or cylinder block	2.Repair or renew.



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