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MAINTENANCE OF DIESEL ENGINE FOR FISHING BOAT

Periodical Checks and Overhauling

Compiled
by
Kazuyuki Tobo

Training Department
Southeast Asian Fisheries Development Center

PREFACE

There are very few books which deal in general terms with maintenance of diesel engine for small fishing boats. One reason for this is that it is difficult to go into detailed procedures for many different types and models of engine now available on the market. Secondly, a trainee or a beginner would not understand the explanations without experience and practice. Most experts and servicemen of diesel engines have acquired their skills through years of experience.

However, every engine has an instruction book or a service manual. If the engine operator has some general or basic knowledge about engine overhauling, he will be able to disassemble, adjust and re-assemble his engine, by following the instruction in the manual. The purpose of this textbook is to help you understand your engine and its accompanying instruction booklet better. I have based this textbook on my lecture notes for Intensive Course for D.O.F. Marine Engineers of Thailand which was held from 1st to 16th October 1984.

May 1985

K. Tobo

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1. GENERAL

1.1 Maintenance

(1) An internal combustion engine is a complicated machine, built with a highest degree of precision throughout. It has the capability of long dependable service if it is kept in good condition; and its good condition depends entirely on suitable maintenance.

It is considered that there are three types of maintenance; periodical maintenance, preventive maintenance, and maintenance based on experience. And there is also, of course, non-maintenance. Figure 1 shows several stages of wear and the corresponding levels of maintenance.

(2) While the engine is in good condition and before any small wear is found, the engine is checked, cleaned, re-adjusted, and some parts changed, according to the periodical check schedule prescribed in the instruction booklet. We call this Periodical Maintenance.

This type of maintenance is based on inspection periods which are timed according to the past performance as observed by the manufacturer and operators. These inspections require partial or complete opening and re-assembling and cleaning of engine parts, and the replacement of universal parts.

However, such procedure has its disadvantages, the chief one being needless disassembly of an engine while it is in good operating condition. No matter how carefully the work is done, trouble may be induced either due to simply disturbing parts which have found a good running fit and finish, or by dust getting into the engine during assembly in spite of careful cleaning procedures. Some manufacturers claim that 90 per cent of bearing failures are due to dust, frequently introduced during to inspection work.

In order to insure good operation after a major overhaul, the engine should have a careful break-in period, similar to that recommended for a new engine. This permits the surfaces to become adjusted to the new conditions.

(3) To counteract those bad effects of periodical maintenance there is another maintenance system. After many hours of engine running in good condition, every engine will have some small wearing in some parts. If the engineer checks the temperature, pressure, and colour of lubricating oil, fuel, cooling system, exhaust system,

ENGINE MAINTENANCE

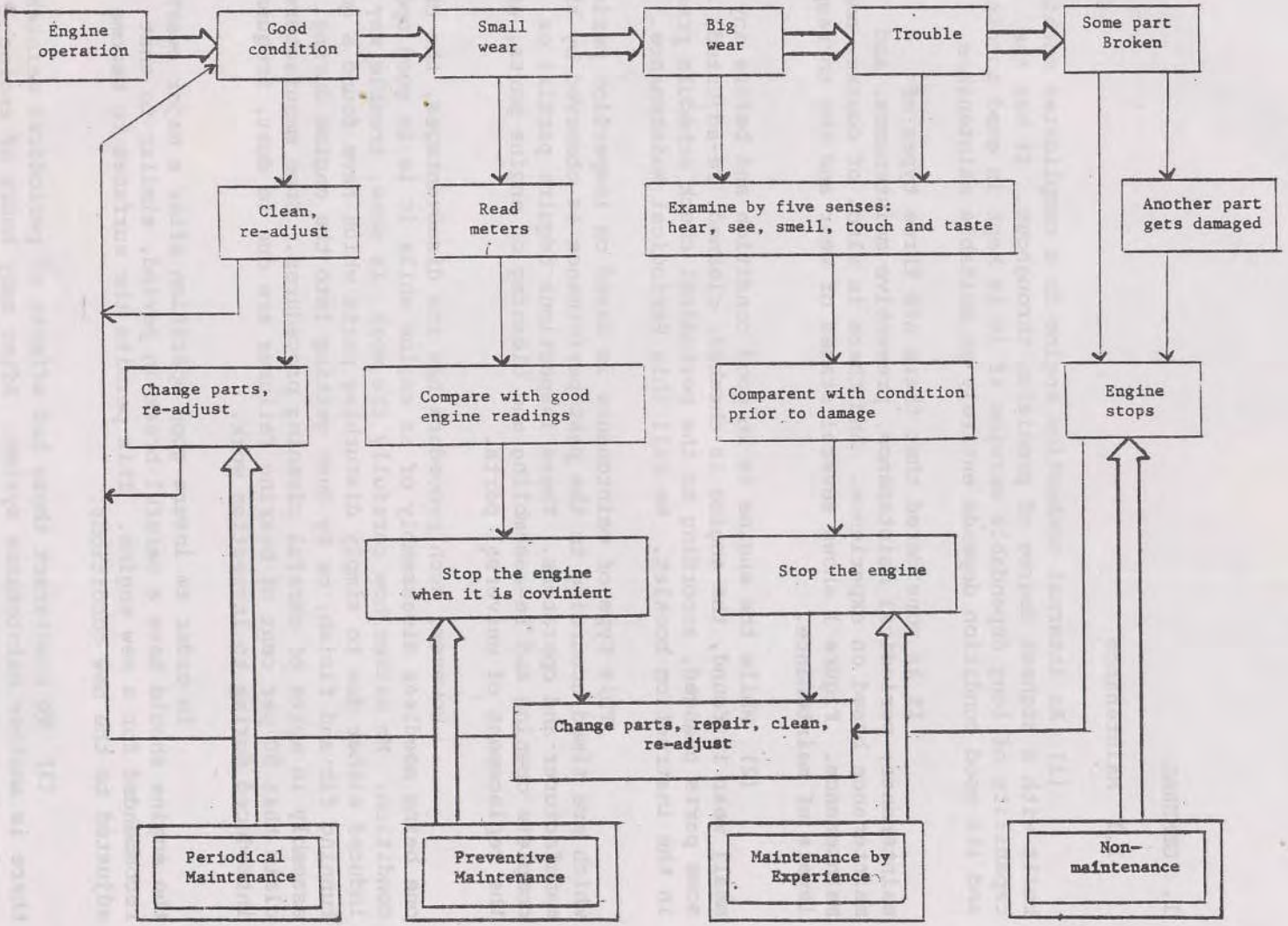

Fig. 1

and so on, and plots the data on section paper accurately, he will find from small differences of the data compared to data of engine in good condition that the time has come for a detailed engine check.

This is known as Preventive Maintenance. It should be combined with periodical maintenance, which than becomes a lighter duty than doing only periodical maintenance.

There is no substitute for the preventive maintenance. It entails periodic inspection of specific items, and an accurate record system which presents the result in such manner that any change in operating conditions will be clearly indicated. Such a system is only as good as the records. They must be kept up to date and be accrate. Records must then be studied and correctly interpreted by competent personnel.

It is obvious that an engine should not be run to destruction before overhaul. Many engine parts will operate longer and better if they are not frequently disassembled. Many engine builders claim that 90% of all failures are preceded by difinite conditions, signs or indications of approaching trouble.

For preventive maintenance, it is very important to keep accurate data of engine, starting from the time the engine was built. Table 1 shows an example of chief engineer's log book. You must remember that the log book's main purpose is to be used for preventive maintenance.

(4) When there is no periodial maintenance or periodical check as preventive maintenance, the engine will work until the engineer finds some abnormality of the engine by using one on more of his five senses. There may be an unusual sound, some strong smell, dark colour exhaust gas, strong vibration or high temperature or, in some rare cases, he may taste the salt in lubrication oil. This kind of maintenance is possible only if the engineer has had considerable experience. This is why we call this Maintenance by Experience. I would not recommend this method; it is totally subjective difficult relies too much on the skill of engineer. It is especially difficult for an engineer to find some abnormality in an engine which is not yet familiar.

There is another season why this method should be avoided. When the engineer finds some abnormality the trouble may be serious and the engine might have to be stopped. To stop the main engine, however, on rough sea far from shore can be very dangerous for a small fishing boat.

Table 1. Chief engineer's log book.

M.S. ..... Date .....

Hours	Watch	R.P.M	Speed in knots	Fuel intake	Temperature: Eng. room	Temperature: Sea water	Exhaust gas: Cylinder No. 1	2	3	4	5	6	7	8	Exhaust gas: Common	Supercharger: Gas outlet	Supercharger: Air outlet	Supercharger: C.W. outlet	Temp. of jacket cooling: Inlet	Highest: Temp.	Highest: No.	Lowest: Temp.	Lowest: No.	Temp. of piston cooling: Inlet	Highest: Temp.	Highest: No.	Lowest: Temp.	Lowest: No.	L.O Drain Valve Sounding
1																													
2																													
3																													
4																													
5																													
6																													
7																													
8																													
9																													
10																													
11																													
12																													
Mean																													

At noon every day	
Hours Main Eng Operating	
Hours Sailing	
Hours Propelling	
Revolutions: Since Noon Previous Day	
Revolutions: Per Minute	
Distance Run: By Screw Propeller	
Distance Run: By Log	
Distance Run: Over the Ground	
Average Speed in Knots per Hour	
Slip in Percentage	

Working hours of aux. eng.	
Main Generator: No. 1	
Main Generator: No. 2	
Main Generator: No. 3	
Aux. Generator	
Air Compressor	
Winches	
Refrigerator	
Donkey Boiler	
Evaporator	
Room Heater	
F. O. Purifier	
Air Conditioned	

Condition of ballast tanks: Tanks	F. O. P	F. O. S	F. W. P	F. W. S	B. W. P	B. W. S
No. 1						
No. 2						
No. 3						
No. 4						
No. 5						
No. 6						
No. 7						
No. 8						
F. P.						
A. P.						

Departure		Arrival	
Port		Port	
Hour		Hour	
Draft	F A	Draft	F A

13																																					
14																																					
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24																																					

Voyage No. ______ From ______ To ______ Lying at ______ Page ______

Pressure			Cooler				Scavenging Air Pressure	F. Oil Service Tank		Temp. of Thrust Bearing	Generator									Weather	State of Sea	Wind direction & Force	Remarks
			L. oil		P. cooling									Pressure			Temperature						
Jacket Cooling	Piston Cooling	L. oil	Before	Aft	Before	Aft		Main Engine	Aux. Engine		No. of generator	Ampere	Voltage	F.O. Press	L.O. Press	C.W. Press	L.O. Temp	C.W. Temp	Exhaust Gas				

Lubricating oil and the other oils												Boiler Water
	Bearing oil	Cyl. oil	Refri. oil	Light oil	Coarse kerosene		Grease	F.O. treatment	Waste	Fuel Oil	M A B	
Brought Forward										M A B		
Received										M A B		
Total										M A B		
Consumption										M A B		
Balance										M A B		

Commander ______

Chief Engineer ______

(5) It must be avoided at all cost to run a faulty engine until it stops by itself. In such a case, the original trouble may cause a secondary damage in another part of engine system. This is expensive, takes a long time to repair, and threatenes the ship and lives of crew.

1.2 General precaution for opening and repairing engine

When engine trouble occurs at sea far from the shore, even an unskilled engineer who does not know his engine well, must open and repair the engine. If the engineer has some general or basic knowledge about engine overhauling, he will be able to disassemble repair, adjust and re-assemble his engine. Two simple but very important points must be remembered: one is to keep the disassembled parts clean and the other is to re-assemble them in the reverse order from disassembling. Repairing sometimes, causes another engine trouble in the test run immediately after. This usually happens because of dirt on the re-assembled parts or a wrong re-assembling order.

1.2.1 Disassembling

(1) Before disassembling the following precautions should be taken:

1) Work area should be made clean;

2) Have ready kerosene for cleaning, and a cleaning pan;

3) Keep the replacement parts in a place where they will not be damaged or soiled;

4) Have the correct tools ready;

5) Do not touch or move parts not directly related to the disassembly procedure;

6) The engine should be cleaned to remove all dirt on the exterior;

7) If the engine is to be completely disassembled, first drain all fuel oil, lube oil, and cooling water.

(2) This is the general procedure for disassembling a diesel engine:

1) Study carefully the construction of each part, its action and fitting situation, and then keep hands off the parts which need not be touched, otherwise it may waste time and cause damage. Also keep good record of the original position of parts before disassembling so as to be able to reassembled completely.

2) Prepare a work-table or a surface for the removed parts. Wash the parts clean and put them on the table item by item according to the disassembling order. Be carefull not to clean the rubber parts with cleaning oil. Those are: oil seal ring, rubber packing, rotor of rotary pump, lip oil seal and so on.

3) Right tools must be used when disassembling, otherwise parts may get damaged. Do not use the adjustable spanner.

4) Bolts, nuts or adjusting liners should be kept together in groups so as to save time in looking for possible missing parts. If possible, bolt and nuts should be returned to the hole without fastening after the main parts have

5) Check the set marks carefully when disassembling and if no mark is found where deemed necessary, place some appropriate marks by yourself. Usually set marks are placed on the following parts:

   Connecting rod big end and bolts; cam gear and crank gear; shaft joints of thrust shaft and propeller shaft (or intermediate shaft); fuel adjusting lever and control ring of fuel injection pump; fuel control ring and plunger of fuel injection pump, and reversing gear body and crank gear; housings of reversing gear body; balancer and balancer driving gear, etc.

6) Careful attention must be paid to any wear or crack on each part, and the cracks and smashed warps should be mended.

7) As to the corners difficult to clean, such as the inside of crankcase, cleaning should be carried out thoroughly during disassembling.

1.2.2 Re-assembling

Re-assembling of the engine is carried out in the reverse order of disassembling work. Do not forget to lubricate where required.

The re-assembly procedure is as follows:

(1) Every part must be washed and cleaned. The conter should be placed correctly by set marks.

(2) Do not wash the oil seal, O-ring and other rubber parts which must be cleaned by wiping with a cloth.

(3) Mounting blots and nuts of a single unit should be tightened with even torque, each being tightened a little at a time. No single nut or bolt should be fully tightened when the others are still slack.

(4) Gaskets, cotter pins and locking washers should be replaced with new ones.

(5) Sub-assemblies should be assembled in advance.

(6) Worn or damaged parts should be either replaced or corrected before assembly.

(7) Do not adjust the clearance of bearing by tightening the bolt. It should be done by pulling out or putting in the liner, and the required clearance should be left.

(8) Bend the end of the split pin afte inserting.

(9) Clean lubricating oil should be fed by hand to slipping parts such as piston and bearings. Don't use rags.

(10) Check for smoothness of motion of moving parts and parts in rubbing contact as the assembly process proceeds.

(11) After reassembling the engine, check if there is any chafing place by revolving the flywheel.

(12) Before starting the engine, check that the cooling water pipe, fuel oil pipe and lubricating oil pipe do not leak.

(13) The set marks of connecting rod big end, adjustment of governor and fuel injection equipment, adjustment of fuel injection timing and adjustment of valve clearance (valve setting) must be checked very carefully.

Upon completion of reassembling, recheck all parts. Feed lubricating oil and fuel, and then make a trial run of the engine.

When a cylinder liner or piston is replaced, at least 3 hours of trial run is required for lapping purpose.

During the operation of the engine including trial lapping operation, check if there are any irregularities. If there is anything wrong or not working well, it must be repaired.

2. Periodical Checks

In order to maintain the engine in the best condition, it is very important to learn how it works and to understand how to handle the functional parts. For this purpose daily and periodical inspections are necessary, not only for satisfactory operation but also for preventing troubles.

The periodic checks vary according to the engine type, engine model, use of engine, operating condition, quality of fuel oil, lubricating oil and handling of engine. It is thus difficult to standardize them. Table 2 will give you a general idea of periodic checks for small marine diesel engine, of about 100 PS. Table 3 gives items of periodic check for engines of less than 750 PS.

The checking procedure is given below, as an example of a small marine diesel engine. The reference book or the manual of each engine should give you more details.

Table 2. Periodical check for small engine (100 PS)

Item	Procedure	Daily	50 hrs.	250 hrs.	500 hrs.	1000 hrs.
Fuel oil	Check up & supply	○				
	Fuel tank draining	○(prior to supply)				
	Fuel strainer draining		○			
	Fuel strainer cleaning			○		
Lub. oil	Check up of lub. oil inside crankcase & reversing gear case	○				
	Lub. oil strainer draining		○			
	Lub. oil strainer cleaning			○		
	Lub. oil replenishment			○		
Cooling water	Check up of packing gland tightening	○				
	Check up of cooling water circulation	○				
Fuel pump	Governor lever greasing	○				
	Fuel injection condition (priming)	○				
	Check up of fuel injection timing			○		
Fuel injection valve	Fuel strainer cleaning			○		
	Needle valve cleaning				○	
Cylinder head	Suction & exhaust valve clearance adjustment			○		
	Retightening			○		
	Combustion chamber inside cleaning				○	
	Pre-combustion chamber cleaning				○	
	Suction & exhaust valve lapping				○	
	Check up of valve lever & guide				○	
Priming	Cleaning			○		
Piston	Dismantling, checking of rings					○
Anti-corrosive zinc					○	

Table 3. Periodical check for marine diesel engine (300-750 PS).

Item		Periodical inspection (H)							
		Daily	50	100	300	600	1000	2000	4-5000 or annual
FUEL SYSTEM									
Fuel tank	inspect fuel level	●							
Sedimentation tank	drain deposite	●							
Fuel filter	drain deposite	●							
	blow off	To blow off when fuel pressure falls lower than 2.0 kg/cm²							
Fuel injection nozzle	disassemble and clean				○				
	inspect injection pressure and spraying condition			(First time) ○		(After second time) ○			
	clean nozzle strainer					○			
Fuel pump	check injection timing				○ (First time)			○ (After second time)	
	check discharge valve seat							○	
	check main components								○
Fuel feed pump	inspect fuel leak from fuel pump seat.	●							
	disassemble and inspect main components								○
OIL SYSTEM									
Crankcase	inspect oil level	●							
	replace contaminated oil			○ (First time)		○ (After second time)			
	clean oil strainer in crankcases	Every time when replacing contaminated oil							
Oil filter	drain deposite			○					
	blow off	To blow when oil pressure falls lower than 0.5 kg/cm² at idle run or 2.0 kg at Max.							
	disassemble and clean and inspect				○				

Table 3. (continued)

Item		Periodical inspection (H)							
		Daily	50	100	300	600	1000	2000	4-5000 or annual
Centrifugal filter	disassemble, clean and inspect		○		○				
Oil pump	disassemble clean and inspect								○
COOLING WATER SYSTEM									
Cooling water pump and bilge pump	inspect packing gland	●							
	inspect valve						○		
	inspect main components								○
Oil cooler	inspect zinc bar and replace if necessary					○			
	clean inside dirt								○
Hot water recirculation device	make fitting of safety valve seat								○
	inspect temperature regulating valve							○	
	inspect check valve							○	
Zinc bar	inspect and replace if necessary					○			
GOVERNOR									
Governor and Governor link	inspect main components				○				
	feed oil	●							
	inspect and adjust				○				
CYLINDER HEAD									
Cylinder head	inspect and remove carbon layer from combustion chamber							○	
	retighten clamping bolts	Retighten at 400-600 hours' run and hence at any time as case may so require							
Inlet and exhaust valves	adjust valve timing						○		
	make fitting of valve seats							○	
	inspect valve springs							○	

Table 3. (continued)

Item		Periodical inspection (H)							
		Daily	50	100	300	600	1000	2000	4-5000 or annual
START AIR SYSTEM									
Starting valve	make fitting of valve seats								
	inspect valve spring							○	
Distributing valve	inspect valve seat							○	
Air tank	inspect air pressure	●						○	
	drain precipitated dregs	● Everyday for 3 days							
PISTON AND CONNECTING ROD									
Piston	draw out piston and remove carbon layer								
	inspect piston rings							○	
	inspect ring groove							○	
	replace piston ring							○	
	inspect piston pin and pin hole							○	
	measure the outside diameter of piston								○
Connecting rod	inspect piston pin bush								○
	inspect crank pin metal								○
	inspect crank pin bolt								○
MAIN BEARING									○
Crankshaft	inspect journal of crank pin								
	inspect distorsion	Inspect after installation and after returning to home port							○
Main bearing metal	inspect bearing metal							○	
	inspect clamping bolt								○

Table 3. (continued)

Item		Periodical inspection (H)							
		Daily	50	100	300	600	1000	2000	4-5000 or annual
MISCELLANEOUS									
Supercharger	replace paper filter element	To replace at 1000 hours run and when pressure difference falls below 1.3 kg/cm²							
	clean blower turbin blade						○		
	inspect main component								○
Inter cooler	purge air	●							
	drain deposite	●							
Outside of engine	retighten bolts and nuts	●							
	inspect oil tank	●							
	inspect leak of oil, fuel, and water	●							
Piping	inspect leak of oil, fuel, and water	●							
Oil filter for wood ward governor							○		

2.1 Daily check

Be sure to carry out the daily inspection. Most of the daily check points are easy and simple to do, and they maintain the engine in good condition. Repair any defects, no matter how small.

(1) Check up supply of fuel

(a) Open drain cock of fuel tank and drain out dirt and water deposited at the bottom of the tank.

(b) Check and supply fuel if it is not sufficient.

(2) Check up supply of lubricating oil

Check if lucricating oil in the crankcase and reduction gear case is sufficient; if not add oil until it comes up to the upper notch of the oil gauge.

(3) Clean up fuel and lubricating oil

Move right and left the handles on the fuel strainer and lubricating oil strainer, and clean dirt off strainer mesh, as shown in Fig. 2.

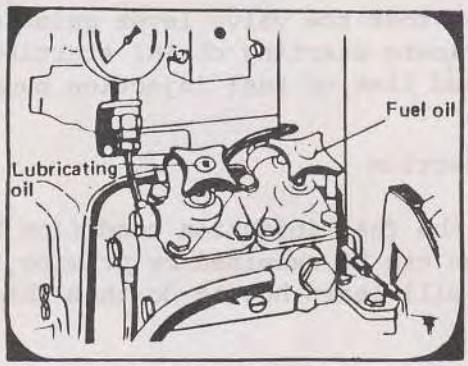


Fig. 2

(4) Check cooling water pump

Make sure that the packing gland of cooling water is tightened enough, as shown in Fig. 3. If not, retighten it as required.

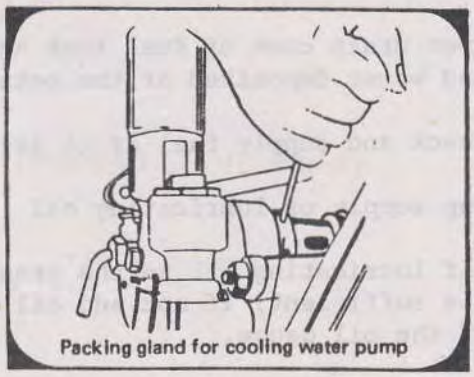


Fig. 3

(5) Lubrication

Make sure that the valve lever guide and others are well lubricated. Lubricate starting chain, starting chain free gear metal, lack pin and link of fuel injection pump.

(6) Fuel injection

Examine the fuel injection condition by priming pump. The injection condition can be examined by priming smoothness and injection sound. You will learn how to do this through experience.

2.2 Every 50 hours

Every 50 hours of engine operation, loosen the drain cock of fuel strainer and the lubricating oil strainer, and remove the deposited water and dirt.

2.3 Every 250 hours

After the first one month of running a new engine, if possible, it is recommended to have service engineer look into the working condition of the engine. After 250 hours the functional parts of the engine should be adjusted and for this the engine must be disassembled. It is better to have an engine specialist inspect it, so as to keep the engine in the best condition. When disassembling, adjusting and re-assembling the engine, you can learn a lot from the engine specialist.

(1) Clearance of suction and exhaust valves

To adjust the clearance of valves, first take off the cylinder head cover. Using a thickness gauge, set the clearance between the valve and the valve lever to be as shown in the manual under the condition of both suction and exhaust valves being closed. Remember that checking and adjustment of valves must be done when the engine is cold.

The adjustment procedure is as follows:

(a) Loosen the nut of the set bolt and adjust the clearance revolving the adjusting screw as shown in Fig. 4.

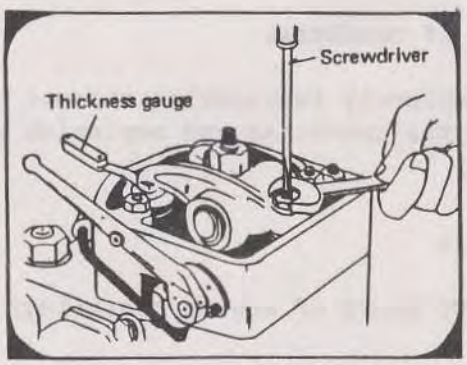


Fig. 4

(b) When the clearance is adjusted, tighten the adjusting screw with the nut.

(2) Bolts

Check and tighten the bolts and nuts, especially those on the cylinder head. Tightening should be done thoroughly and uniformly.

(3) Air-breather

Remove air-breather cover and valve attached to crankscase and clean them up.

When the valve doesn't work well, lubricating oil comes up to the combustion chamber and burns, leading to high consumption of lubricating oil.

(4) Fuel and lubricating oil strainer

Disassemble the fuel strainer and lubricating oil strainer. Clean them and wash away dirt stuck on the mesh plates and clean up the inside of the strainer.

Remove the fuel strainer attached to the fuel injection valve. If it is difficult to remove, use a special tool. Do not use a nail.

(5) Cleaning of crankcase

Drain completely lubricating oil out of the crankcase. Clean up the inside of the crankcase and replenish with fresh lubricating oil.

2.4 Every 500 hours

After every 500 hours of engine operating, the followings items should be done:

(1) clean the cylinder head,

(2) check pre-combustion chamber and injection valve system,

(3) clean suction and exhaust valves,

(4) inspect anti-corrosive zinc,

(5) all items which must be done every 250 hours.

(1) Cleaning of the cylinder head

Dismantle the cylinder head from engine. Disassemble the precombustion chamber, injection valve system, and suction and exhaust valve mechanism. The whole surface of the cylinder head should be cleaned. Carbon deposited on it must be scrubbed off.

(2) Cleaning of precombustion chamber

If the engine has been operated in fair condition, it is not necessary to disassemble the precombustion chamber. But if the engine is operated for a long time with incomplete combustion or with low quality fuel, carbon will be accumulated inside the chamber. In such a case the precombustion chamber (Fig. 5) must be taken off in the following way:

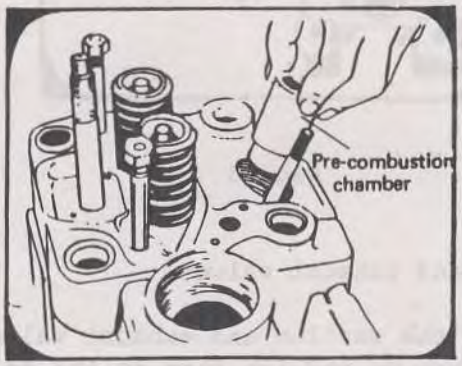


Fig. 5

(a) Take off two cap nuts of fuel injection valve and also fuel injection valve set piece.

(b) Remove fuel injection valve. Fuel over-flow pipe (vinyl pipe) is taken off at this time.

(c) Take off pre-combustion chamber gland by turning it counter-clockwise, applying copper pipe or wooden piece, as shown in Fig. 6.

(d) When the pre-combustion chamber is stuck with carbon, put a piece of cloth inside the chamber, and turn flywheel slowly, then the chamber will come off. Sometimes, the chamber may spring out, so be careful.

(e) Clean up carefully the inside of injection hole and examine copper packing which may cause pressure leakage. Therefore, if some cracks or scars are found on the copper packing, it must be replaced with a new one.

(f) Remove nozzle and needle valve of fuel injection valve and clean them up.

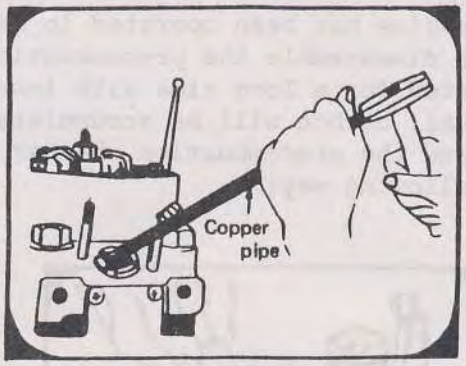


Fig. 6

(3) Suction and exhaust valves

Take off the suction and exhaust valves from the cylinder head, clean them up and lap them in the following way.

(a) As shown in Fig. 7, use a special tool for removing the valve spring, and remove valve spring support.

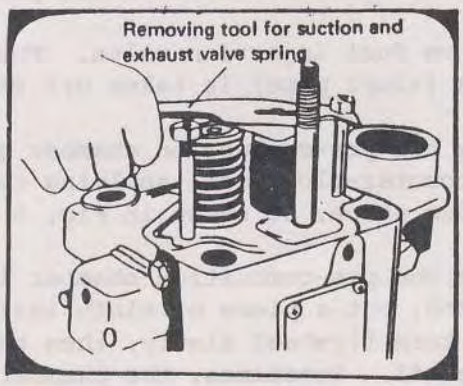


Fig. 7

(b) First lap with rough lapping powder and then with fine lapping one and finally with lub. oil so as to obtain even lap on the seat face, as shown in Fig. 8.

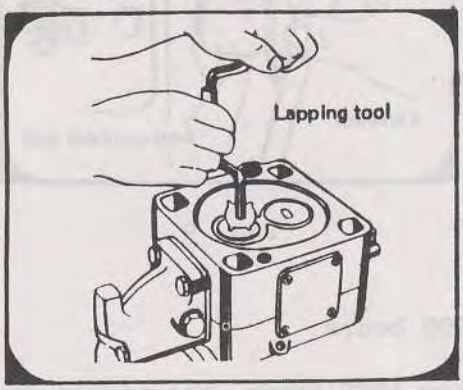


Fig. 8

(c) lapping should be done like this: tap softly the face of valve turning slowly, rather than turn the valve.

(d) After lapping, put some blue paint on the valve seats, and insert the valves into the respective holes, suction or exhaust, then check if the lapping is done well.

(e) Before reassembling, wash away lapping powder and put fresh oil onto the valve seat face and working part.

(4) Anti-corrosive zinc

The zinc is added to the cylinder, exhaust manifold, oil cooler, and other parts of engine which are cooled by sea water. The anti-corrosive zinc is used in order to protect the engine parts from electrolytic corrosion. Check and if necessary replace it as shown in Fig. 9. If there remains more than 65% of the original zinc bar, the zinc-hydroxide should be clean and it can be used another 500 hours.

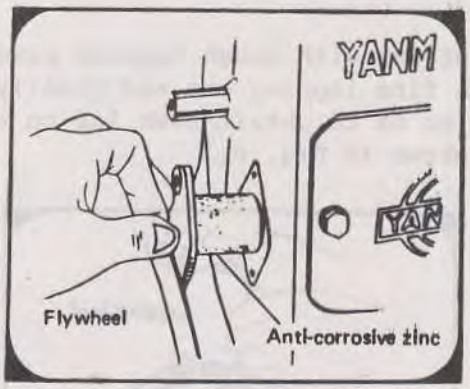


Fig. 9

2.5 Every 1000 hours

After every 1000 hours, the piston should be taken off and the liner, piston rings, piston pin, and connecting rod should be checked.

It is strongly advised that a chrome-plated piston ring should never be used with the chrome-plated liner. The piston ring should be replaced with a new one if it does not appear evenly glossy on the travelling face throughout the whole circumference, or if vertical scratches and gas leakage are discovered, if the clearance between the upper or lower faces and piston ring groove becomes more than 0.2 mm (in small engine).

3. Overhauling of Diesel Engine.

3.1 The purpose of overhauling.

After many hours of engine running, there will be some wear or tear in various equipment or frictional parts. Before serious trouble develops, the engine should be opened, checked, measured, adjusted and parts replaced as required.

After this, the engine is reassembled, put on a test stand, started, and carefully tested. In respect to these engines the word overhauling is some times used to designate major maintenance work such as the simultaneous pulling of all pistons, cleaning of scale from cylinder jackets and heads, and checking of the crankshaft alignment. Marine diesel engines have to be overhauled because they have to operate continuously for many days and weeks at practically full load without stopping and without a chance for much maintenance work while at sea. Therefore, depending upon the type of work, general overhauling of engines is done at regular intervals, every 12 months (3,000 - 6,000 H) or 24 months (12,000 H).

3.2 Time of overhaul

Generally, the time to overhaul the engine is determined on the basis of reduced output of engine power, reduced compression pressure of combustion chamber, increased blow-by gas, increased fuel and/or lubrication oil consumption increasing of pressure drop across the lubrication oil filter, reduced lubricating oil pressure, hard starting etc. This determination should not be done "by feel" but on the basis of data on section paper.

Figure 10 shows some examples, which indicate the time to overhaul, about 450 days after a previous overhaul. (A) is compression pressure in combustion chamber. This pressure should be checked daily by cutting the fuel feed to one cylinder under the same driving condition. Reduced pressure shows that the clearance between the pistons piston rings and liner, or between the value and value sheet has become too large. If the drop of compression pressure exceeds the repair limit, the engine must be overhauled. The repair limit is set in the user's manual, by the manufacturer. However, 80% of compression pressure in assembling standard can be used as a repairing limit.

(B) and (C) in Fig. 10 show the ratio between integral calculus of time (hours) x horsepower and consumed lubrication oil or fuel oil. When the integral calculus of time x horsepower is difficult to calculate, specific oil consumption (the ratio between fuel consumption and lubricating oil consumption) is easy to use for determination of overhauling of lubricating system. Specific oil consumption varies with engine operating conditions, and the quality of lubricating oil and fuel oil. Let this specific oil consumption in a new engine be 100%. If it has decreased to about 70% (it means oil consumption increases), the engine should be overhauled.

(D) in Fig. 10 showes the increase of pressure drop between before and after the lubricating oil filter. Special attention should be taken to the transition of frequency of pressure rising. This means some bearing parts or scrubbing parts may get abnormal clearance and produce metal dust in the lubricating system.

The examples given in Fig. 10 are only some of many possible ones. Larger engines and heavier duty of the engine means that more engine data must be referred to.

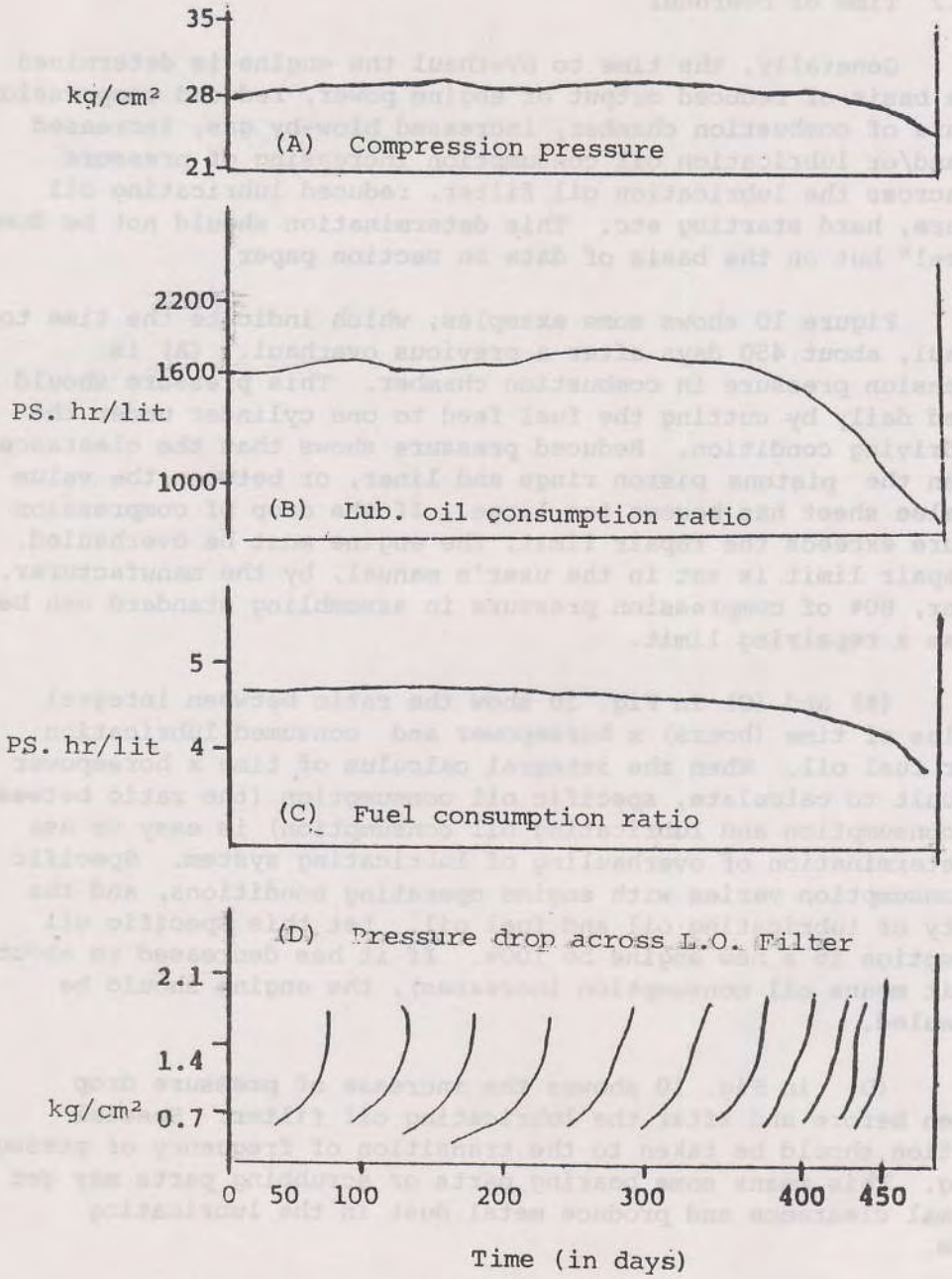

35
kg/cm²
28
21
(A) Compression pressure
2200
1600
PS. hr/lit
1000
(B) Lub. oil consumption ratio
5
PS. hr/lit
4
(C) Fuel consumption ratio
(D) Pressure drop across L.O. Filter
2.1
1.4
kg/cm²
0.7
0
50
100
200
300
400
450
Time (in days)

Fig. 10

3.3 Precautions for overhauling

There are several points which should be rigorously observed when a major inspection and overhaul works is done. One of the most important rules is to make sure that all parts are well marked and identified as engine is dismentled. It is porticularly important to mark camshaft gear and valves if manufactures mark cannot be found. Center-punch markings are the most convenient to use. The second point is to clean thoroughly every dismantled part, carefully examining it for cracks or pitting. After that, accurate measurement must be taken of all dimensions subject to wear and also of adjustment points of the various parts as the dismantling progresses. A complete record should be kept of each and every measurement, properly entered on consecutively numbered sheets to prevent them from being overlooked or lost. The maintenance work is easier and much time is saved if this rule is followed. In order to make these records the maintenance crew should be well equipped with micrometers, (both inside and outside ones), cylinder gauge, dial gauges, scales, etc. It is impossible to obtain accurate readings with inadequate equipment. In taking measurements one must be as careful and accurate as possible. No guesswork is permitted. Inaccurate measurements are worse than none.

3.4 Repair limit of parts and clearance

After many days of engine running, every sliding and bearing part will suffer wear. Further running will increase wear, and at last it will reach the repair limit.

The repair limits differ for various engine models and for various uses or operating conditions. An example is shown in Table 4. This is not the standard for all engines, so you must modify this table following to the manual book for your engine, and according to your operating condition (heavy or hight duty).

The repair limit shows the maximum of wear. When you open up your engine and measure the wear, you must calculate how much it will increase before the next overhauling. If you consider that it is very near to repair limit or be in excess of the limit, you should undertake repair immediately.

Table 4. Repair Limit of Diesel Engine for Fishing Boat.

Unit = mm X = amount of wear, D = diameter of cylinder, d = diameter of crankshaft.

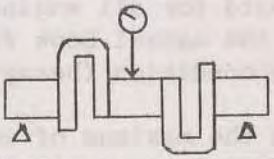
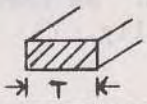
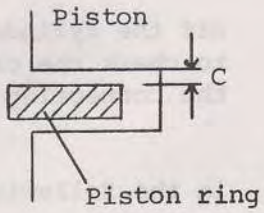
Part	Description	Repair limit		Reference
Cylinder liner	Wear limit	$D \leqq 250$	$X \leqq \frac{1}{100} \times D$	first piston ring position at Top Dead Center.
		$D > 250$	$X \leqq 1.5 + \frac{5}{1{,}000} \times D$	
		Cr-plated liner	until peeling	$X \leqq \frac{0.01 \text{ mm}}{1{,}000 \text{ hr}}$
	Boring limit	$t \geqq \frac{1}{20} \times D$		t: thickness of liner at upper part of chamber
Crank shaft	Wear limit of Journal and pin	Engine rpm < 500	$X \leqq 0.15 + 0.005\,d$	
		Engine rpm ≧ 500	$X \leqq 0.10 + 0.005\,d$	
	Bending limit		$b \leqq 0.1$	b: Bending
	arm deflexion	$a \leqq \frac{2}{10{,}000} \times S$		S: piston stroke a: deflexion.
Main and crank pin bearing		$d \leqq 150$	$c \leqq \frac{2}{10{,}000} \times d$	c: metal clearance
		$d > 150$	$c \leqq 0.15 + 0.001\,d$	

Table 4. (continued)

Part	Description	Repair limit	Reference
Crank pin tightning bolt	Using time limit	$T \leqq 20{,}000$ (hours)	T: using time.
	Permanent elongation limit	$\ell \leqq 1.00$ (mm)	ℓ: permanent elongation.
Piston ring	Wear limit	$X \leqq 0.15 \times T$	T: thickness 
Piston pin	Wear limit	$X \leqq 0.1 + 0.0005 \times d_1$	d_1 = piston pin diameter.
Piston pin metal	Clearance	$C \leqq 0.20 + 0.001 \times d_1$	d_1 = piston pin diameter
Piston	Ring groove wear limit	$X \leqq 0.3$	depth of ring groove.
	Clearance between ring and groove	$C \leqq 0.3$ or $C \leqq 0.25 + \frac{1}{5{,}000} \times D$	
Gear set	Backlash clearance	$C \leqq 0.1 \times M$	M: module

3.5 Overhauling of main parts.

3.5.1 Cylinder head

When you want to dismantle the cylinder head, first of all discharge the cooling water by opening the drain valve or loosening the cooling water pipe. The dismantling of cylinder head is carried out in the following way:

(1) Remove the cylinder head cover, water cooling outlet pipe, intake and exhaust manifold, fuel injection system, and so on.

(2) Loosen the tightening nuts for the rocker arm system. Be careful to loosen the two bolts or nuts evenly and gradually.

(3) Remove the cylinder head tightening nuts. The four nuts for cylinder head must be loosened gradually and crosswise.

(4) Between the cylinder and the cylinder head, there are several layers of packing for lubricating oil and cooling water. Usually they must be replaced.

(5) When re-assembling the cylinder head, tighten four nuts gradually but in the same way as described above for dismantling.

3.5.2 Piston connecting rod

When dismantling the piston, at first, you must take off the cylinder head as described above (3.5.1). But when you want to check the crank-pin metal which is set to the big end side of the connecting rod, there is no need to take the cylinder head off.

Dismantling of the piston assembly is carried out in the following way:

(1) First, take off cylinder side cover and stretch the bent split pins of rod bolts.

(2) Take off rod bolts one after the other as shown in Fig. 11 taking care not to drop the spanner.

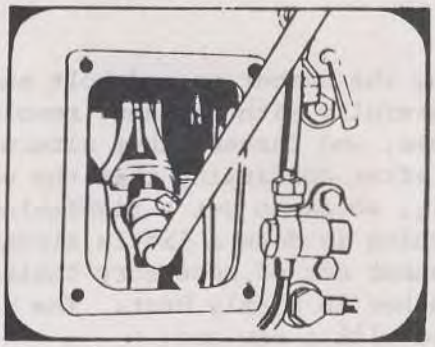


Fig. 11

(3) Take out the piston together with the connecting rod toward the cylinder head.

(4) The connecting rod and bolts should be put together in order to avoid faulty reassembling.

(5) The crank-in bearing is made of kelmet metal, the back is of forged steel and the surface is planted with lead alloy so as to improve the initial fitting. During engine operation, the plated lead alloy may become worn, and yellow kelmet steel shows out. At this stage the engine should not be stopped but should be operated continuously. It is also advisable not to apply any liner to this bearing for adjustment, nor carry out lapping of this bearing.

(6) When re-assembling the piston connecting rod you should be careful about the following points:

(a) The big end of connecting rod has a cut on a position inclined toward the center of connecting rod as shown in Fig. 12, and it must be mounted to the crankshaft in the primary direction. (Be careful not to mount the connecting rod in the wrong direction.)

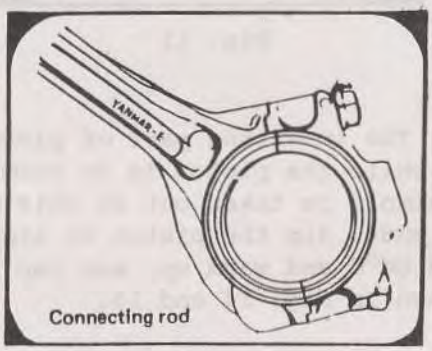


Fig. 12

(b) Matching the number on rod bolt and nut, tighten them carefully with spanner, revolve the crankshaft 4-5 times, and fastern them alternately 2-3 times evenly after confirming that the crankshaft revolves smoothly, so as to get a tightening torque of 9 kg.m. (Tightening is done a little strongly by a special box spanner out of accessory tools). Then, the rod bolt washer is firmly bent. The used washer must be replaced with a new one.

(c) Special care must be paid so that the rod bolt would not be damaged or scratched. Even if slightly damaged or scratched it should be replaced with a new one. The rod bolt which has been in service for 4-5,000 hrs., even if it is not damaged or scratched, should also be replaced.

3.5.3 Piston

(1) The piston ring is taken off and put on by hooking on wires at its end cut as shown in Fig. 13 (be careful not to break it with excessive force).

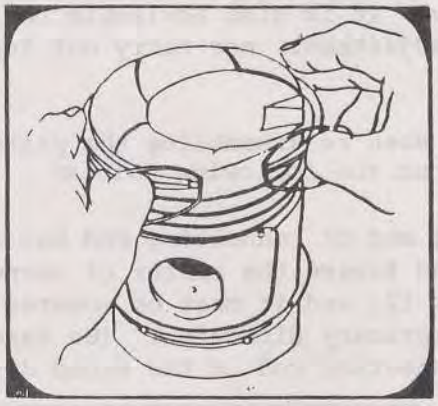


Fig. 13

(2) The inserting part of piston pin shows tightness to a certain extent while the piston is at normal temperature, so the piston pin can simply be taken out in this manner: First, remove the circlip at both ends, dip the piston in light oil for about 10 minutes at around 80°C and warm up, and tap the pin softly over a wooden rod, as shown in Fig. 14 and 15.

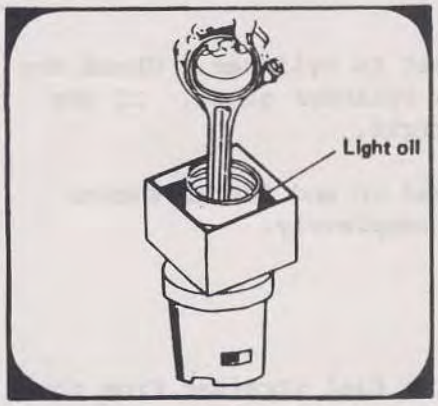


Fig. 14

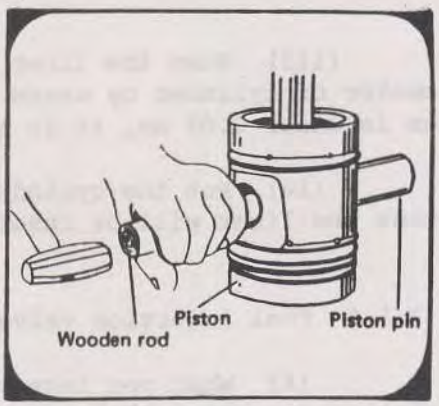


Fig. 15

3.5.4 Cylinder liner

(i) When replacing the cylinder liner, as shown in Fig. 16, put the round plate (1) of liner removing tools at the bottom of the liner and set piece (2) on cylinder head tightening bolt, and slowly fasten the upper nut (4).

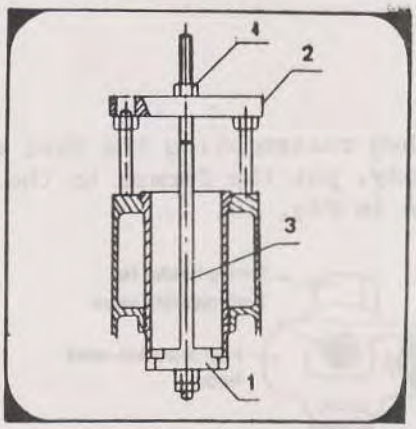


Fig. 16

(ii) Clean up the liner surface of the cylinder and the outer surface of the liner, taking off dirt and paint before inserting a new liner. Put rubber packings in the grooves of liner and be careful not to twist the rubber packings, and paint them. Insert the liner and tap with wooden hammer.

When setting the rubber packing it should be put in the place shown by the arrow. Turn it several times until it comes to the groove.

(iii) When the liner is set to cylinder. Check the inner diameter of cylinder by means of a cylinder gauge. If the distortion is under 0.02 mm, it is all right.

(iv) Put the cylinder head on and fasten 4 nuts evenly, thus the liner will be inserted completely.

3.5.5 Fuel injection valve

(1) When you take out the fuel strainer from the fuel strainer case, (Fig. 17), use the tool specially provided for this purpose, as shown in Fig. 18.

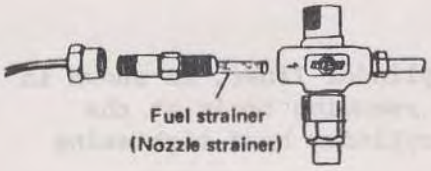


Fig. 17

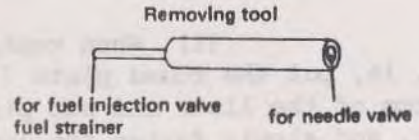


Fig. 18

(2) When reassembling the fuel strainer case with fuel injection valve body, put the former to the arrow-marked side of the latter, as shown in Fig. 19.

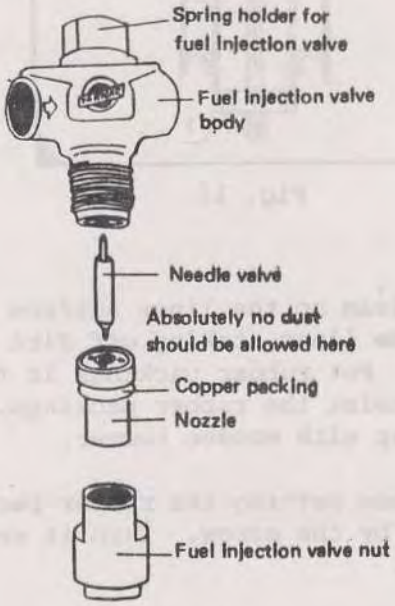


Fig. 19

(3) Before taking out fuel injection valve from cylinder head, it is recommended to loosen the nozzle spring but not take it off completely.

(4) Needle valve and nozzle are precisely machined, so special attention must be paid to keep them free from dirt.

3.5.6 Fuel pump

(1) Fuel pump is disassembled in the following way (See Fig. 20):

(a) Remove the retainer screw of delivery valve, and then delivery valve spring and delivery valve are easily taken out.

(b) To take out delivery valve guide, a tool specially provided for this purpose must be used.

(c) Take off plunger guide circlip(5), and then plunger guide(6), plunger spring support(7), plunger spring(8) and plunger(9) can be taken out as simply downwards as they are.

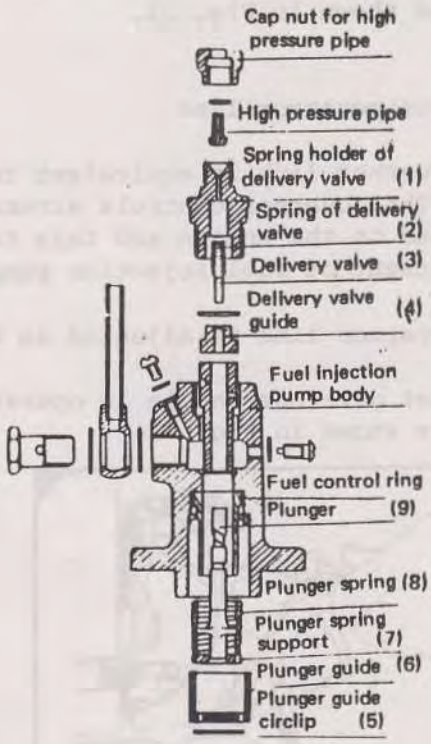


Fig. 20

(2) Plunger and plunger barrel of fuel injection valve are so precisely machined that special care must be paid to handle them. Whenever plunger is replaced with a new one, it must be replaced together with the plunger barrel.

(3) Reassembling is carried out in the severse order of disassembling, taking, care to match the set marks correctly.

(a) Plunger is inserted into fuel control ring by matching O-marks put on both, as shown in Fig. 21.

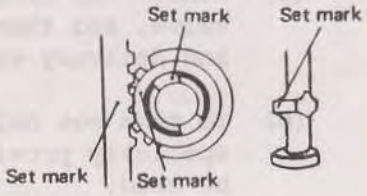


Fig. 21

(b) Adjusting lever is matched with fuel control ring at the marks put on both, as shown in Fig. 21.

3.5.7 Adjustment of governor link

(1) The governor link is equivalent to the nervous system of the human body. The governor controls accurately the increase and decrease of load on the engine and this functions to five instructions for adjustment ot fuel injection pump automatically.

The governor link is adjusted as follows:

(a) Set governor handle in operation position, as shown in Fig. 22.

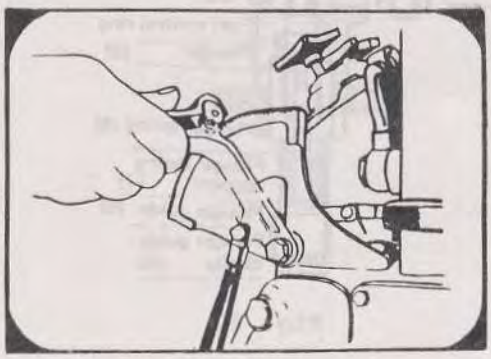


Fig. 22

(b) Then, loosen two lock nuts (3) of governor link (Fig. 23).

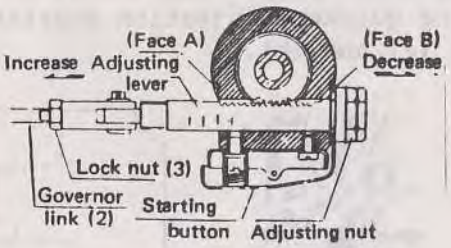


Fig. 23

(c) Adjust the length of governor link (2) by pushing starting button so as to have adjusting lever control ring come in close contact with pump body.

(2) Turn governor link this side and adjusting lever will move toward the right (flywheel side) and decrease the amount of fuel injection, while turning governor link the other side, governor lever will move toward the left (clutch side) and increase the amount of fuel injection.

3.5.8 Adjusting fuel injection timing

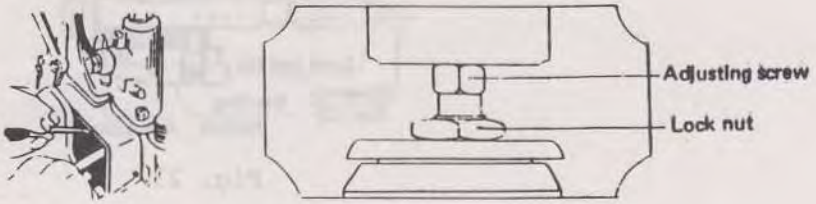
Every engine has its optimal starting position of fuel injection. It is mentioned in operation manual by degree from the top dead center. The top dead center can be found marked as "TD" or "TDC" on the flywheel.

There are two cases that the mark on flywheel meets with the indicator arrow in one cycle. The top dead center in this case is one when both suction and exhaust valves are completely closed in compression stroke.

(1) Set the fuel adjusting lever at setting position which is usually marked on the left hand side of adjusting lever. Then remove the fuel injection pipe and delivery valve.

(2) Turning flywheel slowly by hand, the oil level in delivery valve spring holder comes up. In this way, the starting point of fuel injection can be found. When the oil level comes up, stop turning the flywheel, and check whether the indicator points the correct degree from the top dead center.

(3) The injection start is adjusted by adjusting screw, which is found in the adjusting window provided beneath the fuel injection pump. Tightening or loosening of adjusting screw delays or quickens injection starting, respectively, as shown in Fig. 24 (a) and (b).



(a) (b)

Fig. 24

3.5.9 Reduction and reversing gear

(1) It is difficult to explain how to adjust the reduction and reversing gear system with clutch. The manual of each engine should be followed in this respect.

(2) The dismantling procedure for reversing gear is as follows:

(a) Put reversing gear handle on the "ahead" position. Then take off handle bearing cover and handle.

(b) Remove governor adjusting link and regulator handle mounting.

(c) Take off reversing gear cover bolts and also take off bracket for reversing gear handle bearing toward stern. Pull up reversing gear cover sliding toward stern, then the cover is dismantled. Unbend metal washer for bolts which faster reversing gear with crank gear flange, as shown in Fig. 25 then take off bolts. Then put bolts into the holes provided on the circumference of reversing gear housing as shown in Fig. 26. Holding these bolts, side the reversing gear astern then lift the gear slowly. You must be careful not to break the ring around the flange which connects with crankshaft.

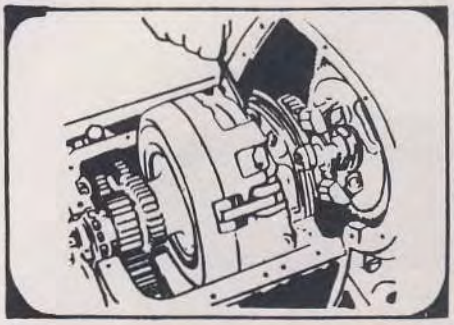


Fig. 25

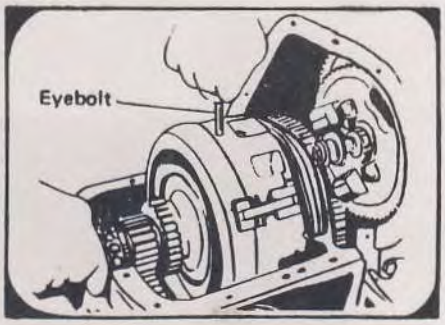


Fig. 26

(3) The reassembling of reversing gear is done in the reverse order of disassemblong. As the parts to be set together are marked, you must set these marks when reassembling. Washers and split pins must be the new ones.

(4) When reassembling a part or whole of crank gear, cam gear or balancer gear, each tooth must be geared in good order, otherwise the opening and closing timing of suction and exhaust valves, fuel injection timing would become irregular or the vibration of engine would increase.