DIESEL GENERATING EQUIPMENT FOR INDONESIAN NAVY

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I. PREFACE

Diesel generating equipments are employed for various purposes, such as, emergency power source, marine use and ordinary power supply source, and their unit capacities are extended over from several kVA to around 2,500 kVA now.

The diesel engine provides very simple accesseries, and its cost is low, further its operation is very easy. Owing to this, it can be found out now that several units are combined in parallel as a several thousand kVA power plant for the power supply during dry season or for the emergency power source during service interuption.

Planning two sets of 1,500 kVA Diesel generators as a 3,000 kVA power plant, economical operations of them are possible, for instance, two sets in full operation at peak load and one set only in operation at light load. And in case of accidents of the one set or repairing and inspecting of the one set, securing of comparative important loads is possible by operating of the another one set, then the reliability of this plant is being very high.

We have recently completed the 6,250 kVA Diesel generating equipments supplied for Indonesian Naval Dockyard under the consideration of above many features, and have a pleasure to introduce the plant in the following lines.

Fig. 1 Map of Indonesia

II. OUTLINE

The equipment are divided into two Plants, that is, the (A) Power Station and the (B) Power Station, and their main machine components are as follows:

(A) Power Station	
1,250 kVA generator	3 sets
1,500 PS Diesel engine	3 sets
Switchboard	15 panels
(B) Power Station	
1,250 kVA generator	2 sets
1,500 PS Diesel engine	2 sets
Switchboard	13 panels

Rules to be applied are all Japanese Standards.

These two Diesel power stations are installed in the Surabaja Dockyard of the Indonesian Navy, and are employed for the power source of the Dockyard in day time and for the lighting source of the Surabaja city in the evening. In the same district, a 3,000 kW steam turbo generator supplied from the German Siemens and ten 100 kW Diesel generator sets are existing, and the new Diesel power stations will be used for peak load in co-operation with these existing powers and are designed, of cource, to be durable for long continuous operation.

III. DIESEL ENGINE

1. Construction and Performance

The Vee type Diesel engine is adopted and have been manufactured by the Fuji Diesel Co., Ltd. one of our subsidiaries. Brief specifications of the engine are as follows:

Type:	Vee type, 4 cycle, single acting, solid injection, trunk piston type
Model:	12 VMD 27.5 H
Normal output:	1,500 PS
Over load capacity:	110% (one hour rating)
Rating:	Continuous
Rated revolution:	600 rpm
Number of cylinders:	12
Cylinder arrangement:	45° V

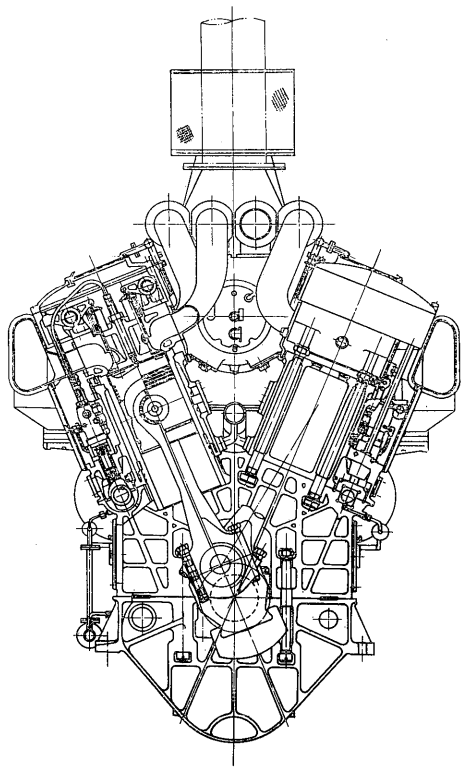

Fig. 2 Section of Vee type Diesel engine

Ignition order: Left 1 5 3 6 2 4
Right 6 2 4 1 5 3
Cylinder inner diameter: 275 mm
Stroke: 320 mm
Compressing ratio: 12.5
Brake mean effective pressure: 9.88 kg/cm²
Mean piston speed: 6.4 m/sec
Combustion system: Direct injection
Applied fuel: A class heavy oil
Fuel oil consumption: 170 gr/PS/hr or less
(at rated output, using fuel oil having net calorific value of 10,000 kcal/kg)
Applied lubricating oil: S. A. E. No. 40 or 30
Lubricating oil consumption:
2 gr/PS/hr (at rated output)
Starting method: Manual starting by compressed air
Lubrication system: Forced oil lubrication system
Cooling system: Water cooling
Speed regulation: Governor motor control
Supercharger: Exhaust gas turbo supercharger (with two air cooler)
Supercharging ratio: 87.5 %
Speed fluctuation: Momentary 10 %
Steady 5 %
Valuation of revolution: 1/800 (Including GD² of generator)
Thermal efficiency: 39% (using 10,000 kcal/kg fuel)
Dimensions: 2,050 mm wide
4,930 mm long
3,010 mm high
Weight: 18,000 kg

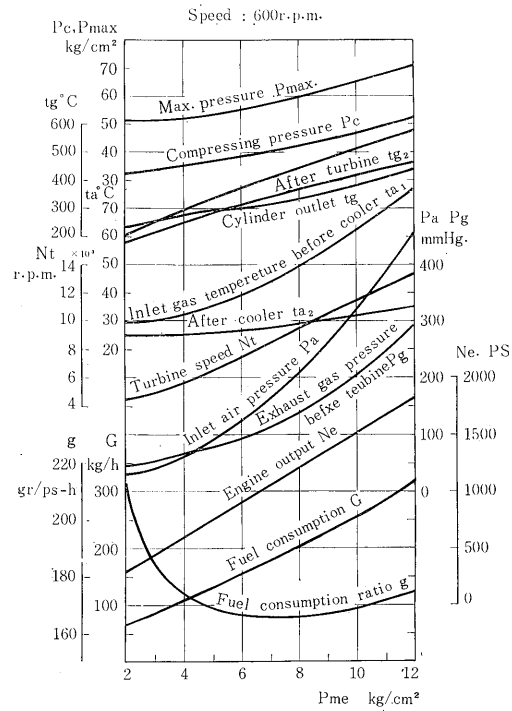

Fig. 3 Charactristic curve of 12VMD 27.5H engine

The Vee type diesel engine was developed by the Fuji Diesel Co., Ltd. after long studies and long experiences. Since the completion of the first Vee type engine for land generator use in 1958, Fuji Diesel Co., Ltd. have manufactured 30 sets ones including dregger and pump use, and all of them have continued their favourable operation without accident.

The Vee type engine has a structural feature of its cylinders arranged in a Vee form, and it has a many features in comparison with the straight line type engine as follows:

1) As adopted Vee type of medium speed, small size cylinder length is realized and by providing of a supercharger, a much lighter weight and a much smaller occupied floor space per

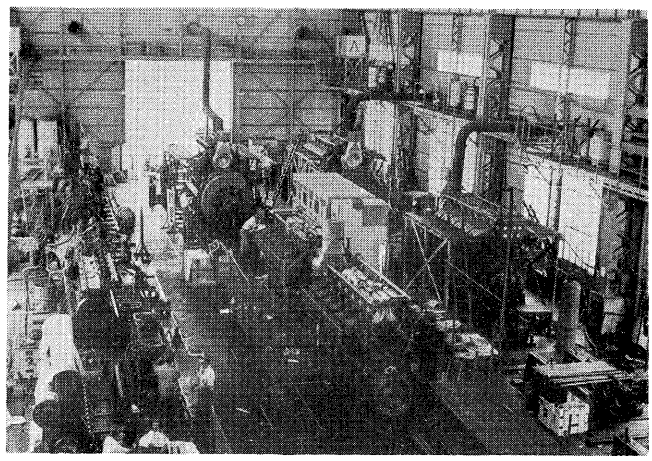

Fig. 4 Home test of engine coupled with generator

unit output is obtained. (In comparison with the old conventional low speed ones of the same output, this type engine is 40% in weight, 60% in occupied floor space)

2) In spite of its increased revolution per minute about twice as much as that of the former low speed ones, its structure is very solid to stand for a long durability, because considerations are paid on the design, dimensions and manufacturing process to be durable for the repeated torsional and bending etc. stress. Particulary, the Tri-metal of a high quality is adopted for the main bearing metal and crank pin metal, and the Kelmet is applied to the piston pin metal, in order to secure a distinguished reliance of those moving parts.

3) Being Vee type engine, a balance of the engine is good and its vibration is little, and besides, smoothless of rotation due to the pulsing torque, i.e. cyclic irregularity is small. Then a flywheel for smoothing of rotation is unnecessary, but a small flywheel only which is to be used for the turning at the time of inspection.

4) The fuel oil consumption is considered as an important problem, since the fuel oil applied is to require almost all costs of its operation. This engine has a high thermal efficiency, and by adopting a cylinder cover of the four valve type (two suction valves and two exhaust valves in each) and a supercharger utilizing the energy of exhaust gas, the fuel combustion is good and the fuel oil consumption at each load is very small. The left row cylinder fuel only can be stopped by the half side fuel stopping handle and the operation of the engine by the right row cylinder only is possible. Therefore, economizing of the fuel is possible and the engine can be also driven in a high efficiency at a light load operation.

5) The compressed air for starting the engine is supplied only for the one side of cylinder rows, and the fuel oil only is injected into the cylinder of the other side, so that the cooling due to the expansion of the compressed air do not effect on the engine and the starting also become easy, and further the consumption of the air is to be small for starting it.

6) As the cam shaft is equipped on the outside of the engine, every moving parts can be inspected and adjusted easily.

7) The driving apparatus is consisting of starting and stopping handles and a oil pressure governor for speed control, and have sensitive and powerful characteristics, and they act, through both left and right fuel regulating rods, on the delivery adjusting rack of fuel pump to regulate and maintain the revolution being constant and the speed fluctuation being good status.

8) An over speed governor is provided as a mechanical protection to stop the engine automatically when the engine speed is in excess of maximum allowable speed and the lubricating oil pressure is being down.

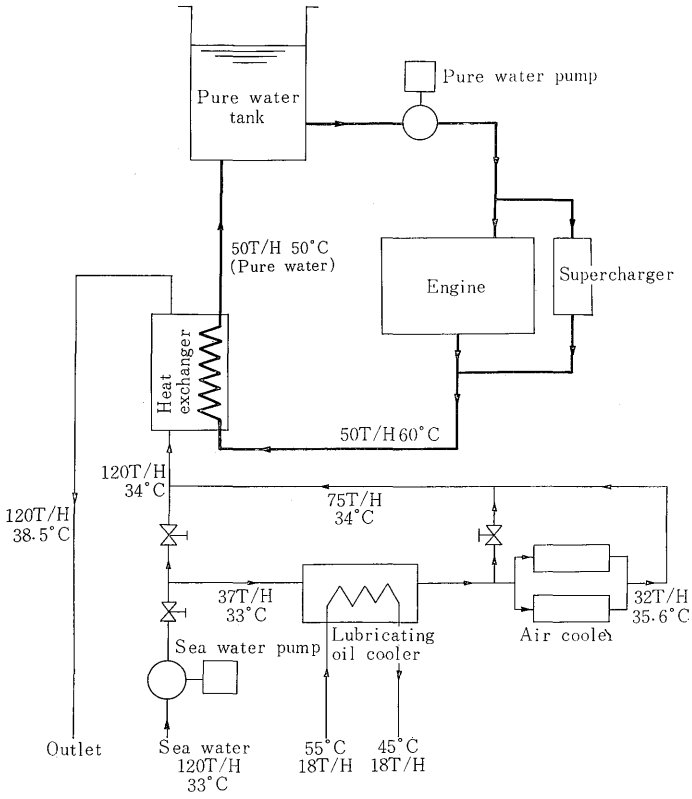

Fig. 5 Cooling system diagram

2. Starting

For a emergency power suppling Diesel engine, recently, the automatically starting system that the engine will start automatically at the time of power source stop, or the push button starting system from the switchboard are applied in many cases. However, this plant does not need such a instantaneous starting, so the manual starting system operated from engine side is adopted. The starting air reservoir has an ample capacity to be able to execute several time startings.

3. Engine Cooling System

As to the cooling of engine, either natural flow cooling system or circulating cooling system is adopted, the former will be applied in case the ample cooling water being obtainable and the latter in case of little cooling water. But for continuous

operation, many quantity discharge of water is not economical, then in many cases the circulating cooling water system provided with the cooling water pool is adopted.

In this case, necessary cooling water quantity is about 30~40 *l*/PS/hr and the water to be applied at site is bad in quality and little in quantity, so the pure water is used for the engine cooling, which is cooled with sea water through a heat exchanger (in case of (B) station, a cooling tower is built because the plant is locating rather far from seaside). The cooling system diagram is shown in *Fig. 5*.

The output of pure water circulating pumps and sea water pumps are 5.5 kW and 17 kW respectively, and they are planned to be independent cooling system per each engine. Of cource, sea water or impure water can be used for the engine, but pure water is more preferable from the point of the life of engine.

III. GENERATOR

The specifications of generators are as follows:

Type:	Open frame, horizontal shaft, revolving field, salient pole type synchronous generator
Model:	F 445/24-10
Number of phase:	3
Output:	1,250 kVA
Over load capacity:	110 % for one hour
Power factor:	80 % in lag
Rating:	Continuous
Voltage:	6,000 V
Frequency:	50 c/s
Number of pole:	10
Normal speed:	600 rpm
Class of insulation:	B
GD^2:	2.657 kg-m^2 (not including shaft)
Equipped with overhang type DC shunt wound exciter, output:	14 kW, 66 V

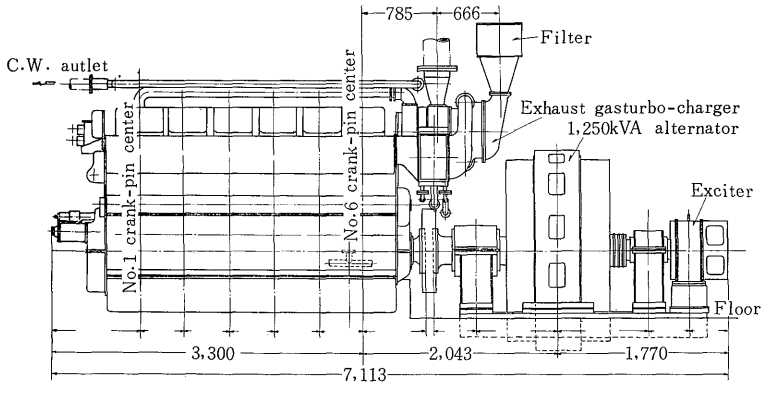

Fig. 7 Outline of generator set

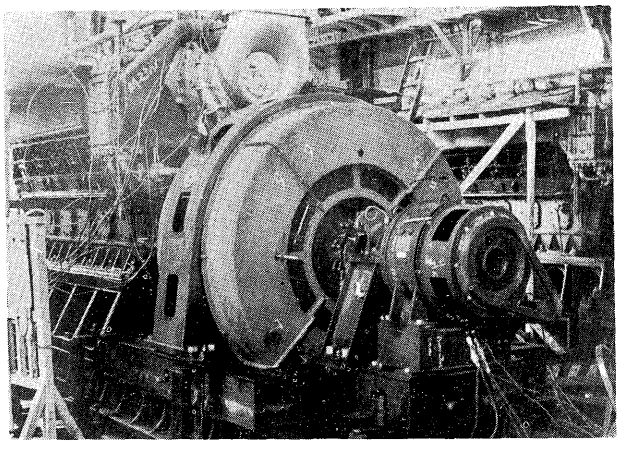

Fig. 6 Outer view of generator

Dimensions: 2,240 mm wide
3,138 mm long
2,050 mm high

B class insulation is applied on the both stator windings and rotor windings. For stator windings, special resin baked glass insulated wires are adopted and the mica paper is baked on them in order to have an ample insulation to earth. For rotor windings, the edgewise winding is applied and their layers are insulated with asbestos each other. All these windings are treated to have heat resistance and moisture resistance for using under tropical conditions.

The resonances between the torsional vibration and pulsing torque of engine and the electrical natural vibration of generator is a most important problem for the generator directly coupled with the engine, then deep considerations are paid on this point so that the generator is to be safety one. Furthermore, the damper winding is provided in order to get a safety parallel operation with another Diesel generators.

IV. OTHER ELECTRICAL EQUIPMENT

As the exciter is provided with Fuji proper Ithmus pole, so the main field regulator and the subexciter are not necessory. The automatic voltage regulator adopts the rocking contact type and its accuracy is within ±1.5%. High tension switchboards are of enclosed cubicle type in which high voltage apparatus are equipped. Oil circuit breakers are having a 6 kV rating, 100 MVA rupturing capacity and DC voltage tripping system is employed. The voltage of auxiliary motors is 380 V and their starting methods are secondary resistance starting as wound motors for above 17 kW one, star-delta starting for above 5.5 kW and direct starting for below 5 kW.

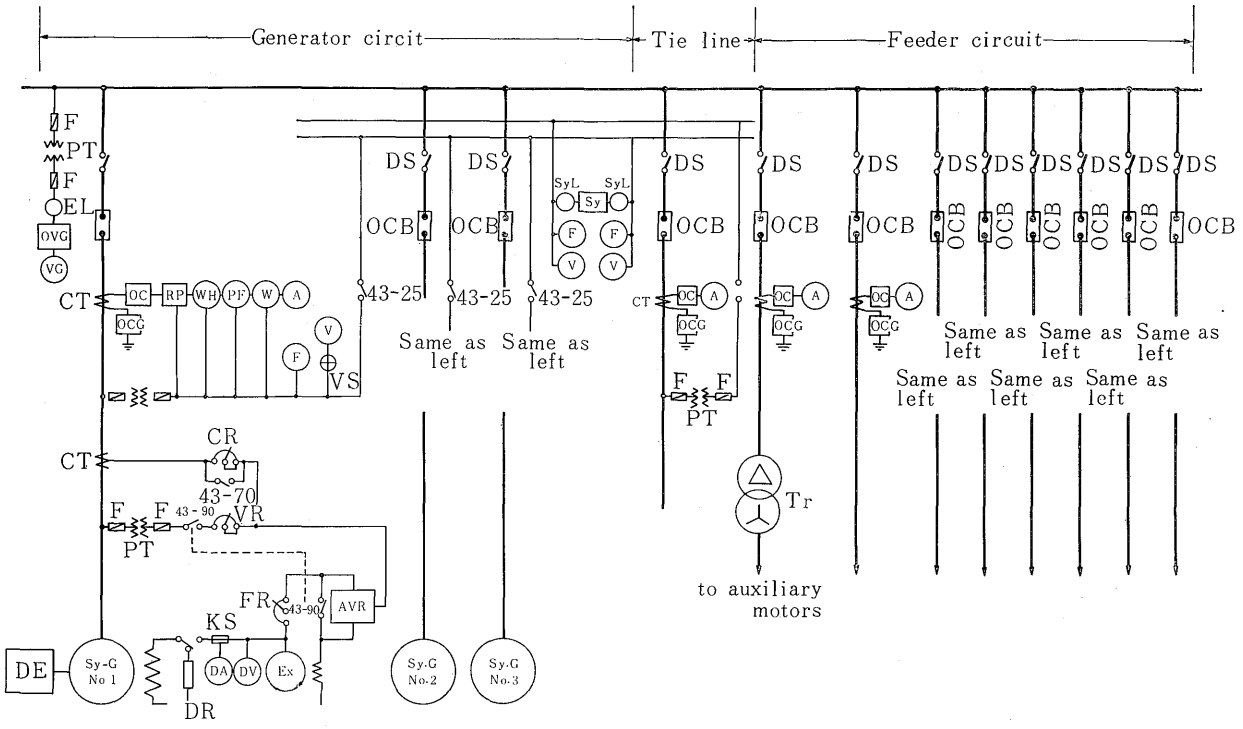

Fig. 8 Skeletion diagram of main circuit of (A) Power Station

V. PROTECTING APPARATUS

When the protecting apparatus show the following values, the Diesel engine will stop automatically.

Lubricating oil pressure down:	below 1.0 kg/cm^2
Cooling water stop:	below abont $^1/_3$
Over speed:	above 110 %
Under speed:	below 90 %

Further, over current relays and reverse power relays trip the oil circuit breakers to protect the generator from failures, and in case of the lubricating oil pressure down (below 1.5 kg/cm^2), cooling water temperature up (above 80°C) and one line grounding the alarm will be given. As to the lubricating oil pressure down and the over speed, the engine is also provided with the mechanical stopping devices to be double protection from failures.

VI. CONCLUSION

In the above lines we introduced the outline of the Diesel generating sets delivered to the Indonesian Navy.

Now, the Diesel generating set is increasing its unit capacity and speed, and with increasing of the unit capacity minimanizing in size in necessary in order to develop the field of the Diesel generating set.

Standard outputs of our Diesel generating sets are from 100 kVA to 2,500 kVA and their revolutions are as follows:

upto	750 kVA:	1,000～1,200 rpm
„	1,500 kVA:	720～ 750 rpm
„	2,250 kVA:	600 rpm
„	2,500 kVA:	500～514 rpm

These revolutions shows 2～2.5 times speed of the old conventional low speed ones and are suitable for long normal operation. We have already supplied these new medium and high speed engines in many quantities, and we are now doing our efforts to develop the new excellent Diesel generating sets and hoping to answer the worldwide customer's expectations.