

Landi Serial Diesel Engine
Operation and Maintenance Manual

Wuxi Power Engineering Co., Ltd

FOREWORD

Landi series diesel engines are our company's newly-developed diesel engines. During the process of continuous development and improvement, domestic and overseas advanced internal combustion engine technologies are introduced.

In order to let customers know and use Landi series diesel engines easily, legibly and fast, the edition of this manual places emphasis on the method on using and maintenance and main faults and remedies during normal using. Therefore, customers must read this manual carefully before using. Customers must also read the attachment manual: 《The operation manual for turbocharger》. In this way, the diesel engine can be properly used and maintained. Contact special manufacturer if you want to know detailed technical parameters, specification and structure.

We may make some necessary amendments at appropriate time with continuous innovation of our products without impartation in advance.

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Chapter One Summary

1. Diesel engine introduction

Landi series diesel engines are, four strokes, direct injection, turbocharged intercooled and water-cooling high speed diesel engine. It can be divided into 6-cylinder in-line and 12-cylinder V-type according to the arrangement mode of cylinders . They are widely used in the field of diesel generating sets, agricultural irrigation, construction machinery, emergency fire protection pump and industry.

Landi series diesel engines use the integrated crankshaft, the body for gantry structure, cylinder head for one cylinder and one cap, each cylinder head has two inlet valves and two exhaust valves, fuel injectors are located in the center of the cylinder. Power is output from the flywheel end. Therefore, suitable power take-offs and necessary accessories must be attached to the engine before it can be properly used. Connection of the output end is SAE type and can also be modified to resilient coupling. Cylinder number designation of model 12V diesel engine: Viewed from the flywheel end, the right hand bank is the first bank and the left hand bank is the second bank; counted from the free end, the order of the first bank is 1-6 , and the second bank is 7-12; Cylinder number designation of 6-cylinder diesel engine is: counted from the free end ,the order of cylinders is 1-6 . Our products adhere to the principle of seriation, standardization and generalization, and the main components can be exchanged.

2. Explanation of power rating

The power rating of Landi series diesel engines is the permissible effective power output for the engine with the air cleaner, but without other accessories which will affect its running such as fan, muffler, coupler, and gear box etc. to operate under the atmospheric condition of 100kPa (750mmHg) barometric pressure, 25℃ ambient temperature and 30% relative humidity. The engine can also be overloaded at 110% of the 12 hour power rating for a short period of not over 1 hour discontinuously or continuously during each 12 hour operation.

Output power of the diesel engine that the nameplate indicates includes the power the fan has consumed when running with the fan but the output power of engine (effective power) should deduct the power, the value of the power that the fan consumed in different engines is: WD360TAD110\1200 is 35KW; WD327TAD92 \100 is 30KW; WD327TAD88 is 30KW ; WD327TAD68/78/82 is 25KW ; WD164TAD43/45 is 15KW。

Because the output power will decrease with altitude, ambient temperature and relative humidity increasing of the using area, so the customer should correct the rated power according to the correcting method of standard GB/T6072.1 when the barometric pressure, ambient temperature or relative humidity is different from the above stated standard atmospheric condition.

Chapter Two Specification and parameter

1. Specification of diesel engine

Model	WD327TAD68	WD327TAD78	WD327TAD82	WD327TAD88
Structure	V-Type			
Cylinder	12			
Stroke	4			
Intake Type	Turbocharged Intercooled			
Bore, mm	145	145	145	145
Stroke, mm	165	165	165	165
Compression Ratio	15	15.5	15.5	14.5
Displacement, L	32.7	32.7	32.7	32.7
Rated power/Speed, kW/ r/min	682/1500	780/1500	820/1500	880/1500
Rated Fuel consumption g/kW • h	≤218	≤218	≤218	≤218
Rated Oil consumption g/kW • h	≤0.8	≤0.8	≤0.8	≤0.8
Rated piston mean speed, m/s	8.25			
Cylinder firing order (from gear train)	1-12-5-8-3-10-6-7-2-11-4-9			
Rotation direction (facing flywheel)	Anti-clockwise			
Cooling Type	Water cooling			
Starting Mode	24V Electric Starting			
Oil Volume (L)	90	90	90	90
Coolant Volume(L)	220	230	230	240

Model	WD327TAD92	WD327TAD100	WD360TAD110	WD360TAD120
Structure	V-Type			
Cylinder	12			
Stroke	4			
Intake Type	Turbocharged Intercooled			
Bore, mm	145	145	152	152
Stroke, mm	165	165	165	165
Compression Ratio	14.5	14.5	14	14
Displacement, L	32.7	32.7	36	36
Rated power/Speed, kW/ r/min	920/1500	1000/1500	1100/1500	1200/1500
Rated Fuel consumption g/kW·h	≤218	≤218	≤218	≤218
Rated Oil consumption g/kW·h	≤0.8	≤0.8	≤0.8	≤0.8
Rated piston mean speed, m/s	8.25			
Cylinder firing order (from gear train)	1-12-5-8-3-10-6-7-2-11-4-9			
Rotation direction (facing flywheel)	Anti-clockwise			
Cooling Type	Water cooling			
Starting Mode	24V Electric Starting			
Oil Volume (L)	90	90	90	90
Coolant Volume(L)	240	240	250	275

Model	WD164TWC40	WD164TAD43	WD164TAD45
Structure	Straight		
Cylinder	6		
Stroke	4		
Intake Type	Turbocharged Intercooled		
Bore, mm	145	145	145
Stroke, mm	165	165	165
Compression Ratio	15.5	15.5	14.5
Displacement, L	16.35	16.35	16.35
Rated power/Speed, kW/ r/min	400/1500	430/1500	450/1500
Rated Fuel consumption g/ kW · h	≤218	≤218	≤218
Rated Oil consumption g/ kW · h	≤0.8	≤0.8	≤0.8
Rated piston mean speed, m/s	8.25		
Cylinder firing order (from gear train)	1-5-3-6-2-4		
Rotation direction (facing flywheel)	Anti-clockwise		
Cooling Type	Water cooling		
Starting Mode	24V Electric Starting		
Oil Volume (L)	70	70	70
Coolant Volume(L)	70	80	80

Note: ①Diesel engine net weight tolerance±80 kg.

②Rated power tolerance ±5%.

③Because of the product improvement, the above parameters and the product model may change, product nameplate parameters shall prevail.

2. Main technical parameters

- (1) Various temperature ranges at rated power
- The temperature at outlet of turbocharger °C ≤ 600
 - Temperature in oil sump °C (highest) ≤ 105
 - Cooling water outlet temperature °C (highest) ≤ 95
 - Cooling water inlet water temperature °C (minimum) ≥ 55
- (2) Oil pressure
- With rated power condition:
 - Main oil gallery pressure KPa 400~600
 - The supercharger inlet oil pressure ≥ 196
 - With idle speed
 - Main oil gallery pressure KPa ≥ 150
- (3) Valve timing (according to crankshaft rotation angle)
- Intake valve: Open initial point under cold condition (before TDC) $20^\circ \pm 3^\circ$
 - Closed end point under cold condition (after BDC) $56^\circ \pm 3^\circ$
 - Valve and rocker arm clearance under cold condition, mm 0.4~0.45
 - Exhaust valve: Open initial point (before TDC) $64^\circ \pm 3^\circ$
 - Closed end point (after BDC) $34^\circ \pm 3^\circ$
 - Valve and rocker arm clearance under cold condition, mm 0.5~0.55
- (4) Fuel supply advance angle (according to crankshaft rotation angle) $24 \pm 1^\circ \text{CA}$
- (5) Battery capacity Ah

Environmental temperature	12-cylinder diesel engine	6-cylinder diesel engine
$\geq 10^\circ \text{C}$	1200	600
$0^\circ \text{C} \sim 10^\circ \text{C}$	1280	640
$-18^\circ \text{C} \sim 0^\circ \text{C}$	1800	900

Chapter Three Operation instruction

1. Fuel, Lubricating oil and cooling water

A. Selection of fuel

Selecting proper fuel is very important and should be according to the environmental temperature the engine runs in. In the southern hot weather area, light diesel fuel with high cloud point is ok, in the cold northern area, light diesel fuel with low cloud point is necessary. For example, under ordinary ambient temperature, light diesel fuel of grade 0 or -10 is ok; in the south with high temperature, light diesel fuel of grade 10 is all right; and in the north with very low temperature, the light diesel fuel of grade -35 or lower is needed.

Water content and mechanical impurities in the diesel fuel must be as little as possible, or it possibly causes premature blockage of the fuel filter and rusting of the engine parts etc. Poor quality diesel fuel mixing water, kerosene, gasoline up is forbidden to be used.

Note: The fuel must be clean, it's necessary to settle the fuel at least 7days or filter it through silk cloth in order to remove the mechanical impurities contained. The fuel without being settled or filtered is forbidden, otherwise, it may easily cause fuel supplying problems.

B. Selection of lubricating oil

The lubricating oil for the engine should be grade CF-4 according to GB11122-2006. For the users in the warm area, you can choose lubricating oil of grade CF all year around which can be very helpful to improve lubricating conditions, reduce mechanical wear and extend its lifetime.

For the users in cold area, special thickening oil with lower freezing point is needed. Kind suggestion is as following: When the lowest ambient temperature is -15°C , oil of grade 20W-40 is needed; if the lowest temperature is -20°C , oil of grade 15W-40 is needed; if the lowest temperature is -25°C , oil should be grade 10W-40; If the lowest temperature is -30°C , oil should be 5W-40; If the lowest environmental temperature is -35°C , please choose grade 0W-40.

Replacement cycle for the lubricating oil

(1) Lubricating oil should be changed in time after first 60 hours run-in operation

(2) Generally, lubricating oil should be renewed when the machine runs every 200h-250h. If the engine runs in a good environment, 300h-350h can be possible. The oil should be exhausted when the machine is hot. You can exhaust the oil as soon as the engine stops.

(3) For none compulsory lubrication type high pressure pump, the oil level in the speed governor of oil pump must be checked before each use, and oil should be added in time when the oil level is lower than the prescribed standard. Oil in the high pressure oil pump should be renewed and the oil filter should be cleaned after oil pump's running for 100h.

Note: This engine belongs to supercharged diesel engine with high strength and intercooler; therefore, the lubricating oil shouldn't be lower than grade CF and mixed different grades together.

C. Selection for cooling water

As for cooling water for the engine, city supply water and clean river water is recommended. Well water and other underground water containing too much minerals should not be used, because scale will formed in the water jacket, affecting the cooling efficiency and thus causing engine fault.

When the engine is operated under the environmental temperature of lower than 0°C, special care must be taken to prevent some concerning parts from being damaged by frozen water. Therefore, please exhaust all the cooling water as soon as the engine stops. However, proper antifreeze can be added into the cooling system. The formulas of antifreeze are as following:

Name	Ingredient (%)					Solidifying point
	ethylene glycol	alcohol	glycerin	water	unit	
Ethylene-Glycol anti-freeze	60			40	Volume ratio	-55
	55			45		-40
	50			50		-32
	40			60		-22
Alcohol-alcohol anti-freeze		30	10	60	Weight ratio	-18
		40	15	45		-26
		42	15	43		-32

Note: 100% antifreeze can't be used as cooling water.

Seawater can't be used as cooling water directly.

If there is too much scale and dirt accumulated in the cooling system, it should be cleaned with cleaning solution, which can be made up in the proportion of 1L water, 40g soda and 10g sodium silicate.

When cleaning the cooling system, first pour the cleaning liquid into the cooling water jacket, start the engine and let it run until the outlet water temperature exceeds 60°C, keep it running for about 2 hours, then stop the engine and drain off the cleaning solution. After the engine has cooled down, clean it with fresh water twice, then drain off the water, fill it with cooling water, start the engine again and let it run until the outlet water temperature exceeds 75°C, then stop the engine and drain off the dirty water. Finally, refill it with fresh cooling water for operation.

D. Grease Lubricant

The grease lubricant for the engine's roller bearing of fan pulley is the same as the cars' lithium grease (GB5671). The grease chamber has been fulfilled before delivery, and users should check and refill it when maintaining the engine.

2. Engine starting

A. preparations before starting

(1) Check all components and systems to see whether they are in proper order. Check the accessories to see whether they are firmly and reliably connected. Eliminate any abnormality.

(2) Check the cooling system and fulfill cooling water.

(3) Fill the oil sump until the required oil level is reached.

(4) Check the fuel tank to see whether it's enough.

(5) Check all electrical wiring connections of starting system to see whether they are correctly and firmly connected. Check the batteries to see whether it fully charged.

(6) Feed fuel into the fuel system with hand pump on the fuel feed pump and at the same time loose the vent screw on the injection pump or the vent plug on the fuel filter to bleed air in the fuel system. When no bubble is found in the fuel flowing out of the vent screw or plug, tighten the vent screw or plug. Thereafter, continue to pump fuel until it spills into the overflow pipe, and then lock the hand pump.

(7) For a new engine or an engine not used for over five days, turn the crankshaft for 3-5 revolutions before starting the engine.

(8) For the stand-by engine, it is recommended to start and run it once every 3-5 days until its water and oil temperature exceed 60°C, so that when necessary, the engine can be put into operation promptly.

B. Starting

After preparations, pressing "ON" button can start the engine under ordinary ambient temperature. If fail at first time, can't start it again until the motor stops spinning.

Note: To protect the starting motor, the engine should be started within 5 seconds; if not, wait at least 2 minutes before starting the engine again.

At the beginning, let the engine run at a speed of 600-750r/min for a while, and inspect the readings of the gauges, especially the oil pressure gauge. If the oil pressure is never higher than 147Kpa, the engine should be stopped and checked and started again after repairing.

Note: In order to protect the bearings of turbochargers from burning-out, the speed of the engine can't be increased until the oil pressure raises, especially for those have replaced lubricating oil, oil filter or been closing down for 5 days. Loosen the connecting parts of oil intake pipe till some oil outflows, then increase the speed and load several minutes later.

C. Prewarming, run-in and operation

a. Prewarming for the engine.

After the engine has started, it takes some time to form oil layer between crankshaft and bearing, pistons and cylinder jackets. Perfect clearance between motion parts can be gained when all the parts reach their normal working temperature.

Therefore, as the heating of the engine, increase the speed from 650r/min to 1000-1200r/min to warm the engine up. The engine is allowed to operate at full load only when its outlet water temperature exceeds 55°C, oil temperature over 45°C.

b. Run-in for the engine

For a new engine or an engine after overhaul, the engine must run in for 60 hours before it can be put into full load operation. Otherwise, it may greatly affect the use and lifetime of the engine.

Users should do run-in as following chart(60h in total):

Sequence No.	Speed(r/min)	Load (rating power %)	Run-in time (h)	Total time (h)
1	700-1500	0	0.25	0.25
2	1500	0	0.25	0.5
3	1500	25%	0.25	0.75
4	1500	50%	1.75	2.5
5	1500	75%	45	47.5
6	1500	90%	5.0	52.5
7	1500	100%	3.0	55.5
8	1500	75%	3.0	58.5
9	1500	50%	1.0	59.5
10	1500	25%	0.5	60.0

Note: 1, In run-in period, pay attention to the exhausted smoke, sounds and heat condition. Settle abnormal situation immediately.

2, In run-in period, pay attention to the oil pressure, oil temperature and exhaust cooling water temperature which should be accordance with the instructions.

3, Inspect readings of the meter frequently.

4, Renew the lubricating oil after run-in period.

c. Operation for the engine

It is not allowed to operate the engine at 50% of rated power output for a long time, as it can cause high fuel consumption, valve jammed etc.

If the temperature of cooling water becomes too low, the unburned fuel may thin the oil in the oil sump, and affect lubricating efficiency.

Note: Any failures occur to parts, such as a sudden surge of oil temperature, a sudden decline of oil pressure and abnormal sounds. Please stop the engine immediately, check and repair it.

Before stopping the engine, run it at idling speed for 3-5 minutes, let cooling water and lubricating oil take the heat away in the engine, which is very important for turbocharged engine. Unless it is in urgent need, the engine shouldn't be stopped suddenly; otherwise, the turbochargers will overheat and cause their bearings to seize up.

The operator should pay attention to the sounds of turbochargers to see whether any impeller knocks at the housing at the moment that the engine is stopped. If a noise of knocking is heard, please dismantle the turbocharger immediately to check the

bearing clearance.

Note: Under very cold situation, exhaust all the cooling water in the engine and its accessories to protect the engine from freezing.

The intake and exhaust manifolds of the turbocharged engine must be free of leakage; otherwise, its performance would be lower. Check the tightness of the connecting nuts or bolts and the hose clamps frequently. If necessary, renew the sealing gasket.

Note: When customers are to select proper engine, consideration should be given to reasonable power of working machinery, as the engine shouldn't be operated at an excessive load or very low load for a long time. Otherwise, it may lower reliability of the engine and cause some faults.

d. The output power for the engine

WD164 series engine outputs its power by flywheel and SAE connector which is used to drive working machinery. Belt pulley can't be fixed to the flywheel directly, and the machine can't be dragged in lateral direction, because they can damage the engine's crankshaft and main bearings easily.

The maximum output power of the engine's front extension shaft should be within 50kw, but some applications include bearings and clutch etc must be fixed to support the shaft. The power it can bear to be dragged in lateral direction must be controlled within 11kw to protect the main crankshaft and driving gears. For those engines with a fan, dragged in lateral direction is forbidden.

Note: The engine shouldn't be started with load, therefore, a engaging and disengaging device should be fixed between the engine and those load devices can't be operated without load, and operator should start the engine when the clutch is released.

Chapter Four Repair and maintenance

Correct maintenance of diesel engine, especially preventive maintenance, though it is the easiest and most economical, it is the key of prolonging service life time of diesel engine and decreasing its operation cost. First of all, daily records of the engine operation should be well made so that necessary adjustments and regulation can be performed accordingly. In addition to the daily records, users should refer to the instructions in this section and work out their own particular maintenance schedule in terms of their specific operating condition and experience.

Generally, the contents of daily records include:

Date, beginning time and end time of every shift; routine record of readings on all meters; load of the engine; leakage and excessive consumption of fuel, lubricating oil and cooling water; exhaust color and abnormal noise; problems and solutions.

1. Main items of maintenance

For reliable engine operation, all maintenance work must be carried out promptly, carefully and correctly. Must carry out diesel engine technology maintenance system, technical maintenance category below:

Daily maintenance (after every work-shift)

First order maintenance (after every 100 accumulated operating hours).

Second order maintenance (after every 500 accumulated operating hours)

Third order maintenance (after every 1000-1500 accumulated operating hours or every 1 year).

No matter what kind of maintenance is carried out, the dismantling, checking and reassembling should always be done in a planned and sequential way. Be sure to use suitable tools and exert proper strength. After dismantling, the surfaces exposed must be kept clean and coated with anti-rusting oil or grease to prevent them from rusting. Take care of the relative positions of the detectable parts, the structural features of the parts which cannot be dismantled, the fit clearances and the adjusting methods. At the same time, keep the engine and its accessories clean and complete.

A. Daily maintenance

1. Check lubricating oil level in engine sump. Oil level should meet the marks indicated on the oil level scale. If insufficient, replenish to the specified limit.

2. Check oil, water and gas leakage.

3. Check rigidity and reliability of all components attached to the engine. Check rigidity and reliability of engine foundation bolts and the connection between the engine and the driven machinery.

4. Check all the meters to see whether the readings are normal. If abnormal, replace or repair it.

5. Check injection pump connecting plate. If there is any alteration of injection timing or the joint bolts are loose, check the injection timing and tighten the bolts.

6. Check the connecting screw between turbocharger and its bracket and bust of connection between turbocharger and air inlet pipe to see whether they are loose.

7. Clean the engine and the surface of the attachment. Oil, water and dust gathered on the engine surface, turbocharger, cylinder head cover and air filter can be wiped clean with a dry rag or cloth dipped in a bit of diesel. Clean off the dust gathered on the charging alternator, radiator, intercooler and fan by wiping or blowing with compressed air.

B. First order maintenance

Besides the maintenance work given in “Daily maintenance”, add the following items:

(1) Check the voltage of the battery and specific gravity of the battery acid. The specific gravity of the battery acid should be within 1.28-1.29 (at ambient temperature of 15°C) and should not be lower than 1.27. Check the level of the battery acid which should be 10-15 mm above the pole plates. If insufficient, add distilled water to required level.

(2) Unscrewing oil drain plug on the the oil pan. Clean it in fuel. (If the oil is rather clean, its change period can be prolonged.)

(3) Fill all grease nipples with the proper grade of grease and fill all oil cups with lubricating oil.

(4) Diesel engine first run accumulate full 50 hours, must be replaced oil filter element; After running accumulate full 150 hours, must be replaced oil filter element to ensure that enter the high pressure oil pump of the diesel cleanness to use requirement, when change, only diesel filter together with shell from the filter holder unscrew and put on the new filter assembly to filter seat, to ensure the seal, when install the new filter, can be on the top of the seal face coated with a small amount of oil, and then screwing in filter in the seat.

(5) After the diesel engine’s running for first 50 hours, oil filter element of turbocharger must be replaced; after the later 150 hours, oil filter element of turbocharger must be replaced.

(6) Move the turbocharger rotor with hand. If the rotor cannot rotate freely and smoothly or stop rotating soon, this means that the bearings may be worn excessively or there occur collision or jam between rotor and its mountings or there may be severe carbon deposit on the air sealing plate of turbo back. In such a case, disassemble the turbocharger and check radial clearance and axial move of rotor to analyze probable causes and remedy them.

(7) Check the tightness of bolts of busts on connection between turbine case and middle case and tighten them if loose.

(8) Disassemble the compressor housing and clean impeller and passage of compressor housing.

(9) Clean air filter and get rid of the dirt in the collector. Take out the filter-element and clean off the dirt by vibrating or blowing with compressed air (its pressure is 98~147kPa) from the center to the outside.

Maintenance about the air filter should be done regularly as the following requirements:

① Open the back cover and clean dust gathered in dust collector for an interval

of every 50-100 operation hours (determined by working condition of diesel engine).

- ② Take out the filter-element and clean it by vibrating or blowing with compressed air (pressure is 98~147kPa) from the center to the outside for every 100~200 operation hours.
- ③ Renew the filter-element for an interval of 500~1000 operation hours or the exhaust smoke is over-rich and exhaust temperature is over-high caused by filter-element choked.
- ④ Keep the filter-element dry and renew it while the filter-element is perforated and polluted by water or oil.
- ⑤ Strictly forbidden to clean the filter-element with any kind of oil and water.

C. Second order maintenance

Apart from the items stated in “First order maintenance”, add the following:

- (1) Check the injection pressure and spray pattern of the injectors. If necessary, dismantle the injector, clean the parts and adjust. (This series of diesel injector for injection pressure is 24 MPa)
- (2) Check the calibration of the injection pump. If necessary, recalibrate it.
- (3) Check valve timing and injection timing. If necessary, adjust these timings.
- (4) Dismantle cylinder head. Check seal and wear of valves. Repair if necessary.
- (5) Check leakage of fresh water pump. Repair or replace if necessary.
- (6) Remove the oil sump and check the cylinder liners for water leakage. If necessary remove the cylinder liner, the liner rubber seal rings should be renewed.
- (7) Remove the timing gear case cover and check the transmission mechanism of gear lubrication condition. If the nozzle hole is blocked, probe it with a wire of proper size.
- (8) Check the lubricating oil cooler and radiator for oil and water leakage. If necessary, repair.
- (9) Check the tightness of the connecting rod bolts, crankshaft bolts and nuts, cylinder head studs and nuts, and main bearing cover bolt. If necessary, remove, check and tighten the rules to torque again.
- (10) Check the wiring contacts of the electric system. Burnt marks should be removed.
- (11) Clean piping of lubricating oil and fuel system including oil sump, lubricating oil piping, lubricating oil cooler, fuel case and fuel piping. Clean off the dirt and blow them dry.
- (12) Clean the cooling system. Compounding and method is described in SECTION II.
- (13) Whether it is necessary to disassemble the turbocharger or not can be judged by the running condition of the engine. If necessary, disassemble the turbocharger and do the following work: clean air seal ring and air seal plate of turbo end, clean the dirt and carbon deposits of turbo impeller and inlet shell, clean oil reservoir of middle shell, check the wear of float bearing. Replace the parts if it is seriously worn. Check the wear of oil seal ring and see whether it is distorted and sintered, replace the parts

if so.

D. Third order maintenance

Apart from the items stated in “Second order maintenance”, add the following:

(1) Check cylinder head assembly. Check wear of valves, valve seats, valve guides, valve springs, as well as fitting surfaces between push rods and rocker arms. If necessary, repair or replace worn parts.

(2) Check piston and connecting rod assembly. Check wear of piston ring, cylinder liners, and connecting rod bearing and bushing. If necessary, replace worn parts.

(3) Check the crankshaft assembly. Check wear of main journal, connecting rod journal and spindle tile. If necessary, replace worn parts.

(4) Check drive mechanism and remove gearcase. Check wear of tooth surfaces of drive gears and measure their backlashes. If necessary, repair or replace worn parts.

(5) Check fuel injection pump and governor. Check the tightness of oil pump plunger matching parts and governor. If necessary, repair or replace worn parts.

(6) Check lubricating oil pump and fresh water pump. Check and measure parts which are liable to wear. If necessary, readjust.

(7) Check gaskets of cylinder head and intake and exhaust manifolds. Any gasket damaged or has lost its sealing effect should be replaced.

(8) Check charging alternator and starting motor. Clean all parts and bearings, blow them dry and fill with new grease, check wear condition of starting motor pinion and see whether transmission mechanism is running freely.

2. Diesel engine bolt, nut tightening torque summary

Table 1 The main thread connecting pieces of tightening torque

No.	Name	Tightening torque (N·m)	
		TWC40	TAD43
1	Cylinder head nuts M18×2	360	360
2	Main bearing cover bolts M20×2	460	460
4	connecting rod bolts M18×1.5	260	260
5	Flywheel bolts M18×1.5	360	360
6	Fuel injection pump drive gear nuts M27×1.5	400	400
7	Oil sump bolts M8	30	30

Ordinary bolt, nut (drawing and technical document does not indicate tightening torque, and used for screwing in steel or cast iron parts) of the tightening torque may refer to the requirement listed in table below, see table 2.

Table 2

unit: N·m

Thread Strength	M6	M8	M10	M12	M14	M16	M18
8.8	8±2.5	22±5	39±7	70±10	115±15	176±20	235±25
10.9	13±2.5	31±5	58±7	100±10	162±15	240±20	330±25

Note: 1. This form is applicable to level 6 precision thread, the oil or anaerobic acid as lubricant.

2. Use galvanized thread, tightening torque should be reduced by 20%

3. Thread hole material is aluminum parts, tightening torque should be reduced by 20%

Chapter Five Fault and solution

1. Diesel engine can't start

No.	Probable causes	Remedies
1	<p>Fault in fuel system:</p> <p>(1) Air trapped in fuel system</p> <p>(2) Fuel piping blocked</p> <p>(3) Fuel filter choked</p> <p>(4) Feed pump supplies fuel irregularly</p> <p>(5) Fuel injected too little or no fuel at all. Fuel spray not atomized.</p>	<p>(1) Check fuel piping connections. If loose, tighten it. Loose the vent screw on the injection pump and fuel filter, work the hand priming pump till fuel flowing out of the vent screws is without air bubbles, tighten the vent screws and the hand pump knob.</p> <p>Loose the injector high pressure piping connector and actuate the injection pump plunger by means of a screw driver till fuel flowing out of the high pressure piping is without air bubbles. Tighten the connector and pump plunger another few strokes so that the injector is filled with fuel.</p> <p>(1) Check and clean.</p> <p>(3) Clean or renew element</p> <p>(4) Check the inlet piping for leakage. If the fuel inlet pipe and its connections are normal, dismantle the feed pump for check and repair.</p> <p>(5) Take the injector out of the cylinder head. Connect it with high pressure fuel piping to observe its spray. Actuate the injection pump plunger and check weather its spray is normal. If necessary, replace couple.</p>
2	<p>Fault in starting system:</p> <p>(1) Wires not correctly connected or not in firm contact.</p> <p>(2) Battery not charged</p> <p>(3) Bad contact between the brushes and commutator of the starting motor</p>	<p>(1) Check and correct</p> <p>(2) Use fully charged batteries or temporarily series connect another battery for starting.</p> <p>(3) Repair or renew the brushes. Polish the commutator surface with sand paper and blow clean.</p>
3	<p>Compression pressure insufficient:</p> <p>(1) Piston rings worn</p> <p>(2) Valves leaked</p>	<p>(1) Renew. If the liner is also worn, renew it at the same time.</p> <p>(2) Check valve lash, valves springs, valve guide and sealing of the valves with their seats. If the valve seating line is not continuous, lap the valve with its respective seat until a bright, even, continuous band is obtained.</p>

2. Diesel engine in normal operation situation suddenly sends out the power of provisions

No.	Probable causes	Probable causes
1	Valve springs damaged	Check and renew
2	Valve timing and injection timing incorrect	Check and adjust. Check tightness of injection pump coupling screws. If loose, tighten them.
3	Valve lash incorrect	Check and adjust to specified value.
4	Compression pressure insufficient. Piston or valve movement sluggish.	Clean and repair.
5	Engine overheated, (Fault in cooling water or lubricating system causing water temperature too high)	Check cooling water and lubricating system. Clean scale in water jacket. Clean lubricating oil cooler.
6	Serious carbon deposits.	Dismantle the cylinder head and clean off the carbon deposits. Find its causes.
7	Air cleaner choked.	Clean or renew the filter element.
8	Exhaust manifold blocked.	Check and clean.
9	Air in fuel system.	According to the foregoing, fuel system of air discharge
10	Injection pump out of order	Check or repair. Renew plunger and barrel couples if necessary.
11	Injector out of order	Check or repair. Renew nozzle couple if necessary.
12	Gas leakage in injector hole of cylinder head (1) Nozzle cap nut copper washer damaged. (2) Dirt on injector seating surface. (3) Leakage in nozzle and nozzle holder contact surface.	(1) Renew. (2) Remove. Clean the surface. (3) Tighten the nozzle cap nut. Lap the contact surface if necessary.
13	Gas leakage in cylinder head gasket (The characteristic is: when change the speed, a stream of air out of the gasket place.) (1) Cylinder head nuts loose. (2) Cylinder head gasket damaged	(1) Tighten to specified torque. (2) Check contact surface of cylinder head and cylinder block. Repair if necessary. (Don't try to repair the damaged gasket.)
14	The connecting rod bearing shell and the crankshaft's connecting rod surface bite together, with some unordinary noise and the dropping of oil pressure.	Dismantle the side cover of the diesel engine, check the clearance of the large end of connecting rod and check the moving. If the large end cannot move, it means there is biting between them, repair the crankshaft and replace the shell.

3. Unordinary noise

No.	Characteristic of trouble	Probable causes	Remedies
1	Clear rhythmic metallic pounding noise from cylinder	Injection timing too early	Readjust injection timing
2	Low dull pounding noise from cylinder.	Injection timing too late.	Readjust injection timing
3	Light clear noise which is especially clear when engine idles.	Clearance between piston pin and connecting rod small end bushing too large.	Renew connecting rod small end bushing.
4	Pounding noise from cylinder right after engine is started. This noise reduces as engine warm up.	Clearance between piston and liner too large.	Renew piston rings. If the liner has worn beyond the specified limit, renew it too.
5	When engine runs at 1500 rpm, the crankcase emits a pounding noise which becomes a dull forceful noise as engine speed suddenly drops.	Connecting rod large end bearing clearance too large.	Check. Renew bearings if necessary.
6	A light rhythmic clicking noise from cylinder head.	Valve spring broken, or valve push rod bent, or tappet worn.	Renew the worn and damaged parts. Adjust valve lash to the specified limit.
7	A dull, even, rhythmic clicking noise from cylinder head. With fingers touching the cylinder head cover crown nut, valve pounding the piston can be felt.	Valve pounding the piston.	Remove cylinder head cover and check which valve pounds the piston. Adjust valve lash. If necessary, replace cylinder head gasket with a thicker one (0.20-0.40mm thicker than standard gaskets can be supplied), or machine down the valve cavity on the piston.
8	Unordinary noise from timing gear case cover. When engine speed suddenly drops, gear pounding noise can be heard.	(1)Gears seriously worn (2)Gear backlash too large	Adjust gear backlash. Renew the gear if it is seriously worn.
9	Dry metallic rubbing noise from cylinder head.	No oil between rocker arm and valve tip.	Add oil.

4. Abnormal exhaust color

When the engine is operating under load, the exhaust usually is of greyish color. At high loads, it may be of deep grey. (It is permitted to operate with such exhaust for short durations.) Exhaust color is considered abnormal when the engine emits black smoke, or when its color becomes blue or white. Ordinarily, engine emits black smoke is due to incomplete combustion. When it emits blue smoke, lubricating oil may have

entered into the combustion chamber and when it is white, fuel injected into the combustion chamber may be not fully ignited. The causes and remedies of these faults are given below:

No.	Characteristic of trouble	Probable causes	Remedies
1	Black smoke	(1) Engine over-load. (2) Uneven delivery of injection pump elements. (3) Valve lash incorrect, or valves leaked. (4) Injection timing too late. Part of the fuel burns in exhaust manifold. (5) Air intake insufficient.	(1) Reduce the load. (2) Recalibrate the injection pump. (3) Check valve lash and condition of the valves and valve springs. Repair or renew. (4) Adjust injection timing. (5) Check the intake pipe of the air cleaner.
2	White smoke	Injector nozzle leaked, or injection pressure too low, or fuel not atomized.	Check. Adjust injection pressure. Renew nozzle couple if necessary.
3	Blue smoke	(1) Piston ring stuck or worn, or ring pressure dropped causing lubricating oil to enter the combustion chamber. (2) Too much oil in the sump.	(1) Clean and check the piston rings. Renew if necessary. (2) Oil filled in should be in accordance with the marks indicated on the oil level.

5. Lubricating oil pressure abnormal

If lubricating oil pressure drops or rises after a period of operation, it can be readjusted by means of the pressure adjusting screw on the lubricating oil filter. If this cannot adjust it back to normal limits, check the following:

No.	Probable causes	Remedies
1	Lubricating oil pump abnormal due to wear of pump gear or incorrect assembly.	Check and test the pump. Readjust the clearance. If necessary, renew the pump gears or the entire pump assembly.
2	Oil passages leaked, blocked or damaged.	Check and repair. Renew if necessary.
3	Oil cooler or oil filter choked.	Check and clean.
4	Oil pressure adjusting spring distorted or damaged, pressure adjusting valve not in good contact with its seat.	Renew the spring, or lap the valve seating surface.
5	Serious oil leakage in front extension shaft, crankshaft flange, oil piping to rocker arm shaft, camshaft bearing or connecting rod bearing.	Check. Repair or renew the worn or damaged parts.
6	Oil pressure gauge damaged or pressure gauge piping blocked.	Renew the gauge or clean the pressure gauge piping.

6. Lubricating oil temperature too high, oil consumption too high and dilution of lubricating oil

No.	Probable causes	Remedies
1	Oil temperature too high: Due to engine overloaded (engine emits black smoke) or oil cooler choked.	Reduce the load or clean the oil cooler.
2	Piston rings stuck or seriously worn, or cylinder liner worn causing lubricating oil to enter the combustion chamber and gas to leak into the crankcase. This is accompanied with blue smoke and the crankcase breather also emits smoke.	Renew the worn rings. If the liner is worn, renew it also
3	Unsuitable lubricating oil used	Use the correct grade of lubricating oil. See SECTION II
4	Oil return holes on the oil scraper ring blocked by carbon deposits.	Remove the carbon deposits and clean the ring. Renew if necessary.

7. Oil level in engine sump rises

If the oil level in the engine oil sump becomes higher than the original level after a period of normal operation, its main cause is probably that cooling water has leaked into the lubricating oil. When this occurs, there will be yellow bubbles in the lubricating oil. (Draw some oil out and put it in a glass. After letting it still for an hour or so, observe whether or not there is water settled at the bottom of the glass.)

No.	Probable causes	Remedies
1	Water seal of cylinder liner damaged.	Renew.
2	Cylinder head cracked. (When this occurs, water content of exhaust increases and water gathers in the exhaust manifold.)	Renew.
3	Cylinder head gasket damaged.	Renew.
4	Lubricating oil cooler (water cooled type) core damaged. (Take a water sample and check whether there is any oil droplet in the water.)	Repair or renew the core.
5	Contact surface between the liner flange and cylinder block leaked.	Check copper gasket. Renew if necessary. (The gasket should be 0.25 mm thick.)
6	Cylinder liner seriously cavitated causing water leakage..	Renew the liner.
7	Water leaks into the sump through the fresh water pump:.	Check and repair. Renew the water seal or the water pump.

8. Engine outlet water temperature too high

No.	Probable causes	Remedies
1	Air leaked into piping causing vapor lock.	Vent by loosening the thermometer connector. Check the pipes and connections for leakage. Tighten the connectors and repair the leakages.

2	Poor circulation, insufficient water supply or pump impeller damaged.	Tighten water pump drive belt. For the open type cooling system, fill water tank to required level. For the close type system, fill radiator full. Check and adjust clearances. Renew damaged parts.
3	Radiator cooling tubes and fins covered with dust.	Clean.
4	Drive belt tension insufficient causing drop of pump and fan speed	Tighten drive belt. If the belt is worn, renew the drive belt.
5	Thermometer reading incorrect. Thermostat out of order.	Check. Renew if necessary.

9. Injection pump faults and remedies

No.	Probable causes	Remedies
1	Pump does not inject fuel; (1) Fuel tank empty. (2) Fuel feed pump out of order. (3) Fuel filter choked or fuel piping blocked. (4) Air in fuel system. (5) Plunger stuck. (6) Bad contact between delivery valve seat and barrel.	(1) Fill. (2) Check and repair. (3) Clean. (4) Vent. (5) Repair or renew. (6) Clean, repair or renew.
2	1.Uneven distribution of fuel: (1) Air in fuel system. (2) Delivery valve spring broken. (3) Delivery valve seating surface worn. (4) Plunger spring damaged. (5) Dirt in plunger and barrel impairing its movement. (6) Fuel feed pressure too low. (7) Toothed quadrant loose.	(1) Vent. (2) Renew. (3) Repair or renew. (4) Renew. (5) Clean. (6) Check fuel feed pump and fuel filter. (7) Adjust to marking. Tighten lock screw
3	1.Fuel injected to little: (1) Delivery valve leaked. (2) Fuel feed pump strainer blocked. (3) Plunger and barrel worn. (4) Incorrect assembly.	(1) Repair or renew. (2) Clean. (3) Renew. (4) Reassemble and recalibrate.
4	4.Fuel injected too much: (1) Uneven distribution of fuel. (2) Incorrect assembly.	(1) Recalibrate. (2) Reassemble and recalibrate.

10. Speed control faults and remedies

Faults and remedies of mechanical governor are given in electronic governor specification which accompanied with diesel engine.

11. Injector faults and remedies

No.	Probable causes	Remedies
1	Fuel injected too little or no injection: (1) Air in fuel system (2) Needle valve stuck (3) Needle valve movement sluggish (4) High pressure piping leaked (5) Fuel delivery of injection pump irregular	(1) Vent (2) Repair or renew (3) Clean or lap (4) Tighten the connectors. Repair or renew (5) Check and repair
2	Injection pressure too low: (1) Pressure adjusting screw loose (2) Pressure regulating spring deformed and fractured	(1) Readjust injection pressure to specified value (2) Repair or renew
3	Injection pressure too high: (1) Spring pressure too high (2) Needle valve stuck (3) Nozzle holes blocked by carbon deposits	(1) Readjust pressure or renew (2) Repair (3) Clean, repair or lap
4	Nozzle seriously leaked: (1) Pressure regulating spring damaged (2) Needle valve seating surface damaged (3) Needle valve stuck (4) Nozzle cap nut deformed (5) Nozzle holder sealing surface leaked	(1) Renew (2) Renew nozzle couple (3) Clean or renew nozzle couple (4) Renew the cap nut (5) Lap or renew
5	Fuel spray not well atomized: (1) Needle deformed or worn (2) Needle valve seating surface damaged or worn (3) Injection pressure too low	(1) Adjust (2) Renew nozzle couple (3) Renew nozzle couple
6	Fuel sprayed in straight line; (1) Nozzle hole blocked (2) Needle valve and needle valve seating surface worn (3) Needle valve stuck	(1) Probe holes with a 0.2~0.3mm diameter steel wire (2) Renew nozzle couple (3) Clean, repair or renew nozzle couple
7	Nozzle surface burnt or has a black bluish color (due to engine overheated)	Check engine cooling system and renew nozzle couple

12. Fuel feed pump faults and remedies

No.	Probable causes	Remedies
1	Fuel supplied by the feed pump insufficient: (1) Feed pump check valve worn or damaged. (2) Piston worn (3) Piping connection leaked. (4) Inlet connection strainer blocked	(1) Renew (2) Renew (3) Tighten or repair (4) Clean

Chapter six System and adjust

1. Adjustment of diesel engine

A. Fuel supply advance Angle adjustment

To ensure normal operation of the engine and to obtain the best economical fuel consumption and good combustion, injection timing should be checked and readjusted after every 500 operating hours and whenever the engine has been dismantled and reassembled.

To adjust injection timing, remove the high pressure fuel piping of the first cylinder and turn the crankshaft until the piston of the first cylinder is at the beginning of its expansion stroke. (To determine whether it is at the beginning of its expansion stroke, turn the crankshaft slightly and observe the movement of the valves. If the valves remain still when the crankshaft is slightly turned, it indicates that the first cylinder is at the beginning of its expansion stroke.) Check the timing pointer on the flywheel housing which should point at the “0” mark on the rim of the flywheel. At this position, the plunger spring of the first pump element of the injection pump should be compressed. (This can be checked by removing the B-type injection pump inspection door cover.) Then turn the crankshaft in the direction opposite to that of its rotation about 40°. After this, turn the crankshaft slowly and smoothly in the direction of its rotation and observe the fuel level in the fuel outlet of the delivery valve holder of the first pump element at the same time. When this fuel level just starts to rise, stop turning the crankshaft immediately. This is the beginning of injection of the first cylinder whose angle can be read out from the degree marking on the flywheel rim at which the timing pointer points. The angle at which injection begins should be at the range of technical parameter of the relevant model diesel engine. If it is not within this limit, it can be adjusted by loosening the two screws (Fig.1 item C) on the injection pump coupling and turn the crankshaft till the coupling has turned the required angle. After adjustment, tighten the two screws and check the injection timing again.

Another way to adjust the injection timing is to turn the injection pump coupling. Turn the crankshaft until the piston of the first cylinder is at the beginning of its expansion stroke. Then turn the crankshaft in the direction opposite to that of its rotation till the timing pointer on the flywheel housing is relevant mark. Remove the injection pump inspection door cover and loosen the two screws on the injection pump coupling. Turn the injection pump camshaft in the direction of its rotation till fuel level in fuel outlet of the delivery valve holder of the first pump element just stars to rise. Then tighten the coupling screws and check the beginning of injection again. The beginning of injection should also be within the range of technical parameter of the relevant model diesel engine.

B. Valve clearance adjustment and distribution timing check

Before adjusting valve clearance, adjust valve bridge is needed. Valve Bridge is used to make a rocker arm controls two valve institution. Adjusting Valve Bridge is designed to make two valves work is consistent, and avoid the valve not at the same time open and produce stress. Specific steps are as follows:

Loosen adjusting nut of the valve bridge, and the adjusting screw (NO.3 in the following figure) unscrew;

The bridge into the valve bridge guide rod (NO.5 in the following figure), fingers gently press contact surface (NO.2 in the following figure) of rocker-arm, make the valve bridge and valve stem (NO.1 in the following figure) contact;

Light tightening valve bridge adjusting screw until its contact with the valve stem (NO.4 in the following figure) tip;

Tighten the nut on the adjusting screw;

According to this requirement, adjust all adjusting screw of Valve Bridge. Then we can adjust the valve clearance

Before adjusting the valve timing, attach a degree plate with 360°marks to the free end of the crankshaft and mount an adjustable pointer onto the timing gear case cover as a reference pointer when the crankshaft is turned.

Remove the cylinder head cover and turn the crankshaft until the timing pointer on the flywheel housing is pointing at the “0” mark on the rim of the flywheel. (Note: There are two punched marks on the timing mark inspection window of the flywheel housing for locating the timing pointer. For correct indication of timing, the timing pointer cannot be distorted and its two sides must be located within these two punched marks.) With the crankshaft at this position, adjust the adjustable pointer mounted on the timing gear case cover to point at the “0” mark on the degree plate.

This indicates that the piston of the first and the sixth cylinders of the engine are at their top dead center position. To determine whether the first cylinder is at the beginning of its expansion stroke, remove the injection pump inspection door cover and check whether the plunger spring of the first pump elements is compressed or slightly bar the crankshaft and observe whether the intake and exhaust valves move. If the plunger spring of the first pump elements is compressed or if the intake and exhaust valves remain still when the crankshaft is slightly barred, it means the first cylinder is at the beginning of is expansion stroke. Then, adjust the valve lash. With the crankshaft at this position, valve lash of the valve can be adjusted as the following.

(1) Adjustment of the valve lash for V12 diesel engine

Table.1 When the 1st cylinder of the engine are at the beginning of their expansion stroke, valve lash of the following valves can be adjusted.

Cyl. No.	1	2	3	4	5	6
Valves can be adjusted	intake, exhaust	intake	exhaust	intake	exhaust	

Turn the crankshaft 75°in direction of its rotation and let the twelfth cylinder at

the beginning of the expansion stroke. Valve lash of the following can be adjusted.

Table.2 When the 12th cylinder of the engine are at the beginning of their expansion stroke, valve lash of the following valves can be adjusted.

Cyl. No.	7	8	9	10	11	12
Valves can be adjusted		exhaust	intake	exhaust	intake	exhaust, intake

Using the same method, make the 6th cylinder and the 7th cylinder at the beginning of their expansion stroke, At this time, intake and exhaust valve lash in table.3 and table.4 can be adjusted.

Table.3 When the 6th cylinder of the engine is at the beginning of their expansion stroke, valve lash of the following valves can be adjusted.

Cyl. No.	1	2	3	4	5	6
Valves can be adjusted		exhaust	intake	exhaust	intake	exhaust, intake

Table.4 When the 7th cylinder of the engine is at the beginning of their expansion stroke, valve lash of the following valves can be adjusted.

Cyl. No.	7	8	9	10	11	12
Valves can be adjusted	exhaust, intake	intake	exhaust	intake	exhaust	

(2) Adjustment of the valve lash for 6-in-line engine

The number of the cylinder whose valve can be adjusted when the piston of the first cylinder is at the beginning of its expansion stroke is 1-2-4 for intake valve and 1-3-5 for exhaust valve. The number of the cylinder whose valve can be adjusted when the piston of the sixth cylinder is at the beginning of its expansion stroke is 3-5-6 for intake valve and 2-4-6 for exhaust valve.

To adjust valve lash, loosen the lock nut and valve lash adjusting screw on the rocker arm by means of a wrench and screw driver. Slip a feeler gauge between the rocker arm and the tip of the valve stem. Adjust the adjusting screw till the rocker arm just presses the feeler gauge against the valve stem tip and the feeler gauge can just be withdrawn by a slight pull. Then lock the adjusting screw with the lock nut, and check the valve lash again.

After adjusting the valve lash, valve timing can be checked. Usually, it is not necessary to check the valve timing. If necessary, begin with the 1st cylinder. While barring the crankshaft over, feel the movement of the push rod by turning it with fingers. As long as there is clearance between the rocker arm and the tip of the valve stem, the push rod of that valve is free to rotate. Thus, while the crankshaft is slowly bared in the direction of its rotation, the moment at which the push rod can just not be turned by hand is the moment at which the valve starts opening. Stop barring the crankshaft immediately and note the reading on the degree plate indicated by the

reference pointer at the free end of the engine. This is the opening angle of that valve.

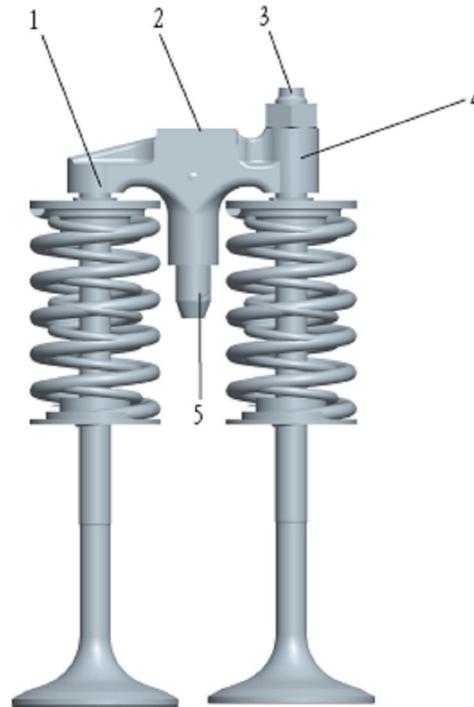


Figure 1 Valve bridge for adjustment and structure

After taking the angle of opening, turn the crankshaft in the same direction until the push rod of that valve can just be rotated with fingers. This is the angle at which the valve just closes. Note the reading indicated by the reference pointer. Valve timing can thus be checked according to the ignition order of the engine. The specified valve timing is accordance with the range in technical parameter. If valve timing is incorrect due to wear of parts, it can be slightly compensated by varying the valve lash. Reducing the valve lash enables the valve to be opened earlier and closed latter. Increasing the valve lash gives the opposite results. But when doing such compensating adjustments, the valve lash must still be within the specified range.

Intake valve: Valve and rocker arm clearance under cold condition 4~0.45 mm

Exhaust valve: Valve and rocker arm clearance under cold condition 0.5~0.55 mm

2. Fuel、 speed control system

Speed control system consists of the oil transfer pump, fuel filter, fuel injection pump, governor, injector, high pressure oil pipe, return line etc , is the main component of diesel engine.

After the fuel delivery pump inducts the fuel from tank, the fuel is sent to fuel filter and filter it clear, goes into the fuel injection pump, the fuel injection pump fuel pressure is increased, according to different conditions will be the fuel delivery, through high pressure tubing is sent to the fuel injector, the fuel injector sprays the fuel into combustion chamber by mist. In order to keep the appearance and clean around of diesel engine and recycle the fuel, little fuel runs out from the fuel injector side return line, the user shall take back to the tank.

Reliability of the fuel system and governor directly affects the operating characteristics of the diesel. Therefore during dismantling, repair, reassembling, adjusting and testing of the fuel system and governor, it is important to keep all parts clean. Remember, cleanliness is of primary importance to quality and reliability.

There are two kinds of speed control system of WD164 series. One of electric consists of speed sensor, electromagnetic performer, speed controller, control switch and connecting cable etc. Speed sensor has been installed on the flywheel housing of the diesel engine. Speed signal would come out from flywheel ring gear of the diesel engine. Electromagnetic performer has been installed in the back of the high pressure oil pump. Speed controller, and connecting cable has been placed or installed in the monitoring instrument of the engine. High-low switch and stop switch (power switch) would be supplied with the engine. The power of the electronic governor is 24V battery which is used to start the engine. Users can refer to the operation manual for electronic governor during operation and maintenance of the electronic governor. When power generation diesel engine adopts electronic governor, its governing performance is obviously increased. The ratio of steady-state governing is no more than 3%. The speed fluctuation is so low that it would satisfy completely the technical requirement of mating power generator.

When the engine is tested at the factory, each parameter of speed controller has been set and lead sealed. Don't adjust it without permission of the specialist of manufacturer. Otherwise, the product would not be placed into the quality assurance service extent. If you want to adjust the engine's starting speed on special condition, you can adjust the remote control potentiometer. If you want to shut down the engine in an emergency, you can shut down the power of the electric governing by shutting down the power switch (stop switch of the diesel engine) of electric governing. The other is mechanical speed governor. The speed limit screw which has been well-adjusted and lead sealed at the factory is not allowed to be sealed without the permission of the specialist of manufacturer, or the engine will not be included in the warranty scope. There is one shutdown handle to stop the engine in an emergency placed on the speed governor front cover. There is low speed stabilizer on the speed governor cover to avoid the instability under low speed. When the low speed is rough, the low speed stabilizer can be switched in until the engine speed is stable (generally the speed varies between ± 25 r/min). The low speed stabilizer is not permitted switching if unnecessary. When the fuel injection pump and speed governor has been disassembled and repaired, the low speed stabilizer can be adjusted if the engine speed is rough. But it is noted that the low speed stabilizer cannot be switched in too much in case of high speed without load which may cause accident.

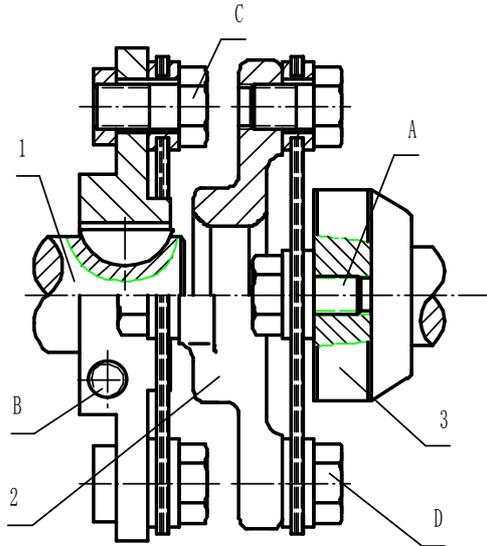


Fig.2 Assembly parts of steel plate coupling

- | | |
|------------------------------------|-------------------------------|
| 1. Gear shaft of injection pump | 2. Steel plate coupling |
| 3. Jointing tray of injection pump | 4. Camshaft of injection pump |

In order to ensure the reliability of transmission agent , WD164 series diesel engines all adopt steel plate coupling between high-pressure fuel pump and transmission shaft of gear chamber .The fitting relation of steel plate coupling and transmission shaft and jointing tray of fuel pump can see the following figure.

At first, install the steel plate coupling on the transmission shaft of injection pump and make sure it can be moved along axial direction. Then loose bolts D (2) and tighten the back-end steel plates (4) of steel plate coupling on the jointing tray of injection pump with bolts A (2), the tighten moment of bolt A is 40N.m. The next is that tighten the bolts D (2) on the steel plate coupling, tighten moment is 40N.m too. Then, adjust the axial location of steel plate coupling and ensure the steel plates are no deflection, tight bolt B (1) and the moment is 40-50N.m and make the steel plate coupling fixed with the transmission shaft of injection pump reliability. At last, loose bolts C (2) and adjust the fuel supply advance angle to specified range, then tighten the bolts C (2) to 40NM. Thus, the installation of steel plate is finished.

3. Lubrication system

In the splash lubricating system, oil is splashed up from the oil pan or oil trays in the lower part of the crankcase. The oil is thrown upward as droplets or fine mist and provides adequate lubrication to valve mechanisms, piston pins, cylinder walls, and piston rings. In the combination splash and pressure feed lubricating system, an oil pump takes oil from the oil pan and forces it through holes drilled in the engine block and crankshaft. This oil thereby reaches the various bearings that support rotating shafts and the different moving parts in the engine. It covers the surfaces of the moving parts in the engine. It covers the surfaces of the moving parts to prevent metal- to- metal contact and undue wear of the parts. In this system, cylinder walls are lubricated by splashing oil thrown off from the connecting-rod bearing. The lubricating oil circulating through the engine to all moving parts requiring lubrication

performs When the Lubrication system is breakdown, it will cause serious accident, one should always check.

4. Cooling system

The cooling system of WD164 series on a turbocharged inter-cooled diesel engine can divide into opened and closed. Pressurization air - air cold model use only closed cycle.

When users overhaul pump installation, strictly prohibit knock, loaded askew and damage mounting surface. In less than 0 °C after the winter use, we shall promptly open cooling system all parts on the water drain valve, put all cavity hydrops to prevent pump frost crack.

Thermostat is used to adjust the water temperature of diesel engine. When the cooling water in low temperature, close thermostat valve, the cylinder cover all the thermostat bypass back into the circulating pump When the water temperature in the $72+2^{\circ}\text{C}$, thermostat valve began to open, now the water is still part of the thermostat bypass back into the circulating pump, part of the water with the thermostat valve discharge. When the water temperature reached 84°C , thermostat valve fully open, bypass closed, all the thermostat water valve discharge.

When need to check the thermostat, can put it in the water slowly heating. When the temperature reached $72+2^{\circ}\text{C}$, the thermostat will begin to open. When temperature is up to 84°C , the thermostat should be fully open. Thermostat need very good maintenance, don't touch injury or let contamination jams, in order not to disturb the normal work of it. No thermostat, will lead to diesel engine cooling water temperature is too low, bad for diesel engine normal operation. Therefore, thermostat damage should be repaired or replaced after, don't cancel.

5. Starting system

Starting system mainly has battery, starter motor, charging generator and some accessories wire, etc.

In the work, always pay attention to the battery voltage and the proportion of electrolyte, the proportion of electrolyte should be $1.28 \sim 1.29$ (atmospheric temperature 15°C), usually is not less than 1.27. Under normal circumstances, diesel engine charging generator can guarantee to maintain the state of sufficient electric battery. But in special circumstances, such as diesel engine stopped for a long time, possible battery voltage shortage phenomenon, at this time should be in other power supply to the battery charge.

Always check starting motor fasteners coupling is strong or not, wire contact is close or not, and eliminate accumulated pollutant, coated with a little grease to prevent rust. Always check the wire insulation is damaged or not. Periodically remove dust band. Check the commutator surface is bright and clean. Within the framework of the carbon brush in whether there is stuck phenomenon. Carbon brush spring pressure is normal or not, and remove dust. If discover the carbon brush wear too much, commutator surface singeing serious and other fault, should remove the repair.

Charging generator by triangular rubber belt drive in use shall regularly check

the triangular rubber belt tension force, to ensure the normal charge. Silicon rectifier generator and battery must be used together, the line connection conducted as per requirement, and connection should be correct, reliable anode must not pick the wrong or pick back, or will damage the generator. Silicon rectifier generator and the plate with ball bearing, bearing lubrication with composite calcium base grease, grease in the use of about 1000 h ours need to change, when changing, filling quantity should be appropriate, back cover bearing inner oil unfavorable overmuch, too much easy to overflow splash in the slip ring caused bad contact, affect the performance of the charging generator. Silicon rectifier generator structure is simple, do not need special maintenance, usually just use bellows or compressed air to motor in the dust, keep air way clear, observe the carbon brush and slip ring contact situation, check the carbon brush wear and the fastener tighten situation.

Note: Generator operation, are not allowed to use screwdriver (driver), and other metal items will be positive and terminal and casing or negative sub to see if there is a spark to determine whether charging generator, so easy to damage the components.

6. Inlet and exhaust system

The inlet and exhaust system of 12V diesel engine are mainly about column inlet pipe, pipe, or so column exhaust transition pipe, inlet nozzle, gasket, pipe cover, air filter, etc of parts.

6-in-line diesel engines have only one intake pipe, however 12V diesel engine with one intake pipe for each column. Intake pipe are made from cast aluminum, volume is larger, can rise to regulated effect. Lumen both airway also have channel, intercooler will supercharger compression after the high temperature air cooling, after each cylinder after inlet into the cylinders for combustion; At the same time by the body of each cylinder on hole into the cylinder head of the cooling water collect in front of thermostat outlet pipe into the tank. Inlet pipe installation must be pay attention to, the intake pipe and cylinder head joint surface must be sealed to prevent water inlet pipe leakage, do not allow metal scraps any sundry, or suction cylinder will cause part damage accident.

Generator engine exhaust pipe of WD series is made of cast iron. Each of the two columns of exhaust pipe of 12V is made up of two pipes which are sealed by sealing ring. Exhaust outside tube general to outdoor or underground pipeline, pipes should not be too long or sharp turn, bend should not be more than three, and took over the inside diameter not less than $\phi 150$ mm, lest increase exhaust back pressure, reduce the power output. Exhaust back pressure is not more than 6kpa. In the external pipe position should be equipped with temperature difference expansion joints, pipe support and exhaust temperature measuring joint and other equipment. Also, note: do not over the weight bearing in the supercharger or diesel engine exhaust pipe, otherwise easy to make pipe and connecting bolt vibration fracture or damage the supercharger. Connected to the outdoor pipe mouth should consider to fireproofing, heat insulation and rainproof measures.

Ship engine exhaust pipe of WD164 series is made of cast iron. Water channel is

arranged around the exhaust pipe that is cooled by the coolant from heat exchanger. Thus the temperature of the cabin can be largely lowered. But it should be noticed that the height of water outlet of exhaust pipe cannot be lower than it of exhaust pipe in case of poor cooling water circulating. Cooling the exhaust pipe directly with sea water is not allowed which can lead to explosion of exhaust pipe under the hot and cold temperature. When the temperature is below zero, the drain valve must be opened to empty the coolant to prevent the iced water from cracking the exhaust pipe.

7. Diesel Engine Use Characteristic

The engine can't speed up until it works at low speed for a period from starting or it will cause the bearing of turbo charger burnt out. Especially when the situation that the oil is replaced, oil filter is cleaned or the filter element is replaced, or the engine is shut down for a week above happened, the oil inlet port of oil filter of turbo charger must be loosened to let the oil flow out before tightened on idle condition after started. The diesel engine can't be loaded until the idle condition runs for several minutes.

The oil inlet port of turbo charger must be removed and 50ml-60ml of oil should be added to each turbo charger when using new engine or replacing the turbo charger in the risk of burning out the turbo charger's bearing caused by lack of oil.

Idle condition and condition under 50% of rated power should be avoided, or the oil leakage into booster from turbo charger will burst out the exhaust pipe.

Idle condition must be run by 2min-3min before the engine is shut down. In common case, the diesel engine is not allowed to shut down abruptly to keep from bearing seizure caused by turbo charger overheating.

Whether the abnormal friction between the blades and cover of the turbo charger happens should be monitored rightly after the diesel engine stops. If abnormal, gaps between the bearings must be tested.

Seal of intake pipe and exhaust pipe must be kept or the engine performance will be affected. Whether tight nut or bolt, hose clamp, sealing gasket is loosen should be checked frequently.

[Load power should be matched when using supercharged diesel engine. Long-time overload operation will cause unnecessary trouble which will reduce working performance.]

Warranty period of diesel engines:

For users of WD series diesel engines, we guarantee our product can operate satisfactorily if it is properly operated and maintained for a period of 12 months, or 1500h of operation (The warranty period will be terminated after either of these two conditions expires). If any part is damaged due to quality within this period, we will be responsible to repair or renew the damaged part for free.

Appendix. Power correction FACTOR

Power correction factor table

Table.1 Power correction factor C of turbocharged air-air cooling diesel engine

Altitude /m	Atmospheric Pressure	Atmospheric Temperature °C									
	mmHg	0	5	10	15	20	25	30	35	40	45
0	760	—	—	—	—	—	—	0.973	0.939	0.906	0.875
200	742	—	—	—	—	—	0.993	0.957	0.923	0.891	0.860
400	725	—	—	—	—	—	0.977	0.941	0.908	0.877	0.847
600	708	—	—	—	—	0.997	0.960	0.926	0.893	0.862	0.833
800	691	—	—	—	—	0.980	0.944	0.910	0.878	0.848	0.819
1000	674	—	—	—	1.000	0.963	0.928	0.895	0.863	0.833	0.804
1500	634	—	—	0.996	0.958	0.923	0.889	0.857	0.827	0.798	0.771
2000	596	—	0.992	0.954	0.918	0.884	0.851	0.821	0.792	0.764	0.738
2500	560	0.988	0.950	0.913	0.879	0.846	0.815	0.786	0.758	0.732	0.707
3000	526	0.946	0.909	0.874	0.841	0.810	0.780	0.752	0.725	0.700	0.676
3500	493	0.904	0.869	0.835	0.804	0.774	0.746	0.719	0.693	0.669	0.646
4000	462	0.864	0.830	0.798	0.768	0.739	0.712	0.687	0.662	0.639	0.618

Table.2 Power correction factor C of turbocharged water-air cooling diesel engine

The temperature of coolant of the intercooler is 25 °C

Altitude /m	Atmospheric Pressure P	Atmospheric Temperature °C									
	mmHg	0	5	10	15	20	25	30	35	40	45
0	760	—	—	—	—	—	—	0.989	0.970	0.952	0.934
200	742	—	—	—	—	—	0.993	0.973	0.954	0.936	0.918
400	725	—	—	—	—	0.997	0.977	0.957	0.939	0.921	0.903
600	708	—	—	—	—	0.980	0.960	0.941	0.923	0.905	0.888
800	691	—	—	—	0.984	0.964	0.944	0.926	0.908	0.890	0.873
1000	674	—	—	0.987	0.967	0.947	0.928	0.910	0.892	0.875	0.858
1500	634	0.988	0.966	0.946	0.926	0.907	0.889	0.871	0.855	0.838	0.822
2000	596	0.946	0.925	0.906	0.887	0.869	0.851	0.835	0.818	0.803	0.788
2500	560	0.905	0.886	0.867	0.849	0.832	0.815	0.799	0.783	0.768	0.754
3000	526	0.867	0.848	0.830	0.813	0.796	0.780	0.765	0.750	0.735	0.722
3500	493	0.828	0.810	0.793	0.777	0.761	0.746	0.731	0.717	0.703	0.690
4000	462	0.791	0.774	0.758	0.742	0.727	0.712	0.698	0.685	0.672	0.659

Table.3 Power correction factor C of turbocharged water-air cooling diesel engine

The temperature of coolant of the intercooler is 35 °C

Altitude /m	Atmospheric Pressure	Atmospheric Temperature °C									
	mmHg	0	5	10	15	20	25	30	35	40	45
0	760	—	—	—	—	0.997	0.977	0.957	0.939	0.921	0.903
200	742	—	—	—	—	0.980	0.960	0.941	0.923	0.905	0.888
400	725	—	—	—	0.984	0.964	0.945	0.926	0.908	0.891	0.874
600	708	—	—	0.989	0.968	0.948	0.929	0.911	0.893	0.876	0.860
800	691	—	0.993	0.972	0.952	0.932	0.914	0.896	0.878	0.861	0.845
1000	674	0.997	0.976	0.955	0.935	0.916	0.898	0.880	0.863	0.846	0.830
1500	634	0.956	0.935	0.915	0.896	0.878	0.860	0.843	0.827	0.811	0.796
2000	596	0.915	0.895	0.876	0.858	0.841	0.824	0.807	0.792	0.777	0.762
2500	560	0.876	0.857	0.839	0.822	0.805	0.789	0.773	0.758	0.743	0.729
3000	526	0.838	0.820	0.803	0.786	0.770	0.755	0.740	0.725	0.712	0.698
3500	493	0.801	0.784	0.767	0.751	0.736	0.721	0.707	0.693	0.680	0.667
4000	462	0.766	0.749	0.733	0.718	0.703	0.689	0.676	0.662	0.650	0.638

Table.4 Power correction factor C of turbocharged water-air cooling diesel engine

The temperature of coolant of the intercooler is 45 °C

Altitude /m	Atmospheric Pressure	Atmospheric Temperature °C									
	mmHg	0	5	10	15	20	25	30	35	40	45
0	760	—	—	—	0.985	0.965	0.946	0.927	0.909	0.892	0.875
200	742	—	—	0.990	0.969	0.949	0.930	0.912	0.894	0.877	0.860
400	725	—	0.995	0.974	0.953	0.934	0.915	0.897	0.880	0.863	0.847
600	708	—	0.978	0.958	0.938	0.919	0.900	0.882	0.865	0.849	0.833
800	691	0.983	0.962	0.941	0.922	0.903	0.885	0.867	0.851	0.834	0.819
1000	674	0.966	0.945	0.925	0.906	0.887	0.870	0.852	0.836	0.820	0.804
1500	634	0.925	0.906	0.886	0.868	0.850	0.833	0.817	0.801	0.785	0.771
2000	596	0.886	0.867	0.849	0.831	0.814	0.798	0.782	0.767	0.752	0.738
2500	560	0.848	0.830	0.813	0.796	0.779	0.764	0.749	0.734	0.720	0.707
3000	526	0.812	0.795	0.778	0.762	0.746	0.731	0.717	0.703	0.689	0.676
3500	493	0.776	0.759	0.743	0.728	0.713	0.699	0.685	0.671	0.659	0.646
4000	462	0.742	0.726	0.710	0.695	0.681	0.668	0.654	0.642	0.629	0.618