Publication No. GYH0617N

Operation and Maintenance Manual

Diesel Engine

AF3860 Series

CONTENTS

Chapter I Technical specification and data of diesel engine

I. Technical specification of main models of AF3860 series diesel engine

Table 1.1

Engine model	AF3860	AF3860	AF3860
Type	4-cylinder 4-stroke		
Air intake type	Natural	Turbocharged	Turbo&intercooling
Cooling mode	Water cooling		
Governor mode	Mechanical&electronic		
Bore x Stroke(mm)	102 x 118		
Compression ratio	17:1		
Rated speed(rpm)	1500		
Dis placement(L)	3.86		
Rated power(without fan)(KW)	33	37	48
Standby power(without fan)(KW)	36	41	53
Fuel consumption(g/KWh)	230	220	215
Oil consumption(L/h)	0.06	0.05	0.05
Steady state speed regulation(%)	≤5	≤5	≤5
Oil capacity including filter(L)	12.5	13	13
Emission compliant	Stage II		
The flywheel shell interface	SAE3		
	Flywheel for 11.5"flexible coupling		
Dryweight base(kg)	350	380	380
Dryweight of Gen Pac(kg)	375	405	410
Overall dimension(base)(mm)	810X680X800	810X700X850	
Overall dimension(G.P)(mm)	1155X680X835		1480X705X900
Fan consumption(KW)	2	2.5	3
27℃ air consumption(m^3/min)	2.6	3.2	3.9
Heat rejection of exhaust(KW)	34.5	36.4	43.5
Exhaust gas temperature after turbine(℃)	580	480	480
Exhaust gas flow(m^3/min)	8.3	8.4	10.4
Heat rejection from engine(KW)	2	2.6	3.3
Heat rejection of coolant(KW)	21.5	24.1	29
Base configuration	Standard configuration(add on the base)		
Engine with fan	Intake and exhaust system:Air filter and connecting pipes; Connecting flang of exhaust pipe		
Alternator 500W 14V Starter motor 3.5KW 12V	Cooling system:Radiator with connecting pipes;Fan guard; Belt guard		

Table 1.1 continued

Engine model	AF3860	AF3860	AF3860
Type	4-cylinder 4-stroke		
Air intake type	Natural	Turbocharged	Turbo&intercooling
Cooling mode	Water cooling		
Governor mode	Mechanical&electronic		
Bore x Stroke(mm)	102 x 118		
Compression ratio	17:1		
Rated speed(rpm)	1800		
Dis placement(L)	3.86		
Rated power(without fan)(KW)	39	45	60
Standby power(without fan)(KW)	43	50	66
Fuel consumption(g/KWh)	230	220	215
Oil consumption(L/h)	0.06	0.05	0.05
Steady state speed regulation(%)	≤5 or ≤3		
Oil capacity including filter(L)	12.5	13	13
Emission compliant	Stage II		
The flywheel shell interface	SAE3		
	Flywheel for 11.5"flexible coupling		
Dryweight base(kg)	350	380	380
Dryweight of Gen Pac(kg)	375	405	410
Overall dimension(base)(mm)	810X680X800	810X700X850	
Overall dimension(G.P)(mm)	1155X670X835		1480X705X900
Fan consumption(KW)	2.2	2.5	3
27℃ air consumption(m^3/min)	3.1	3.5	4.5
Heat rejection of exhaust(KW)	40	38	47
Exhaust gas temperature after turbine(℃)	580	500	500
Exhaust gas flow(m^3/min)	10.1	10.5	13
Heat rejection from engine(KW)	6.4	7	9.2
Heat rejection of coolant(KW)	29	28	36
Base configuration	Standard configuration(add on the base)		
Engine with fan	Intake and exhaust system:Air filter and connecting pipes; Connecting flang of exhaust pipe		
Alternator 500W 14V Starter motor 3.5KW 12V	Cooling system:Radiator with connecting pipes;Fan guard; Belt guard		

II. Fit clearance of main parts of diesel engine

Unit: mm

Series No.	Fit part		Dimension on drawing	Fit type	Fit clearance interference
1	Exhaust valve seat hole / Exhaust valve set	Naturally aspirated turbocharging	$\Phi39^{+0.025}_{0}$ /$\Phi39^{+0.073}_{+0.048}$	Interference	0.023~0.073
		Turbocharged & intercooled	$\Phi40^{+0.025}_{0}$ /$\Phi40^{+0.073}_{+0.048}$		
2	Intake valve seat / intake seat	Naturally aspirated turbocharging	$\Phi47^{+0.025}_{0}$ /$\Phi47^{+0.079}_{+0.054}$	Interference	0.029~0.079
		Turbocharged & intercooled	$\Phi46^{+0.025}_{0}$ /$\Phi46^{+0.079}_{+0.054}$		
3	Cylinder cover guide hole / Valve guide		$\Phi14^{+0.018}_{0}$ /$\Phi14^{+0.039}_{+0.028}$	Interference	0.010~0.039
4	Valve guide hole / Exhaust valve		$\Phi9^{+0.022}_{0}$ /$\Phi9^{-0.04}_{-0.062}$	Radial clearance	0.040~0.084
5	Valve guide hole / Intake valve		$\Phi9^{+0.022}_{0}$ /$\Phi9^{-0.025}_{-0.047}$	Radial clearance	0.025~0.069
6	Valve sinking depth		Intake 0.9±0.15 Exhaust 0.9±0.15		
7	Front valve rockshaft seat hole/ Valve rockshaft		$\Phi20^{+0.010}_{-0.010}$ /$\Phi20^{0}_{-0.020}$	Transition	-0.01~0.03
8	Rear and middle valve rockshaft seat hole/ Valve rockshaft		$\Phi20^{+0.028}_{+0.007}$ /$\Phi20^{0}_{-0.020}$	Radial clearance	0.007~0.048
9	Cylinder liner / Piston skirt section	4DX1 series	$\Phi100^{+0.06}_{+0.02}$ /$\Phi100^{-0.07}_{-0.11}$	Radial clearance	0.09~0.17
		4DX2 series	$\Phi102^{+0.06}_{+0.02}$ /$\Phi102^{-0.07}_{-0.11}$		
10	Valve tappet hole / Valve tappet		$\Phi28^{+0.021}_{0}$ /$\Phi28^{-0.04}_{-0.061}$	Radial clearance	0.040~0.082
11	Cam bearing hole / Camshaft journal		$\Phi60^{+0.03}_{0}$ /$\Phi60^{+0.106}_{+0.087}$	Interference	0.057~0.106
12	Camshaft bush hole / Camshaft journal		$\Phi56^{+0.03}_{0}$ /$\Phi56^{-0.03}_{-0.06}$	Radial clearance	0.03~0.09
13	Timing idle gear bush hole / Idle gear shaft		$\Phi45^{+0.025}_{0}$ /$\Phi45^{-0.025}_{-0.050}$	Radial clearance	0.025~0.075
14	Timing idle gear / Idle gear shaft		$26^{-0.065}_{-0.117}$ /$26^{+0.052}_{0}$	Axial clearance	0.065~0.169

Series No.	Fit part	Dimension on drawing		Fit type	Fit clearance interference
15	Piston ring groove / First gas ring	Naturally aspirated and supercharged	$3^{+0.10}_{+0.08}/3^{0}_{-0.015}$	Clearance	0.08~0.115
		Turbocharged and intercooled	Single ring groove / Single gas rng		
16	Piston ring groove / Second gas ring	Naturally aspirated and supercharged	$2.5^{-0.07}_{-0.05}/2.5^{0}_{-0.02}$	Clearance	0.05~0.09
		Turbocharged and intercooled	$2.5^{-0.07}_{-0.05}/2.5^{0}_{-0.02}$		0.05~0.09
17	Piston ring groove / Oil ring	Naturally aspirated and supercharged	$5^{-0.05}_{-0.03}/5^{0}_{-0.02}$	Clearance	0.03~0.07
		Turbocharged and intercooled	$4^{-0.05}_{-0.03}/4^{0}_{-0.015}$		0.03~0.065
18	Open clearance when piston ring pressed into the corresponding gauge	First ring		Clearance	0.2~0.4
		Second ring			0.45~0.65
		Third ring			0.25~0.45
19	Connecting rod bearing bush hole / Connecting rod journal	$\Phi64^{-0.019}_{-0.01}/\Phi64^{-0.06}_{-0.079}$		Radial Clearance	0.05~0.098
20	Rod bushing bore / Piston pin	$\Phi35^{+0.03}_{+0.015}/\Phi35^{0}_{-0.009}$		Radial clearance	0.015~0.039
21	Piston pin seat hole / Piston pin	$\Phi35^{+0.010}_{-0.003}/\Phi35^{0}_{-0.005}$		Radial clearance	0.003~0.015
22	Main bearing bush hole / Main journal	$\Phi80^{+0.022}_{-0.01}/\Phi80^{-0.065}_{-0.084}$		Radial clearance	0.055~0.106
23	Crankshaft thrust surface / Crankshaft thrust washer	$2.5^{+0.206}_{+0.09}/2.5^{-0.025}_{-0.050}$		Axial clearance	0.115~0.256
24	Camshaft thrust surface / Camshaft thrust plate	$5^{+0.078}_{+0.030}/5^{-0.03}_{-0.06}$		Axial clearance	0.06~0.138
25	Flank clearance between crankshaft gear and idler gear			Flank clearance	0.10～0.18
26	Flank clearance between idler gear and camshaft			Flank clearance	0.12～0.21
27	Flank clearance between idler gear and injection pump			Flank clearance	0.12~0.21
28	Clearance between intake valve and rocker (cold)			Clearance	0.4±0.05
29	Clearance between exhaust valve and rocker (cold)			Clearance	0.4±0.05
30	Compression clearance			Clearance	0.9~1.1

III. Tightening torque of main thread connections of diesel engine

Series No.	Thread specification	Name	Tightening torque N·m
1	M12×1.5	Cylinder head bolts	108~118
2	M12×1.5	Connecting rod bolts	118~127
3	M14×1.5	Flywheel bolts	186~206
4	M16×1.5	Main bearing bolts	216~235
5	M8	Rear oil seal seat bolts	25~41
6	M8	Fixed bolts of injection pump transition plate	25~41
7	M8×1	Clamp nuts of injector	50~70
8	M8	Fixed bolts of rocker shaft seat	25~41
9	M10×1.25	Piston cooling nozzle	45~55
10	M14×1.5	Fastening bolts of camshaft gear	110~120
11	M8	Oil sump bolts	25~41
12	M27×1.5	Pressure maintaining valve of main oil passage	60~70
13	M27×1.5	Clamp nuts of shock absorber	392~441

Remarks:

1. The above fastening bolts should be tightened with torque wrench. If the kg torque wrench is used, please converse it with formula of 1kgf • m = 9.8N • m.

2. The main bolts listed in the column of Series No. of 1-4 should be evenly tightened to the specified value two or three times according to tightening procedure.

3. The main bolts should be coated with a little engine oil before installation.

Chapter II Usage and operation of diesel engine

I. Diesel, lubricating oil and cooling water

(1) Diesel

Choose the corresponding brand light diesel oil based on the different ambient temperature (GB/T252).

Ambient temperature	Above 0℃	0℃~ -10℃	-10℃~ -20℃	-20℃~ -35℃
Diesel grade	No. 0	No. -10	No. -20	No. -35

Note:
Keep the diesel high clean. Before filling into the fuel tank of diesel engine, place the diesel statically for more than three days and nights, to allow the dust or moisture in the diesel sediment at the bottom for the use of clean diesel of upper layer.

(2) Lubricating oil

Choose the correspond brand L- ECD or L- ECF engine oil according to ambient temperature for diesel engine (GB/T11122).

Area	Cold winter area	Full year for general area	Summer at southern area
Lubricating oil grade	5W/30	30 or 15W/30	30 or 40

The proper choice of engine oil has a larger effect to the normal operation, life and emission improvement of diesel engine, with high-grade oil required for supercharged and supercharged & intercooled diesel engine, so the special attention should be given by the user. In addition, the lubricating oil must be clean, to avoid the mixture of different grades of oil.

(3) Cooling water

The diesel engine should adopt the clean soft water: such as tap water, rainwater, and river water. If the well water or spring water etc. hard water is used, add 2g trisodium phosphate into a liter of water to soften before application. Otherwise, the scale may be generated quickly in the waterways of diesel engine to block water flow, causing the poor engine cooling.

If the atmospheric temperature is below zero, in order to prevent freezing, the antifreeze should be added into the cooling water.

Solution volume ratio %		Freezing point of solution ℃	
Water	Alcohol	Add denatured alcohol	Add water alcohol
90	10	-3	-5
80	20	-7	-12
70	30	-12	-19
60	40	-19	-29
50	50	-28	-50

When adding the antifreeze, pay attention to the following items:

(1) The antifreeze is toxic, with entering into mouth forbidden.

(2) If the diesel engine warms up, the antifreeze temperature can not exceed 80 , to avoid alcohol evaporate.℃

(3) The antifreezes with different ingredient or brands can not be mixed.

(4)To avoid spalling the cooling water tank, the filling volume of antifreeze should be less 6g than the original water, because the expansion coefficient of heated antifreeze is larger.

II. Preparation before startup

(1) Check that the oil level of sump should be between the upper and lower limits of vernier, with the oil volume of sump of about 12L.

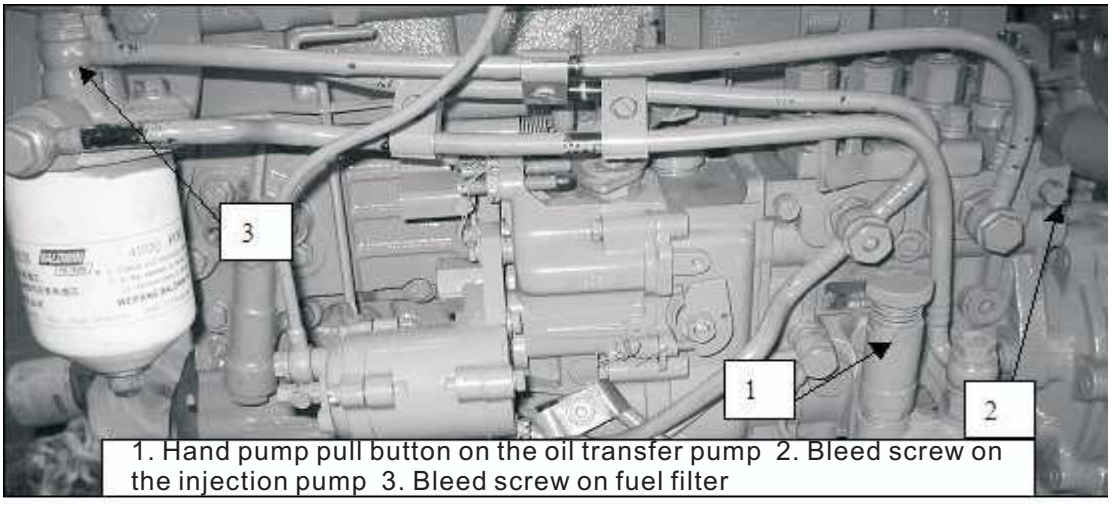
(2) Check the oil volume in the fuel tank.

(3) Open the fuel tank switch to allow the diesel flow to injection pump.

(4) Drain the air in the fuel system for new machine. (See Fig. 2-1)

(5) Check the cooling system and add the water if necessary.

(6) In case of cold freezing weather, place the diesel engine in antifreeze and cold defend site. When working in outer field, first preheat the oil sump and add the hot water two or three times to warm up the diesel engine before startup.



1. Hand pump pull button on the oil transfer pump 2. Bleed screw on the injection pump 3. Bleed screw on fuel filter

Fig. 2-1 Air drainage

III. Startup

Only after the preparation before startup is complete successfully, the engine can start. The clutch should be disengaged before startup, with startup step as follows:

(1) Turn the locking switch to start the diesel engine. The starting time can not exceed 15s each time, to prevent the starter and batteries. If the engine fails to start, wait 60s before restart. If three continuous startups fail, find out the cause before restart. After the engine starts, release the start button immediately and turn the locking switch to the original position.

(2) Check the oil pressure immediately after startup

When the diesel engine runs at idle speed, the oil pressure can not below 98 KPa. After the newly assembled diesel engine starts up for five minutes, check the oil level of sump and add the oil if necessary, allowing the level between upper and lower marks of oil scale.

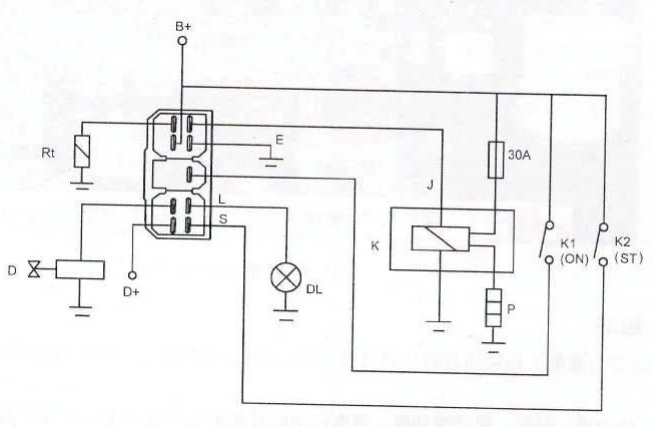
1. Low-temperature startup

Generally, our diesel engine can be successfully started under temperature of above -5 ℃ without taking any preheating measure. However, the engine is difficult to start at winter due to low temperature. Therefore, according to the matching requirement of car, we will choose one of following intake preheating devices as the intake heating measure to successfully start at winter.

① Air heater

The air heater uses the resistor disc to heat the air into the cylinder, to successfully start the engine under -5 ℃~ -10 at winter. This heater is a resistance wire, with consumption power of 1kw. Before startup, the continuous ℃heating time of about 40s is allowed (the resistance wire may be easily burn if the heating time is too long). If the preheat button is pressed, the indicator lamp is on and the air heater is powered. After heating about 40s (not exceed 50s), the air heater has been heated above 1000 . Turn off the preheat button and quickly press the ℃start button to power on the starter power, the diesel engine can start successfully;

② Flame preheating device with control unit



External wiring diagram of preheat controller

K1: Ignition switch ON

K2: Ignition switch ST

P: Preheat plug

DL: Preheat indicator lamp

D: Oil supply solenoid valve

D+: Connect with D+ end of generator

K: Preheat relay

Rt: Preheat temperature sensor

The flame preheating device with control unit is a low-temperature start device that can directly inject the burn flame of diesel into the intake pipe to greatly increase the intake air temperature, ensuing that the diesel engine can start successfully under -5 ℃~ −25 cold condition. ℃The rated voltage of solenoid valve of flame preheating device is 24V and the rated current is no more than 1.1A. The rated voltage of preheat plug is 24V and the working current is 24A, and the continuous current is 10A.

Before starting the engine, first insert the key and turn it to the ON position. The indicator lamp will be off after preheating, to inform driver. Afterwards, press the start button (to ST position) to start the engine. When the engine is at the stable running state, the driver turns the key switch to the position before startup (ON position) to shut off the flame preheating device.

Precaution of use of flame preheating device with control unit:

1. With the decreasing of air temperature, first check that your fuel and lubricant meet the requirement of low-temperature oil specified in this manual. However, the corresponding low-temperature batteries should be adopted. (The discharge capacity of general batteries will drop substantially at low temperature, so as not to normally start the engine).

2. Press the start button not exceeding 30s as much as possible. If no fire within 30s, this time may be extended, but not more than 45s, so as not to damage the starter. If the speed is very low, stop the starting operation immediately to check whether the oil viscosity is too thick, whether the batteries voltage is normal and remove the starter to check whether the speed is too low after power on and whether the meshing travel is normal.

3. If the diesel engine does not work within 3s of pressing the start button after the completion of preheating procedure and then the start button releases, this device will continuous to work through re-pressing the startup button within 5.5s at low-temperature state.

4. If the engine can not start successfully or the start button can not be pressed after the preheating indicator lamp is off for 30s, the flame preheating device will automatically stop. At this time, the original start procedure will begin after two minutes.

5. After the engine starts successfully at cold state, the engine speed should be limited to 800 ~ 1000r/min for several minutes until the indicator lamp is off before normal operation.

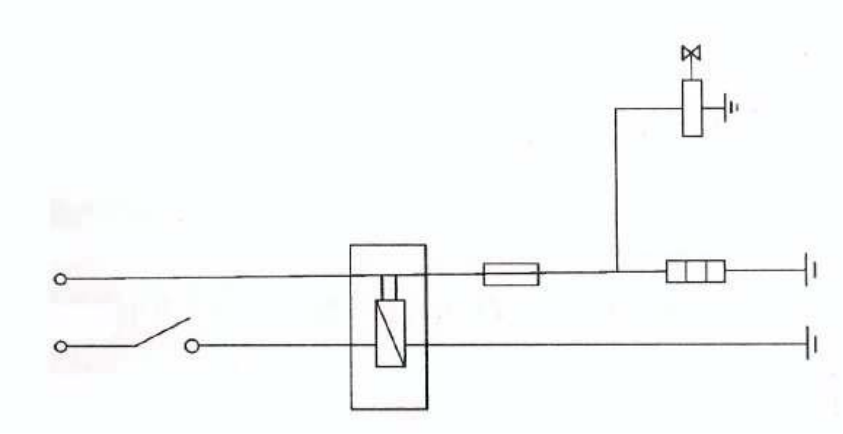
6. If the flame preheating controller works but the indicator lamp is off in case the water temperature exceeds 0℃, there indicates that the flame heater can not be adopted at this time and that the user can directly start the diesel engine.

③ Flame preheating device without control unit

1. Composition of flame preheating device without control unit

The flame preheating device without control unit is a low-temperature start device that directly inject the burn diesel flame into the intake pipe to greatly increase the intake temperature, ensuing that the diesel engine can successfully start under -5℃~ -25℃ cold condition. The rated voltage of flame preheating device is 24V; the rated voltage of preheating plug is 24V and the rated current is no more than 8A. The flame preheating device consists of flame preheating plug, solenoid valve and corresponding pipes, as shown below.

2. Wiring diagram of flame preheating device without control unit



3. Use precaution of flame preheating device without control unit

1) The contact switch is adopted as preheating switch, to avoid burning the preheating device if the power can not turn off after startup.

2) Before turning on the starter power, first power the flame preheating device for 15s before starting the starter.

3) The longest working time of flame preheating device is 5min.

IV. Operation

(1) After the diesel engine starts, it can not run at full load state immediately and should run at low and middle speeds in turn for preheating without load.

(2) In operation, often pay attention to the oil pressure and cooling water temperature. For speed calibration, the oil pressure should not be less than 300 KPa and the cooling water outlet temperature should be within 95.℃

(3) Often check whether there is abnormal sound when operation, and stop the engine immediately for troubleshooting.

(4) Often check all oil passage and waterway connections for sealing situation and eliminate it if leakage.

(5) The new or overhauled diesel engine running at full speed with full load is allowed only after 50 running hours with low load (or 2000 KM).

V. Parking

(1)The engine can stop after the load is released and 5 minutes at low speed or idle speed. Especially for the turbocharged diesel engine, it can stop only after the ultra-high-speed of supercharger increases.

(2) At the temperature of below 5, if the antifreeze is not used, the cooling water should be drained out after ℃parking (see Fig. 2-2), to avoid cracking the body.

(3) After each parking, eliminate the fault found during operation in timely way, with necessary check done. The regular inspection and maintenance of diesel engine or the timely elimination of some slight fault is a necessary condition to keep the diesel engine at normal state and to avoid serious fault and to obtain the good economic benefit.

(4) If parking for a long time, do the cleaning work and assemble the necessary oil seals to prevent rust.

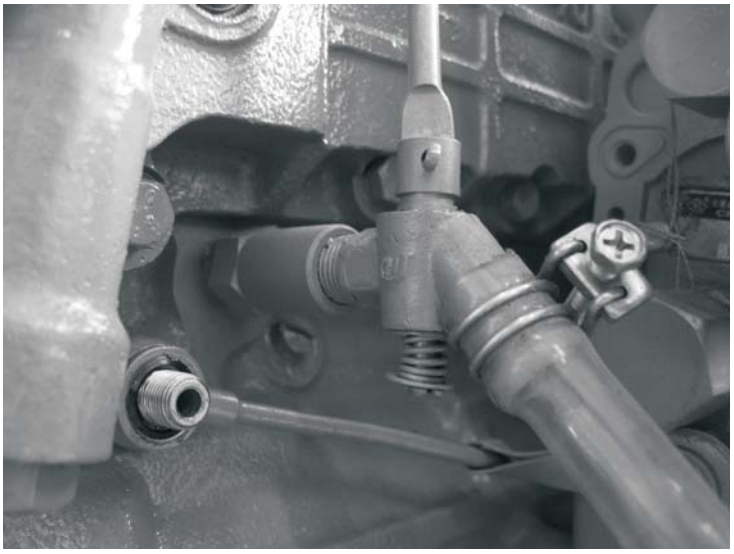


Fig. 2-2 Water drain valve

Chapter III Maintenance and adjustment requirement of diesel engine

Proper maintenance of diesel engine has a decisive influence to ensure the better performance and service life of diesel engine and also is a necessary condition to ensure the long-term reliable operation and use economy of diesel engine. Therefore, the engine should be maintained by user strictly in accordance with the technical requirement specified in this manual in daily operation.

I. New machine running-in and technical maintenance

There are the new machine running-in technical maintenance and the technical maintenance (generally referred as three-level maintenance) after formal operation, with maintenance items shown as Tables 3-1 and 3-2.

The new machine running –in purpose is to achieve the better fit state after the 2000km of trial run of the friction pairs of all moving parts of diesel engine at low and middle speed with low or middle load. The diesel engine that is maintained according to the requirement in Table 3-1 can be put into formal operation after running-in.

Table 3-1 Technical maintenance items after running-in

Interval	Series No.	Maintenance content
After running-in (2000km or 50h)	1	Drain the oil in sump or injection pump and carefully clean the oil sump, and replace it with lubricating oil if necessary.
	2	Clean the oil collector filter
	3	Check the main bearing bolts for tightening torque
	4	Check the connecting rod bolts for tightening torque
	5	Check the cylinder head bolts for tightening torque
	6	Check the valve clearance and adjust it if necessary
	7	Replace diesel filter and oil filter and remove the dust from air filter
	8	Check oil supply advance angle
	9	Check fan belt for tightness
	10	Check whether the suspension cushion is cracked and whether the nuts are loose.

The daily and three-level technical maintenance should be done for diesel engine based on the schedule specified in following table after formal operation.

Table 3-2 Technical maintenance items

Interval	Series No.	Maintenance content
Daily maintenance	1	Check the oil level in sump and cooling water volume in water tank
	2	Check all connections of water, oil and gas passages of diesel engine for tightness
	3	Clean
	4	Eliminate the found fault and abnormal phenomenon
First-level maintenance (2500km or 50h)	1~4	Same with daily maintenance
	5	Check fan belt for tightness
	6	Remove dust from air filter
	7	Check all pipe connections of supercharged and intercooled filter
Two-level maintenance (10000km or 200h)	1~7	Same with first-level maintenance
	8	Clean the oil sump and oil collector and replace the oil in the sump and injection pump
	9	Replace diesel filter elements
	10	Replace diesel filter elements
	11	Clean the diesel tank, oil transfer pump filter and diesel pipes
	12	Check the valve clearance and adjust it if necessary
	13	Check the oil supply advance angle and adjust it if necessary
	14	Check the injection pump for injection pressure and atomization quality of
Three-level maintenance (50000km or 1000h)	1~14	Same with two-level maintenance
	15	Clean oil cooler
	16	Check the cylinder head bolts, connecting rod bolts and main bearing bolts for tightness
	17	Whether the cylinder head is removed to grind the valve is determined by the operation situation
	18	Whether the injection pump is delivered to special repair unit to check or adjust based on the operation situation.
	19	Remove the carbon deposit from the supercharger compressor, turbine rotor blades or shell
Remarks	Here we emphasize to the user: the air filter, diesel filter and oil filter is very important to the service life of diesel engine, with filter elements adopted from original manufacturer for quality assurance.	

II. Maintenance requirements

1. Check oil level of sump of diesel engine

To check the oil level, the diesel engine should keep at level state as much as possible. Check that the oil level is between the upper and lower lines of oil scale.

2. Maintenance of air filter

The careful and timely maintenance is very important to the service lives of cylinder liner, piston, piston ring and valves of diesel engine because of the prevention of dust into cylinder. The maintenance period of air filter should be determined according to the dust containing situation in the working environment. The maintenance period should be short in the adverse environment and dusty areas, and vice versa. The air filter is equipped with the clogging indicator. The air filter should be maintained if the inductive indicator cab signal light is on. For the filter equipped with mechanical clogging indicator, open the vehicle cover to pull the throttle until the vehicle runs at high speed without load after parking. The filter should be maintained if the indicator is at the red position.

At present, there are primary filter element and safety filter element for the common paper secondary air filter. For maintaining the air filter, first unscrew the nuts of cover to open the filter cover and then take out the filter element to remove the dust in the shell. Rotate the filter element while slightly knocking both sides of filter element with hands or wooden rod to remove the dust. Carefully blow the filter element from inside with the clean compressed air with pressure of not more than 600kPa to remove the dust. At the same time, check the safety filter element (small element in the primary filter element) for dust. If any, maintenance is done same with the above procedure.

Generally, the primary filter element should be replaced after six times of maintenance as well as safety element. The safety element can not be maintained together with the primary filter element. If found there is dust on the safety element, there indicates that eh primary filer element has been damaged and then replaced.

3. Check tightness of fan belt

The fan belt should be often checked for tightness. If too tighten, the pump bearings or generator bearings will damage early; if too loose, the belt will slip or heat to reduce the belt life.

4. Maintenance to diesel filter

The diesel filter adopts the disposable spin-on filter element that can not be removed for washing, to filter out the impurities, ensuring the clean diesel entering into the injection pump and injector for normal and durable operation. However, the filter should be replaced after the car is traveling for about 10000 km.

Due to all kinds of impurities may accumulate in the car oil tank, on the oil transfer pump filter screen or in the diesel pipes, to keep the diesel clean, the filter should be cleaned after 10000 km according to maintenance specification.

5. Check and adjust the valve clearance

The correct valve clearance is important for the normal performance of diesel engine and the reliable operation of valve mechanism. Therefore, properly check the valve clearance and adjust it if necessary. Valve clearance check and adjustment method as follows:

After confirming the first cylinder at compression top dead center point, first adjust the valve clearance of first cylinder, and then adjust others according to the 1-3-4-2 firing order. However, the valve clearance should be adjusted with filler gauge according to Clause 1.2 (see Fig. 3-1). Recheck all adjusted clearance and then start the diesel engine, and observe and feel the valve clearance for proper adjustment at idle state.

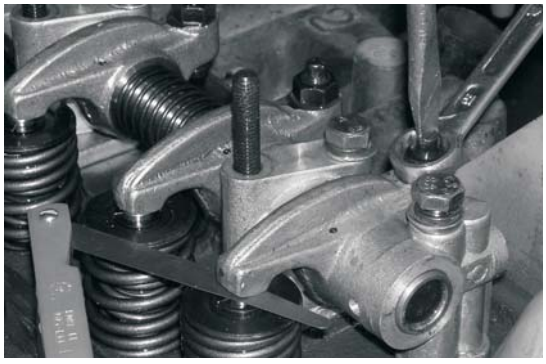


Fig. 3-1 Valve clearance adjustment

6. Replace diesel

The engine oil may be continuously aged and deteriorated under high temperature during the operation of diesel engine and contaminated by the metal impurities generated in operation, so the regular replacement of oil is very important to extend the service life of diesel engine. In cold region, the replacement mileage of diesel should be shortened. For example, he replacement mileage under the temperature of below -10 should be ℃changed to 5000km.

The engine oil should be replaced at hot state, because the hot oil is easier to take away the impurities in the oil. Add the new oil only after the drain plug (with new washer preferable) is tightened.

7. Injection pump assemble and oil supply advance angle adjustment

（1) Injection pump assemble

Place the crankshaft of diesel engine at the position of 30 ° before the compression top dead center of first cylinder (near the fan end), as shown in Fig. 3-3. Turn the injection pump drive gear clockwise (view from pump drive end) until the oil is supplied from the first cylinder (feel resistance) and then release the hands to make the camshaft of injection pump at free state (the camshaft may reverse a certain angle, with the scale mark on the drive gear aligning with the white triangular mark on the locating flange of transition disc of injection pump, as shown the right side of Fig. 3-3. If the marks are not aligned, turn the gear for alignment). At this time, assemble the injection pump in the notch of injection pump in the gear chamber of diesel engine and tighten the flange bolts. If you can see that the scale mark on the driven disc of advancer of injection pump aligns with the inspection hole mark from the inspection hole on the gear chamber cover after the crankshaft turns at the compression TDC position of first cylinder (see Fig. 3-2), there indicates the proper installation.

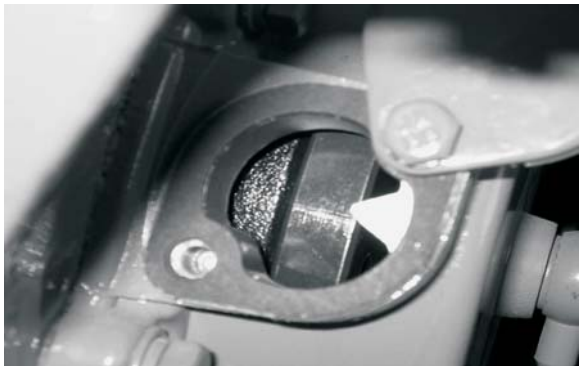


Fig. 3-2 Inspection hole on gear chamber cover

（2) Adjustment of oil supply advance angle of injection pump

The adjustment of oil supply advance angle has a larger influence to the performance, reliability and emission of diesel engine.

Turn the crankshaft clockwise (view from flywheel) to the position of 40° before compression TDC of first cylinder and then counterclockwise rotate it until the oil level of oil drain valve seat of first cylinder of injection pump fluctuates. At this time, the scale of torsional vibration damper pointed by the pointer on the gear chamber cover is the oil supply advance angle (see Fig. 3-3). If the adjustment is needed, loosen the four bolts connecting the injection pump and transition disc (see Fig. 3-4) and turn the pump body to make the pump outlet nozzle near the diesel engine, so the advance angle will increase; and vice versa the oil supply advance angle will decrease if the pump outlet nozzle leaves the diesel engine. Tighten four bolts firmly after adjusting the advance angle. Finally, tighten the locking nuts of oil pump bracket to recheck the oil supply advance angle. The oil supply advance angles of all models of engines should be adjusted according to the data specified in Table 1-2 of Chapter 1.

Fig. 3-3 Scale on torsional vibration damper

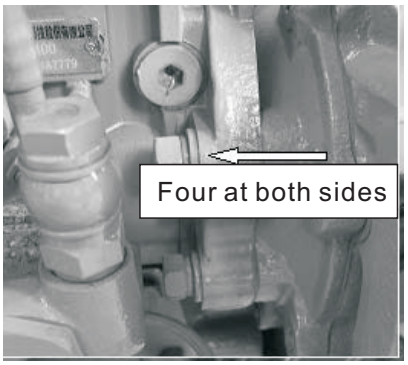


Fig. 3-4 Connection between injection pump and transition disc

8. Check injection pressure and atomizing quality of injector

The injection pressure and atomizing quality of injector should be done on the special test bench. If pumping oil at 30 times per minute, the injector atomization should be even; the oil cut-off should be thorough, with special clear sound heard.

The adjusting pressure of S-type injector is 18.65~ 19.55 MPa. If the pressure is too high or too low, the oil pressure adjusting bolts should be loose or tightened to achieve the specified value. The oil injection adjusting pressure of P-type injector is 24~ 25.4 MPa., which is different with the S-type, with the shims of different thickness adopted for adjustment. The thickness of this shim is from 1.0mm to 2.0mm. There is a type every 0.1mm. The injector manufacturer generally adopts the shim with thickness of 1.7~1.9mm.

Carefully clean the injector couplings and all parts at P nozzle when assembly, without any scratch or impurities on all sealing surfaces. Furthermore, the needle valve couplings that tilt 45° angle can freely slip into the needle valve.

The tightening torque of P-type injector is 40-50 N•m and of S-type injector is 60-80 N•m. Too tightening may cause the needle valve deform, resulting in the coupling needle valve block. To prevent the difficult disassembly due to dirt accumulation, the injector should be equipped with the dirt-proof shield after being inserted into the cylinder head. The tightening torque of injector nuts is 60 ± 10 N•m, with too much not allowed.

9. Maintenance to pressurizing system

No any air leakage at the connections between the supercharger and exhaust pipe and between the supercharger and intake and exhaust pipes of intercooler. If the air leaks between the exhaust pipe and supercharger, the supercharger efficiency will greatly reduced and the diesel engine exhaust temperature will sharply rise, which is extremely unfavorable to the normal operation of diesel engine; if the air leaks between the intake and exhaust pipes of intercooler and the intake pipe of diesel engine, the intake pressure will decrease, the engine performance will reduce and the exhaust temperature will rise.

If there is air leakage in the exhaust pipe, the running sound of diesel engine will abnormal and the carbon deposition occurs at the leakage place, so the user can eliminate the fault according to these phenomenon. Due to the internal pressures of all intake pipes when the supercharged or supercharged and intercooled diesel engine is running are higher than external air pressure, the user can coat the self-made soapy water on the pipe connection places for tightness. However, the same method is taken for the intercooler that may damage due to long-term operation.

Before starting the new machine, dismantle the oil intake pipe of supercharger to fill the clean oil into the fuel feed hole, to lubricate the supercharger bearings with the startup of engine

Before parking, run the diesel engine for 3-5 minutes at idle speed, to reduce the supercharger speed, to decrease the temperature and to check the supercharger running sound. If found the abnormal situation, stop the machine to check. For example, the supercharger that can not freely rotate or there is wearing sound must be sent to the qualified repair station.

After 500 working hours or 30000 km, check whether the clearance of supercharger rotor shaft meets the requirement and remove the oil dirty or carbon deposition from the compressor, turbine rotor and shell. At this time, the supercharger should be removed from the diesel engine, with the removal of sediment with gasoline or other cleaning liquid that can not rust the parts rather than mechanical method, because this may cause the blade and rotor deform. Note not make the rotating parts of supercharger damage or deform, as well as the rubber sealing parts. The sealing gasket between the supercharger and exhaust pipe should be replaced when re-assembly.

The supercharger is equipped with bypass valve that opens or closes based on the pressure of compressor. If the pressure exceeds the specified value, the bypass valve should open with the regulator rod, to directly drain waste gas from most cylinders into the muffler, which not only improve the diesel performance at low speed but also prevent the savage operation and the oil consumption rise.

The supercharger regulator equipped with bypass valve has been strictly adjusted in factory, so the user can not adjust and dismantle it without permission, and not lift the supercharger with regular rod or make the bypass valve regular deform.

Chapter IV Main structure and assembly precaution of diesel engine

I. Instruction to structures of diesel engine

1. Description of main structures of diesel engine

Cylinder block: In order to strengthen the rigidity of the cylinder block, and to reduce vibration or noise, the cylinder block skirt should be designed into barrel shape and the vertical and transverse ribs should be arranged at both sides of block. The cylinder liner adopts the thin-wall dry liner and the naturally aspirated machine is made of boron cast iron and the supercharger and supercharged and intercooled machine is made of boron-copper cast iron. The cylinder linear should be removed with the special tool for replacement. Furthermore, the new cylinder linear and block should be clean, dry and free of oil when assembly.

Cylinder head: Under the premise of ensuring the structural strength, the intake and exhaust sides of cylinder head should adopt the single-layer plate structure, thus reducing the machine weight; the triangular space of bottom plate of cylinder head adopt the thin layer, which effectively reduce the heat load; to optimize the performance, the different intake and exhaust valves, injector and intake and exhaust pipes should be selected for the corresponding type of engine. For this, the different marks are casted on the top of cylinder head, such as A01, A41 (naturally aspirated), A02 and A42 (supercharged) and A04 and A44 (supercharged and intercooled), so the user should pay attention to this when purchasing the spare parts.

Piston: The combustion chamber is of necking ω type. To optimize the performance and to reduce the emission, the pistons used for naturally aspirated, supercharged and supercharged & intercooled engine are not universal due to different combustion chamber. Furthermore, the heat load is larger for the supercharged & intercooled engine, so the first gas ring groove of piston adopts the groove embedded with steel ring.

Crankshaft: The ductile iron crankshaft is used for naturally aspirated engine, and the forged steel crankshaft is for supercharged and intercooled engine, with the surface nitriding treatment and the fillet rolling process adopted, thus improving the fatigue strength of the crankshaft. However, the eight pieces of balance blocks are adopted to reduce the vibration. The main journey adopts the double oil hole, so there is an oil groove on the upper main bearing bush rather than the lower main bearing bush. This may greatly improve the bearing capacity of main bearing bush. However, the lower main bush should be replaced by the grooved one if the single oil hole crankshaft is replaced by the user, or the bush sticking accident may occur. Therefore, the attention should be given for this. Furthermore, the main bearing bush and connecting rod bush of naturally aspirated engine is made of high tin aluminum alloy; the main bushing bushes of supercharged and supercharged & intercooled engines are made of moderate tin aluminum alloy and the connecting rod bush is made of copper-lead alloy.

Camshaft: The cam profile is optimally designed, thus improving the overall performance.

Injector: The naturally aspirated and supercharged models use the S-type injector, with the spray hole of 5 × φ0.28mm and with the opening pressure of 18.65 ~ 19.55Mpa. The supercharged & intercooled model adopts the P-type injector, with the spray hole of 5×φ0.26mm and with the opening pressure of 24 ~ 25.4 Mpa.

Piston ring: The first gas ring of the naturally aspirated engine adopts the chrome-plated barrel-type ring; the second ring adopts the distorted cone ring with notch on excircle, and with the thickness of 2.5mm. The thickness of oil ring is 5mm. the first ring of the supercharged machine adopts the molybdenum-spray wedge barrel-type ring and the second ring and oil ring are universal with these of naturally aspirated machine. The first ring of supercharged & intercooled machine adopts the single-surface trapezoidal ring and the second ring adopts the distorted cone ring with internal rounding, with the thickness same with that of naturally aspirated and supercharged models; the thickness of oil ring is 4mm.

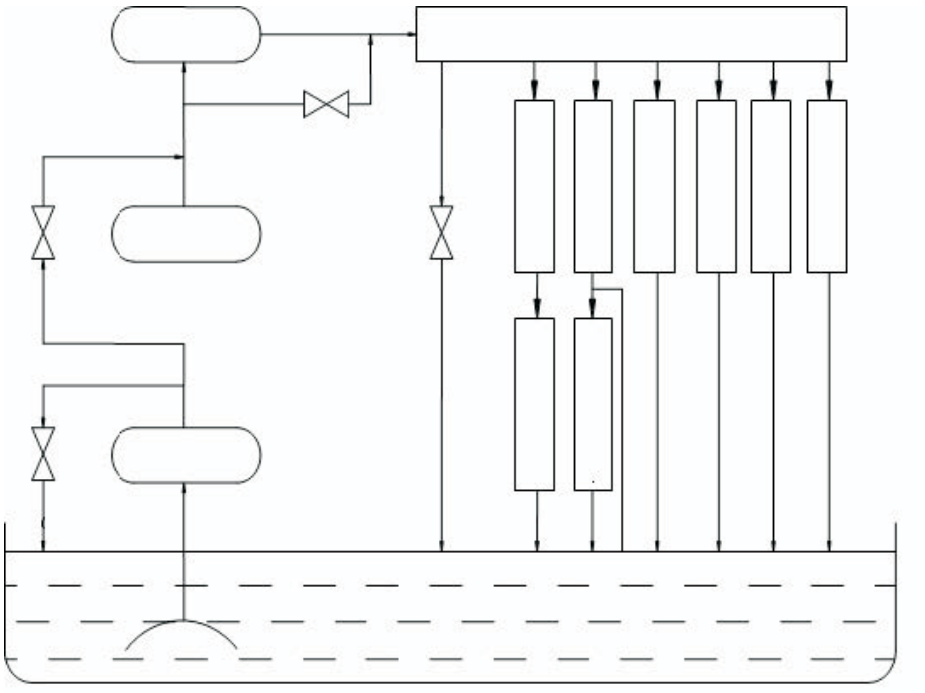
2. Lubricating system

The lubricating system consists of oil sump, oil pump, oil filter, oil cooler, piston cooling nozzle, main oil passage regulating valve and pipes (see Fig. 4-1). The composite lubricating way with the composition of pressure lubrication and splash lubrication is adopted for diesel engine.

The oil pump is located at the oil sump under the third cylinder of engine and fixed in the block, with the oil suction filter under it. The oil pump is driven by the bevel gear between the third and fourth cylinders together with the spline under its meshing transition shaft. The oil pump is equipped with pressure maintaining valve. If the oil pump outlet pressure exceeds 784kPa, this valve opens, making part of lubricating oil directly into the oil sump rather than into the oil transfer pipe, to allow the pressures of all parts of lubricating system not too high when the diesel engine starts at cold state. Duet to supercharged and supercharged & intercooled engines have large mechanical load and are equipped with piston cooling nozzle, the pump flows of three models are different (mainly different thickness of oil pump gears), with minimum value for naturally aspirated model and maximum value for supercharged & intercooled model. The oil is pumped out from the oil sump and then flow into the oil filter through the outlet pipe. After passing through the oil filter, the oil first enters into the oil cooler and then into the main oil passage and then into the corresponding main bearing through the oil passage on the baffle of cylinder block and finally into the connecting rod bearings through the oblique hole on the crankshaft. There is oil passage on the baffle, passing to the idle gear bush and the bushes of three bearings of camshaft. And the oil from the front bush of camshaft that connects with the rocker-arm support through the vertical oil passage and cylinder head bolt holes lubricates all rockers and valve stems through the rocker-arm holes.

Due to the pistons of supercharged and supercharged & intercooled engines have high thermal load, the engine block is equipped with piston cooling nozzle. The spray oil from piston cooling nozzle will properly spray into the piston chamber to cool the pistons and piston rings. There are left (three pieces per engine) and right (one piece per engine, located on first cylinder) cooling nozzles. The locating pin on the nozzle body should be inserted into the pin hole when installation. There is a one-way valve in the piston cooling nozzle fastening bolts (the oil will spray if the oil pressure is more than 200kPa), so the hollow bolts can not bear too much tightening torque. If too tighten, the one-way valve will be blocked and can not spray oil, resulting in a major failure, such as cylinder sticking, due to poor cooling of piston. Therefore, the tightening torque of piston cooling nozzle fastening bolts should be strictly within the range of 50±5N·m. In addition, the fastening bolts of cooling nozzle body and nozzle should be assembled in pair. At the same time coating the thread sealant is not allowed to avoid the one-way valve block.

The oil bath lubrication is adopted for the cams on the camshaft, with splash lubrication for gear meshing surfaces and with pressure lubrication for idler gear shaft.



Note: Piston cooling nozzle adopted for supercharged & intercooled engine

Fig. 4-1 Lubricating system diagram

There is a main oil passage pressure maintaining valve under the injection pump of cylinder block, to keep the normal oil pressure of main oil passage. The wear of diesel engine will make the clearance between all bearing shells and bushes increase and make the oil pressure reduce. If the oil pressure at idle speed under hot engine state is lower than 98kPa and at high speed without load is lower than 300kPa, check the clearance between all bearings and replace the bearing shell if necessary.

For the 4DX series supercharged & intercooled engine, the oil lubrication supercharger is equipped at the front of oil cooler, so the engine oil from the supercharger bearings will flow back to the oil sump through the oil return pipe; there is an oil passage (at the oil alarm) at the right side of engine, through which the oil lubricates the injection pump as well as the advancers of the supercharged and supercharged & intercooled engines through the gear chamber cover.

The oil filter adopts the spin-on filter. If the clogging resistance of filter blocked by impurities increases above 137kPa, the bypass valve on the filter assembly will open (the oil directly flow into the main oil passage rather than filter). Therefore, the oil filter element should be replaced regularly.

The water-cooled plate-fin oil cooler is used to reduce the oil temperature, to avoid the premature oxidative deterioration of oil due to too high temperature. Because the thermal loads of supercharged and supercharged & intercooled engines are high and oil spray cooling way is adopted for pistons to transfer much heat into the engine oil, the heat emission area of oil cooler of supercharged and supercharged & intercooled engines are larger than that of naturally aspirated engine (two cooling fins for naturally aspirated model and three cooling fins for other models).

3. Cooling system

The cooling system consists of water pump, oil cooler, thermostat, fan, water drain switch and car cooling water tank. The cooling water from the radiator tank is pumped into the inlet hole at the left side of cylinder by the centrifugal water pump and then into the corresponding water chamfer through the oil cooler and into the cylinder head, and then finally into the thermostat chamber at the front of cylinder head. The thermostat to adjust the water temperature is equipped in the thermostat chamber, with its working principal as follows: If the temperature of cooling water flowing into the thermostat chamber is lower than the thermostat opening temperature, the thermostat closes, so the cooling water can be directly back to the water pump through the small-circle hose (not flowing through the radiator named as small circle); if the temperature of cooling water is up to the thermostat full-open temperature, the thermostat control valve fully opens (at this time the cooling water flows into the radiator due to the small-circle water channel is blocked); this is named as larger circle. If the water outlet temperature is more then the opening but less than the fully-opening temperature, the cooling water of diesel engine will be between the small and larger cycles. The wax-type thermostat is adopted for this machine, with the opening lift of not less than 8mm at the full-open state of thermostat. If the thermostat fails to be opened, the outlet water temperature will sharply rise. Therefore, the thermostat should be replaced immediately. The boiling thermostat step by step is done to check whether the thermostat is normal.

The thermostat with different opening temperature should be selected according to different use condition (see table below). The front two in Table are available for China's plains and the last applies to the plateau with the altitude above 3000m.

Type of thermostat	K-1306010	136020/CK-1	1306010G-K
Opening temperature (℃)	76±2	82±2	65±2
Full-open temperature (℃)	86±2	95±2	75±2
Full-open lift (mm)	≥8	≥8	≥8
Remarks	Available for the condition of high temperature and larger load	Available for the use condition of low temperature and light load	Available for plateau area (depression of boiling point of cooling water due to air pressure)

The water pump adopts the centrifugal vane pump, with the flow of 140L/min and with the lift of not less than 2.3m at the speed of 2000r/min.

The diameter of cooling fan and the number of blades should be selected according to the powers of all engines and the matching vehicles. The vehicle fan is of air suction way, with reverse assembly not allowed. The water temperature inductive plug is equipped on the thermostat seat, connecting with the water thermometer in cab, to show the outlet water temperature of diesel engine.

4. Fuel supply system

The fuel supply system consists of diesel filter, injection pump, high-pressure oil pipe, injector, oil return pipe, car oil tank and diesel first filter. The injection pump assembly contains the regulator and oil transfer pump. The regulator is of mechanical centrifugal type. The fuel is pumped by the oil transfer pump from the fuel tank and flows into the diesel filter after the larger impurities are filtered out through the diesel first filter on car to remove the slight impurities and then into the

low-pressure chamber of injector pump. And the fuel is forced out by the pressurized plunger and into the injector through the high-pressure oil pipe. If the oil pressure exceeds the opening pressure, the injector needle valve opens to spray the oil into the cylinder. The slight fuel leaking from the clearance of injector coupling flows into the much fuel in the low-pressure chamber of injection pump through the oil return pipe and then back to fuel tank through the oil return pipe (see Fig. 4-2).

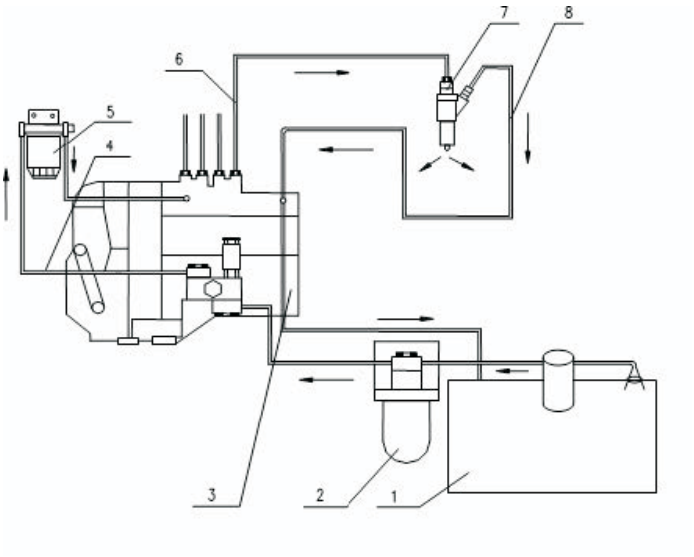


Fig. 4-2 Fuel supply system diagram

1- Fuel tank 2- Diesel first filter 3- Injection pump 4- Low-pressure oil pipe
5- Diesel filter 6- High-pressure oil pipe 7- Injector 8- Oil return pipe

5. Diesel filter

The diesel filter adopts the spin-on filter. The diesel filter is to remove the mechanical impurities and moisture in the diesel, ensuring the service life due to the reduction of wear of injection pump and injector plunger coupling.

The diesel filter elements should be replaced regularly; the tightening torque of screws of inlet and outlet pipe connectors should be limited to 25±5N·m, with too tightening or too loose not allowed.

6. Supercharged and supercharged & intercooled system

The supercharged and supercharged & intercooled system consists of the supercharger, intercooler and corresponding inlet and outlet pipes. The supercharger consists of waste gas turbine and compressor, with its working principal as follows: the turbine shell is connected with the exhaust manifold of diesel engine; the high-temperature waste gas having a certain energy enters into the turbine chamber at high speed to push the turbine and compressor impellers rotate at high speed, increasing the flesh air flow and pressure in the cylinder, to create the condition for improvement of power of diesel engine. The supercharger structure is shown (Fig. 4-3).

The intercooler located at the front of tank radiator is to reduce the diesel engine air inlet temperature to increase the air inlet density with the cooling fan of diesel engine and the cooling blow air when the vehicle is traveling, thus increasing the diesel engine power and improving the performance. The intercooler is supplied by the car manufacturer.

Due to the working speed of rotor shaft of supercharger turbine compressor is more than 100000 rpm, it is important to keep the lubricating oil in the supercharger rotor floating bearings clean and sufficient. Add the clean oil into the supercharger oil inlet hole after the new engine starts or the supercharger is dismantled for inspection.

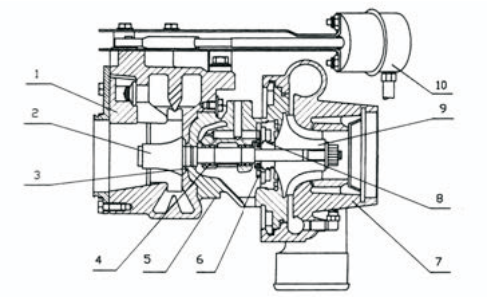


Fig. 4-3 Turbine supercharger

1- Turbine shell 2- Turbine parts 3- Turbine sealing ring 4- Floating bearing
5- Mediate shell 6- Thrust bearing 7- Compressor shell 8- Compressor sealing ring
9- Compressor impeller 10- Exhaust air relief valve

II. Electrical system

1. Main parts of electrical system

The electrical system of 4DX series diesel engine adopts 24V voltage. However, the diesel engine is equipped with the generator, starter, and oil pressure and water temperature sensor, as well as electrical heating device to facilitate to cold start the engine at winter.

The silicon rectifier AC generator is adopted, with reverse negative ground connection not allowed (electrical schematic shown in Fig. 4-4). The vacuum pump is equipped at the rear of car generator having the vacuum brake, which is connected with the generator shaft.

The starter voltage is 24V, with rated power of 3.7kW, having the better starting performance.

The oil pressure sensor is equipped under the engine oil cooler and the water temperature sensor is installed on the thermostat seat, which can display the oil pressure and water temperature when the diesel engine is running together with instruments on the car instrument panel.

The electrical heating device is to preheat the inlet air before the startup of diesel engine at cold weather, to facilitate to start the cold machine. The electrical heating device is a electrical heater located between inlet pipe and inlet manifold.

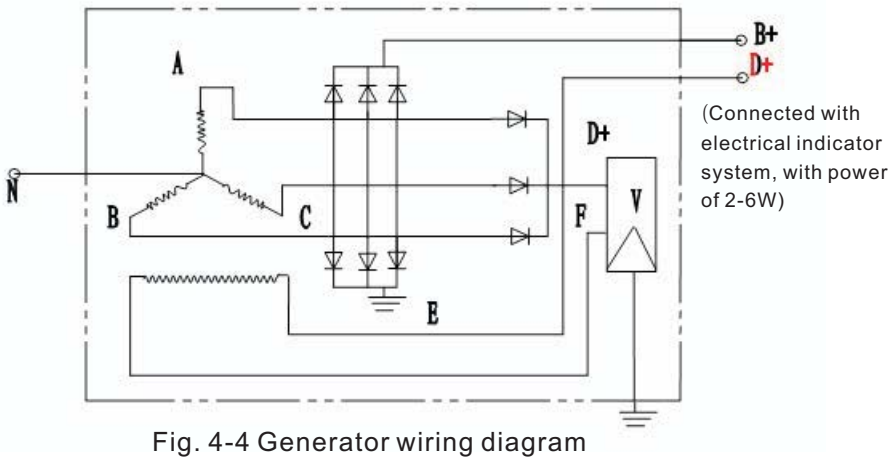


Fig. 4-4 Generator wiring diagram

III. Assembly precaution

To ensure the reliable operation of diesel engine, the engine should be assembled properly according to the technical requirement specified in this manual. Therefore, please carefully read the assembly points described in this Chapter before disassembling or overhauling the diesel engine.

1. Technical requirement to overall assembly

(1)All parts must be carefully clean before re-assembly. Especially the lubricating oil passages and oil pipes must be blown with compressed air after cleaning, to ensure no scrap iron, oil dirt or impurities left. Furthermore, all surfaces of parts must be clean.

(2)All sealing gaskets and rubber sealing rings should be replaced or the original parts are free of any defect.

(3) All moving surfaces should be coated with lubricating oil before assembly.

(4)All key parts to be tightened having the torque and tightening order requirements must be tightened to the specified value according to the specified order. The remaining parts should be tightened according to the tightening torque of general bolts. However, the important bolts and nuts of connecting rod, flywheel and torsional damper should be coated with thread sealant to prevent loose if they are dismantled and assembled many times.

(5)When assembly, pay attention to the assembly direction and marks of parts (such as main bearing cover, connecting rod larger head cover and crankshaft thrust washer), with wrong or reverse assembly not allowed. At the same the main bearing cover and connecting rod must be assembled according to the cylinder matching marks, otherwise the major failures may occur, such as bearing shell sticking. The assembly order of some parts (such as piston, cylinder linear, piston ring, connecting rod, valve and bearing shell) can not be confused when re-assembly. That is, these parts should be re-assembled at the original place of original cylinder, to ensure the better running-in state of these pairs.

(6) To prevent oil or water leakage, some parts should be coated with appropriate sealant strictly according to the sealant use instruction.

(7) After the completion of the assembly of each main moving part (such as crankshaft, connecting rod piston, camshaft and gear) and the overall assembly, run the diesel engine several circles for assembly inspection.

(8)To ensure that the emission reaches the standard: The injection advance angle, injector injection pressure and cylinder head extended height should be adjusted strictly according to this manual; in repair, the injection pump, injector or turbocharger should be replaced by the original one with the same model if damaged.

2. Assembly of crankshaft

(1)Place the bottom surface of machine flatly upwards, and assemble the upper main bearing shell into the main bearing seat hole in turn (with main bearing shell tab inserted into the groove of main bearing seat hole). Check whether the main bearing seat oil hole is connected with main bearing shell oil hole, with engine oil coating on the internal surfaces of main bearing shell. Assemble the crankshaft thrust washer on the bearing seat thrust surface of third gear. Pay attention to that the side with two grooves on thrust bearing plate adopts the antifriction alloy layer. This side should face outwards to contact with the moving surface of crankshaft when installation, with reverse assembly not allowed.

(2) Stably place the clean crankshaft on the main bearing shell coating with clean engine oil, and rotate the crankshaft several circles to well fit with the main bearing shell.

(3) Assembly of main bearing cover

Assembly the lower main bearing shells into the main bearing cover respectively, and then install two crankshaft thrust plates into two end face of main bearing cover of third gear (with the side having groove of thrust plate faces outwards), and coat the surfaces of bearing shell with clean oil.

According to the main bearing cover upper surface matching steel impression marks and boss marks towards front end (wrong or reverse assembly forbidden), place the main bearing covers on the corresponding main bearing seat in turn. Slightly knock the main bearing cover with wood hammer to fit with the engine, with dislocation of two sides of main bearing cover and side face of engine seat hole not allowed (there are two locating grooves on the main bearing cover of third gear equipping with crankshaft thrust plate).

(4) Assemble the main bearing bolts that have been coated with thread sealant into the thread hole and then tighten the main bearing cover in twice from the middle to two ends according to the program shown in figure (see Fig. 4-7); after all main bearing bolts are tightened, the crankshaft should be run freely, free of blocked phenomenon. At last, push the crankshaft towards the front end, and check whether the crankshaft axial clearance is within the range of 0.115-0.256mm through inserting the feeler gauge into the thrust plate near the front end.

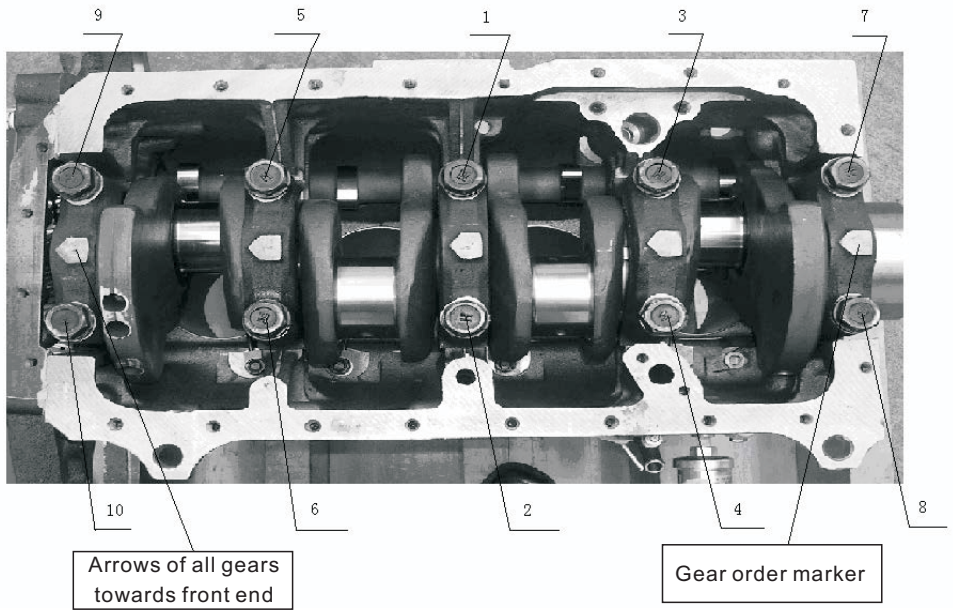


Fig. 4-7 Main bearing covers assembly order diagram

3. Assembly of piston connecting rod

The piston connecting rod should be grouped for assembly, with the difference between pistons weights on the same diesel engine of not more than 8g and with the connecting rod weight difference of not more than 20g. When assembling all connecting rods and large head covers, their marks should be in pair, with reverse assembly forbidden. At the same time, the small ball marks at the side of larger head cover and the arrow at the top of piston should face towards the fan end of

engine, to ensure the proper installation position of piston combustion chamber (see Fig. 4-5). To facilitate assembly, heat the piston in the boiling water before assembling the piston pin, with circlips at both ends of piston pin assembled into the groove allowed.

The piston rings adopted for naturally aspirated, supercharged, and supercharged & intercooled engines have been described in Section 4.1.1. The difference in three models is as follows: (1) The piston rings and ring grooves on piston for naturally aspirated and supercharged models have the same installation dimensions (thickness of oil ring of 5mm). However, the chromate treatment is adopted for the excircle of first ring of naturally aspirated model, with sprayed molybdenum treatment for supercharged model. The second ring is universal for these two models rather than the oil ring due to different surface treatment. (2) The third piston ring and the corresponding piston ring groove of supercharged & intercooled model are different with that of naturally aspirated and supercharged models. For supercharged & intercooled model, the first ring adopts the single-sided keystone ring and the second ring adopts the torsional ring, and the thickness of oil ring is 4mm. The installation direction of second rings of three models must be shown in Fig. 4-5. That is, for the second ring, the excircle notch faces downwards for the naturally aspirated and supercharged models and the fillet chamber faces downwards for the supercharged & intercooled model. For assembling the oil ring, first assemble the spring expander ring into the ring groove to connect the lap and then assemble the oil ring on the spring expander ring to stagger 180 ° between opening and lap. The piston ring should rotate freely in the ring groove, with the angle between first ring and piston pin axial line of 30°. The openings of second and third rings should be staggered 120° (see Fig. 4-8).

Note: In overhaul, if your purchased cylinder linear of engine is the chrome-plated steel cylinder liner (no matter naturally aspirated, supercharged or turbocharged & intercooled model), the first ring with spray molybdenum treatment for surface and the oil ring with phosphating treatment for outer surface must be used instead of the original ring with chromed excircle surface. Otherwise, the cylinder sticking accident may occur. The connecting rod bush, crankshaft connecting rod journal, piston and piston ring should be coated with engine oil before the piston connecting rod is assembled into the crankshaft. Check the cylinder order, installation direction (to ensure the proper relative position of piston combustion chamber) and piston ring opening position. The connecting rod bolts should be tightened diagonally two or three times.

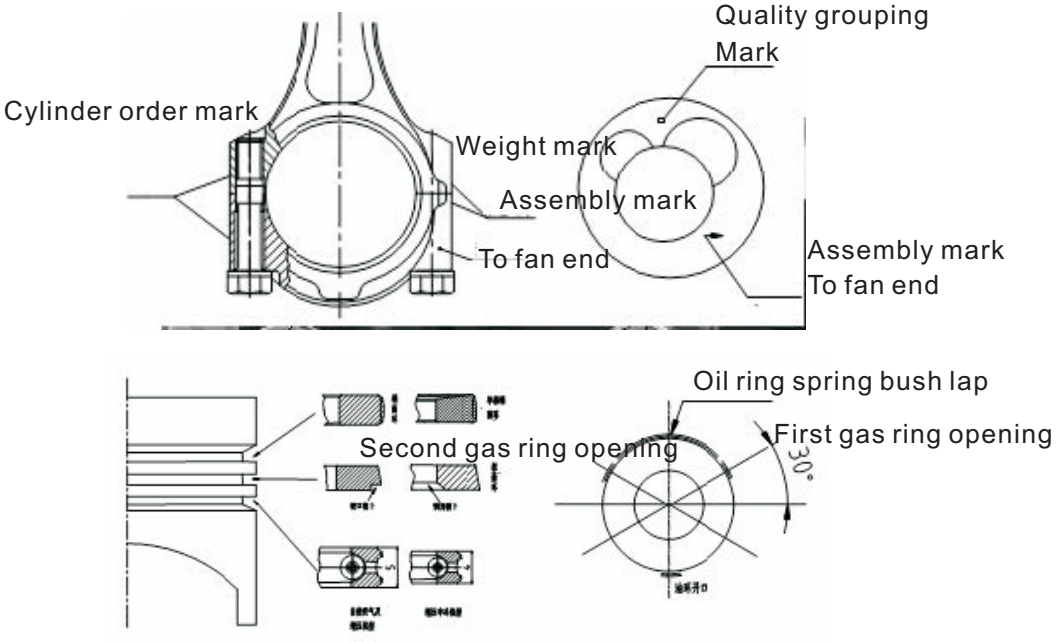


Fig. 4-8 Assembly of connecting rod piston and ring

4. Assembly of camshaft

First assemble the thrust plate into the camshaft and then assemble the flat key and then timing gear (side with marked timing mark of gear faces outwards); insert the camshaft assembly into the camshaft bush hole of cylinder after the bolts are tightened, and then tighten the camshaft thrust plate on the cylinder to check the axial clearance. If the air compression pump is driven by gears, this drive gears should be tightened on the camshaft drive gear with bolts (see Fig. 4-9).

Fig. 4-9 Assembly of camshaft

5. Assembly of gear train

After the completion of assembly of crankshaft and camshaft, the timing idler gear can be assembled. At this time, the corresponding meshing marks at end face of gear should meet the requirement of Fig. 4-10. Add the lubricating oil into the timing idler gear shaft, bush and all gears when assembly.

6. Assembly of cylinder head and valve actuating mechanism

(1)Before assembling the cylinder head, check the sealing area between all cylinder valves and valve seats (for continuation of sealing area). If necessary, they should be grinded in pair. All grinded cylinder heads and valves should be cleaned, and the valves of all cylinders can not be exchanged.
(2)After assembling the lower seat of valve spring, press the valve guide sealing ring on the upper of guide tube.
(3)Assemble the exhaust valve, valve spring, spring upper seat and cotter, with the cotter and valve spring well fit (knock the valve top with wooden spike for inspection), to ensure the cotter at proper position and not fall off.

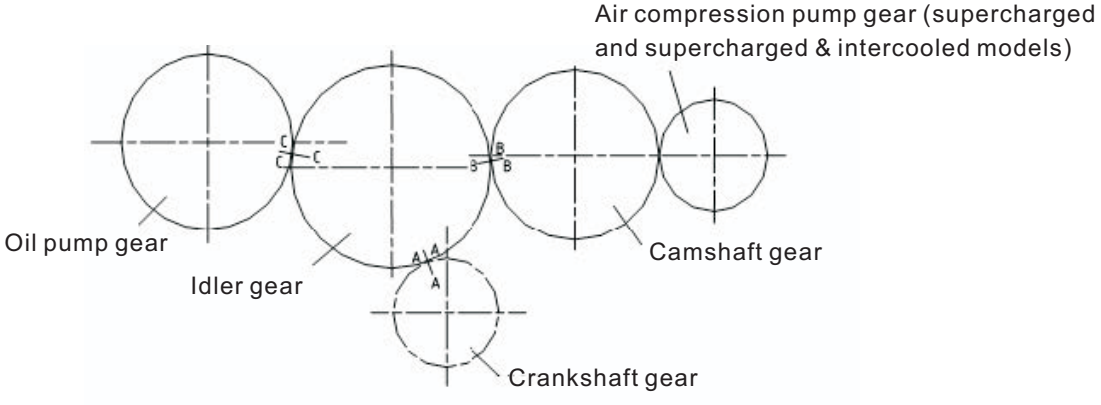


Fig. 4-10 Assembly of gear train

(4) The tightening torque of clamp nuts of pressure plates of S-type and P-type injectors should be within the range of 60±10N·m and the height of tip of injector projecting from the lower surface of cylinder head should be 2.8~ 3.2mm.
(5) Coat the tappet with engine oil on and assemble it into the hole of cylinder, and check that it can slide up and down freely.
(6) Assemble the locating pin and cylinder linear on the upper surface of cylinder and tighten all cylinder head bolts after the alignment of the cylinder head and locating pin of cylinder block. The cylinder head bolts should be tightened from the middle place of cylinder cover according to tightening order (see Fig. 4-11).

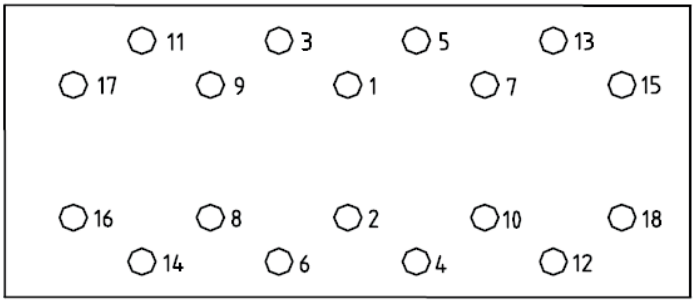


Fig. 4-11 Cylinder head bolts tightening order diagram

(7) Assemble the valve push rod and rocker and then adjust the intake and exhaust valve clearances to specified value; run the diesel engine to recheck all cylinder valve clearances and whether the push rod is bended.

7. Assembly of flywheel

The output torque of diesel engine can be transferred outwards through flywheel. Therefore the flywheel bolts should be tightened diagonally according to the tightening torque specified in this manual.

8. Assembly of crankshaft torsional vibration damper

The crankshaft torsional vibration damper is to reduce the torsional vibration amplitude of crankshaft, with the rubber torsional vibration damper adopted for this series models. The rubber damping ring is inserted between the inner and outer rings of torsional vibration damper, to reduce the torsional vibration amplitude of running crankshaft. The user should often check it in use. This rubber ring should be scrapped to be replaced if there found that the scale on the iron pieces on inner and outer rings of damper was slipped to proper position and that there is squeezed crack phenomenon on the rubber ring; however, the damper should be replaced if the flywheel bolts are loose abnormally or broken or the traveling distance is above 100000 km, to ensure the reliable operation of diesel engine.

The clamp nuts of torsional vibration damper should be tightened according to this manual.

9. Assembly of diesel engine peripheral attachments and machine adjustment

The diesel engine peripheral attachments mainly include the injection pump, thermostat chamber, water pump, inlet and outlet pipes, supercharger, oil filter, diesel filter, air compression pump, generator, starter, fan and all connections of diesel, oil and cooling water pipes. Keep all

parts clean when assembly, with on any impurity falling into the turbocharger, airway of cylinder head, and inlet and outlet pipes; all connecting pipe connectors should be at proper positions and well sealed.

After assembly, the machine should be adjusted and run according to this manual, with data carefully adjusted.

Chapter V Fault and troubleshooting of diesel engine

You should immediately find out the fault cause if the diesel engine fails, with the proper measure taken for elimination. The fault cause and troubleshooting described in this Chapter are only for reference by user.

I. Diesel engine can not start

Fault cause	Troubleshooting
Air in the fuel system;	Drain air from fuel system;
Fuel pipe or fuel filter is blocked;	Clean or wash the fuel pipe and fuel filter;
Poor oil spray or oil spraying pressure is too low;	Clean and check injector;
Oil supply advance angle is incorrect;	Adjust the oil supply advance angle;
Electrical equipment connectors are loose;	Connect the connectors;
Lack of batteries capacity and slow speed of flywheel;	Batteries are charged fully or replaced;
Diesel engine temperature is too low;	Adopt lubricating oil and fuel available for winter and power on the heater;
Lack of piston compression pressure.	Replace over-worn piston ring and cylinder linear; Replace seriously damaged or burn valves and valve seats.

II. Lack of power of diesel engine

Fault cause	Troubleshooting
Air filter paper element is blocked, with lack of air supply;	Reversely blow with compressed air or replace paper element;
Exhaust pipe or muffler is block;	Clean exhaust pipe or muffler;
Fuel pipe or fuel filter is blocked, with lack of oil supply;	Clean fuel pipe and filter or replace filter element;
Moisture in the fuel;	Drain accumulated water or replace fuel;
Injection pump or injector fails or oil supply angle moves;	Check, replace or re-adjust;
Supercharger bearings are seriously worn or blades deformed;	Check or replace ;
Supercharged inlet pipes are not sealed or intercooler is damaged;	Check or replace

III. Diesel engine operation suddenly stops

Fault cause	Troubleshooting
Air enters into the fuel system;	Drain air in fuel system ;
Fuel transfer pump fails;	Check or replace ;
Oil pressure is too low or crankshaft sticks the bearing shell due to lack of oil;	Replace crankshaft bearing shell ;
Fuel filter is blocked;	Clean or replace filter element ;
Lack of water or no oil spraying from piston cooling nozzle causes the piston stick the cylinder;	Check part and replace if necessary;

IV. Diesel engine speed surges (runaway)

Fault cause	Troubleshooting
Regulator failed;	Cut off oil supply pipe or plug the inlet port to stop vehicle for inspection or replacement;
Regulating spring is broken or rack is blocked ;	Cut off oil supply pipe or plug the inlet port to stop vehicle for inspection or replacement;

V. Knock arising in diesel engine

Fault cause	Troubleshooting
Clearance between valve and rocker is too larger, and there is knocking sound in the valve mechanism;	Check the valve clearance and adjust it if necessary;
Clearance between piston and cylinder is too larger and rumble knocking sound rises throughout the whole cylinder;	Check, repair or replace ;
Piston pin and connecting rod bearing clearance is too larger, with aloud metal knocking sound given;	Check, repair or replace;
Connecting rod bearing clearance is too larger, with mutism knocking sound given;	Replace bearing shell;
The main bearing clearance is too larger, with knocking sound same with that from connecting rod bearing;	Replace bearing shell;
Knocking sound of valve and piston;	Check valve timing (gear pair mark);

VI. Smoke arising from the exhaust of diesel engine

Fault cause	Troubleshooting
Diesel engine overloaded, with black smoke rise;	Reduce load;
Spray mist is too thick, with black smoke rise;	Check oil outlet valve and injector and replace it if necessary;

Fault cause	Troubleshooting
Oil supply advance angel is incorrect, with black or white smoke rise;	Adjust;
Lack of air, with black smoke rise;	Clean air filter and replace it if necessary;
Piston ring is worn or blocked, with bluish smoke rise;	Clean piston ring and replace it if necessary;
Water in the fuel, with white smoke rise;	Clean fuel tank and filter and replace fuel;

VII. Diesel engine overheating

Fault cause	Troubleshooting
Water jacket blocked ;	Remove water scale;
Cooling fan is damaged;	Repair or replace;
Cooling water pump is damaged;	Repair or replace;
Oil supply angle moves or nozzle atomization is poor;	Check and adjust;
Diesel engine overloads;	Reduce load;
Oil cooler is blocked;	Remove dirty or replace oil cooler assembly;
Supercharger or air inlet pipe is abnorma;	Check or replace;

VIII. Lubricating oil diluted

Fault cause	Troubleshooting
Machine oil temperature is often too high;	Check cooling system and oil cooler;
Fuel enters into the lubricating oil;	Check injector and injection pump;
Cooling water enters into the lubricating oil;	Check cylinder head and block plugging plate;

IX. Lack of pressure of lubricating oil

Fault cause	Troubleshooting
Lubricating oil in oil sump is too little;	Add lubricating oil;
Lubrication system leaks;	Check pipes of lubricating system;
Bearing clearance is too larger;	Check main bearings or connecting bearings and replace them if necessary;
Oil pump is worn;	Check or replace;
Oil cooler or oil filter is blocked;	Clean;
Pressure regulating valve spring is damaged;	Replace spring;
Oil pressure gauge display is incorrect;	Replace pressure gauge;
Oil pump oil suction filter is blocked;	Clean;

X. Level of lubricating oil in oil sump rises

Fault cause	Troubleshooting
Cylinder head or block cracks to cause water leakage;	Check or replace if necessary;
Cylinder linear is burn and can not be well sealed;	Replace damaged part ;

XI. Lubricating oil in cooling water

Fault cause	Troubleshooting
Oil leaks from oil cooler;	Replace oil cooler;
Oil cooler rubber sealing ring was damaged;	Replace rubber sealing ring;

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