25 MW Gas Turbine MFT-8 for Compressor Driver

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Recently, energy conversion from petroleum to natural gas is being promoted, and plant constructions of gas pipe lines and gas fields are increasing globally. In plants having 25 MW class compressors, gas turbines are often used as compressor drivers. Against this background, Mitsubishi Heavy Industries, Ltd. (MHI) has modified its 25 MW gas turbine MFT-8, highly noted for marine propulsion and power generation use, for compressor driver, and evaluated the performance and reliability of the equipment in shop load test. As a result, the installation space of gas turbine is reduced by about 40% as compared with gas turbines of the same class of other manufacturers. In shop actual loading test, reliability of the equipment is confirmed, and at the rated load, the same high thermal efficiency as that of the original MFT-8 is confirmed, while in addition at partial load, sufficient practical performance is observed.

1. Introduction

Recently, as energy conversion from petroleum to natural gas is being promoted, plant constructions of gas pipe lines and gas fields have been increasing globally. In plants having 25 MW class compressors, gas turbines are often used as drivers.

MHI's 25 MW gas turbine MFT-8, which has been highly evaluated for marine propulsion and power generation use, has been newly modified for compressor driver, and its performance and reliability have been evaluated in shop load test.

2. Modification for compressor driver

Fig. 1 is a cross section of the modified gas turbine MFT-8 for compressor driver. This gas turbine is composed of a gas generator GG8 based on the aircraft engine of Pratt & Whitney Power Systems (PWPS), and a power turbine of MHI.

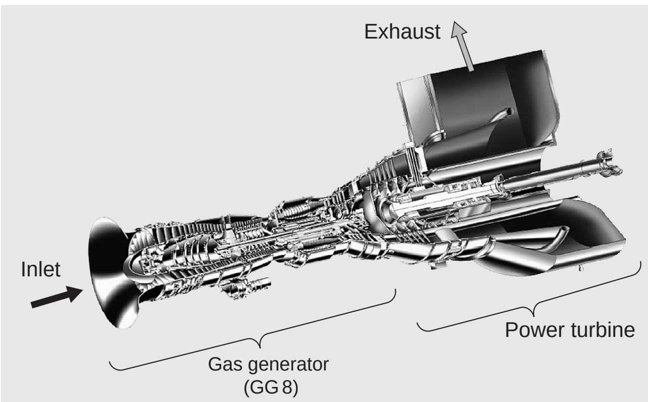

Fig. 1 Cross section of compressor driver MFT-8

Table 1 shows the main characteristics of gas turbine MFT-8 for compressor driver. While maintaining the high thermal efficiency of the original MFT-8, it has been optimally modified for compressor driver.

To be applicable to long-term continuous operation, which is an essential point as gas turbine for compressor driver, parts of the structure have been simplified from the original MFT-8 which has been developed because of the necessity for reduction of weight and quick starting as a marine propulsion engine.

Table 1 Specifications of MFT-8 for compressor driver

Specifications				
Type				Simple cycle 3-shaft
Output			(kW)	26 800*
Thermal efficiency			(%)	38.7*
Operating range			(min^{-1})	3 333 (70%) – 5 000 (105%)
Fuel type				Natural gas fuel
Power turbine lubricating oil				ISO-VG 32 (Mineral oil)
Structure	Gas generator GG 8	Compressor		Low pressure, axial flow, 8 stages
				High pressure, axial flow, 7 stages
		Combustor		Cannular, 9 cans
		Turbine		High pressure, axial flow, 1 stage
				Low pressure, axial flow, 2 stages
	Power turbine (PT)			Axial flow, 3 stages
	Bearing type			GG8: ball-and-roller PT: tilting pad bearing
Package dimensions			(m)	L 9.9 × W 3.2 × H 3.5
Rotating direction				Clockwise (view from compressor side)

* Values in ISO standard atmospheric condition, using gas fuel, without inlet and exhaust loss, at shaft end.

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Principal changes are shown in **Fig. 2** and **Fig. 3**.

2.1 Power turbine

The power turbine of the original MFT-8 uses ball-and-roller bearings, and expensive synthetic oil is used as lubricating oil. For the compressor driver, the bearings of the power turbine are changed to tilting pad bearings, and mineral oil is used for lubrication, thus reducing the running cost.

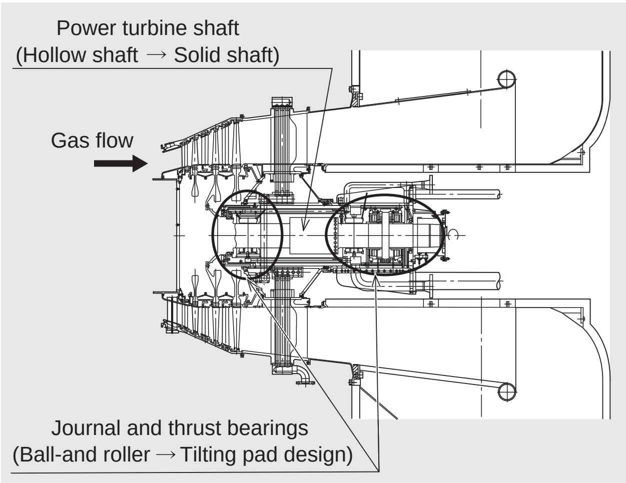

Fig. 2 Improvements to power turbine

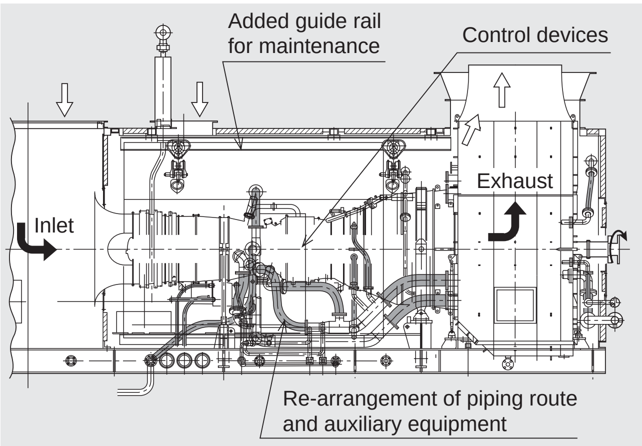

Fig. 3 Improvements to auxiliary equipment

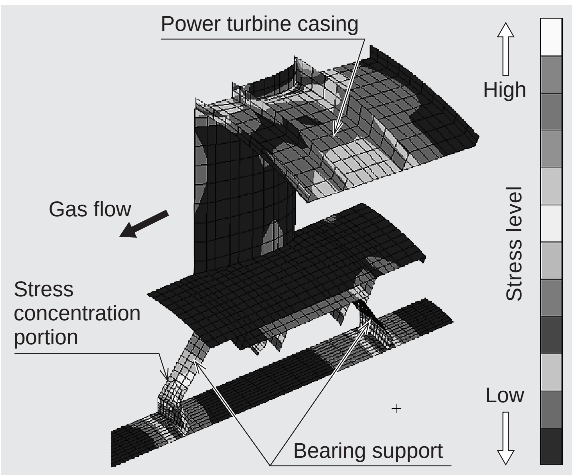

Fig. 4 Unsteady thermal stress analysis

As a result of the change of bearing type of the power turbine, the lubricating oil drain temperature is lowered by about 50℃. The thermal stress generated in the exhaust frame around the bearing was tested by unsteady FEM analysis as shown in **Fig. 4**, and the reliability was verified.

In the stress concentrated portion of bearing support, its stress level was low, and it has been confirmed that there is no problem in low cycle fatigue strength.

2.2 Auxiliary equipment

Major changes in the gas turbine are as follows.

(1) Change of control method

Fig. 5 shows a gas turbine operation screen, and **Fig. 6** shows an monitoring screen for the gas turbine and compressor.

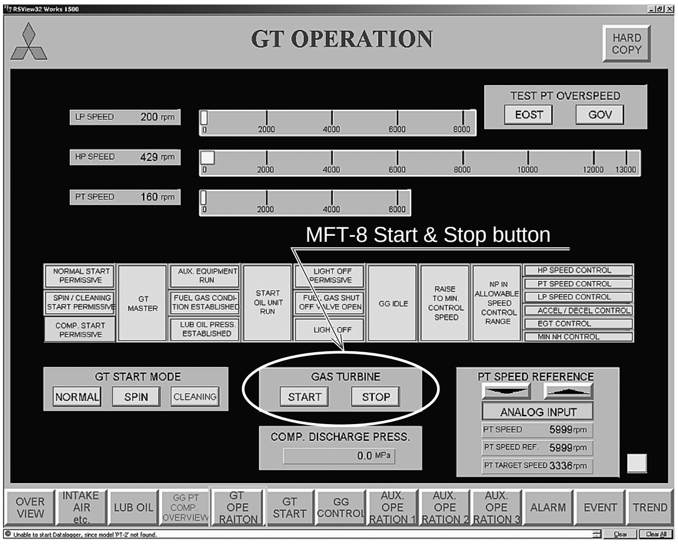

Fig. 5 MFT-8 control touch panel

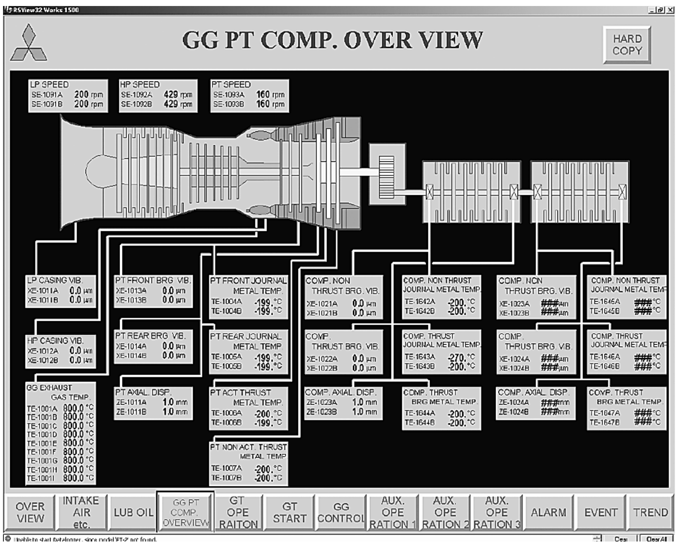

Fig. 6 Monitoring screen for operation condition of MFT-8 gas turbine and compressor

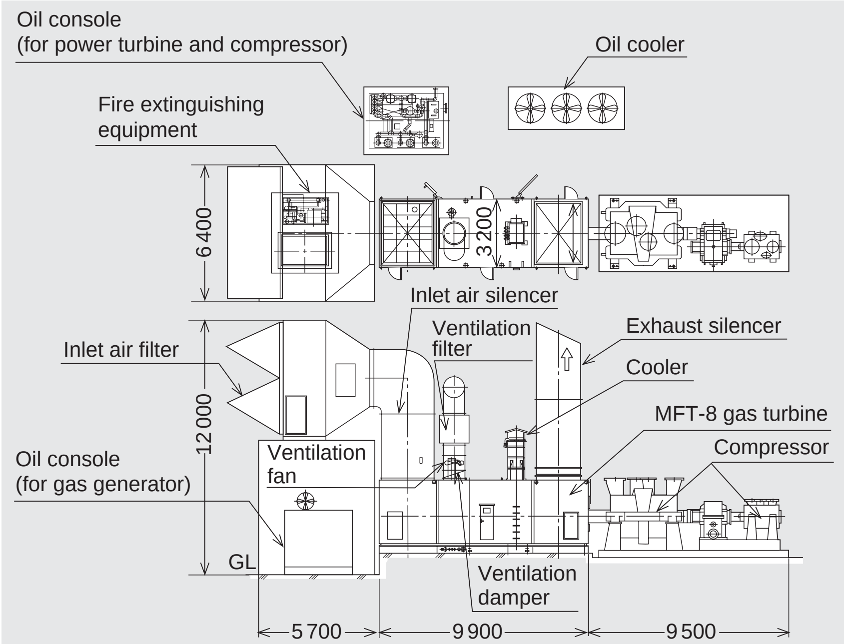

Fig. 7 Package arrangement of MFT-8

As the control device of gas generator of PWPS, Micronet of Woodward is used, while the PLC of Allen-Bradley is used as the control device of the power turbine of MHI.

Further, by automating starting of the gas turbine main body and starting of the auxiliary machine, acceleration up to 70% of power turbine rotating speed (lowest speed in operation range 3 333 min-1) is realized in a single action. In deceleration, a function is provided for selecting the step-down method automatically depending on the cause of stop, and this is automated including stopping of auxiliary machine.

(2) improvement to the enclosure structure

Maintenance rails are provided in the enclosure, the engine can be removed without disassembly the enclosure, and easy maintenance is realized.

3. Comparison with other manufacturers

Fig. 7 shows the example of the typical arrangement of compressor train with Mitsubishi Advanced Compressor (MAC) and MFT-8 for compressor driver, and **Table 2** shows a comparison of gas turbine package dimensions of the same class from other manufacturers.

The package is made compact by adjusting the piping route and equipment layout, and the package installation area is reduced by about 40% as compared with other manufacturers.

Table 2 Comparison of gas turbine package dimensions

(Unit: m)

MHI (MFT-8)	Manufacturer A	Manufacturer B
W=3.2, L=9.9 Installation area 32 m²	W=3.4, L=15.3 52 m²	W=4.0, L=12.8 51m²

4. Load and performance test

A trial machine of MFT-8 for compressor driver was fabricated in accordance with these changes and modifications, and a shop load test was conducted for the purpose of evaluating the reliability and performance of the equipment.

Fig. 8 shows an outline of the load test facility. A water dynamometer was used as the load device.

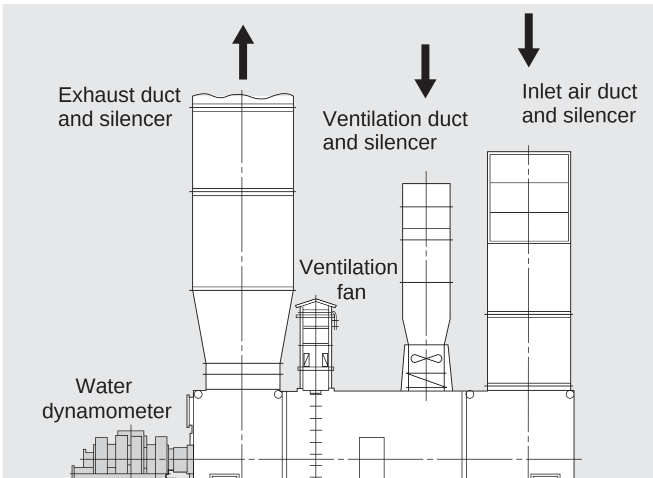

Fig. 8 Outline of test equipment for MFT-8

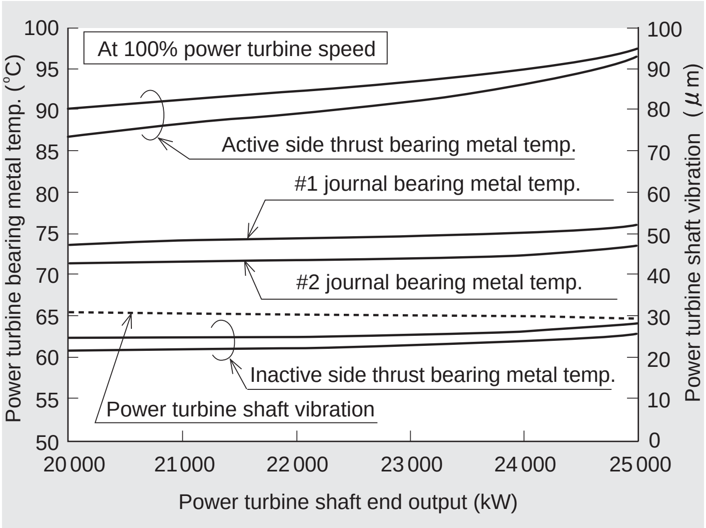

Fig. 9 Measurement results of power turbine bearing metal temperature and shaft vibration

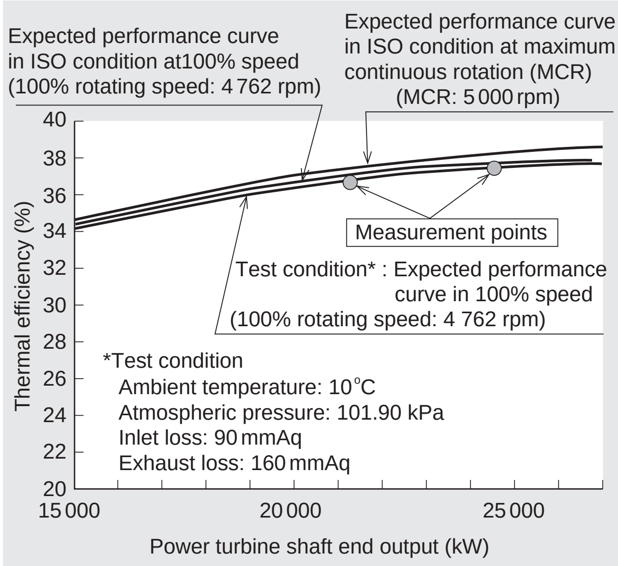

Fig. 10 Measurement results of power turbine performance

To confirm the reliability of the improved points of the power turbine, about 100 points were measured and the data were collected in real time.

Fig. 9 shows the results of measurement of bearing metal temperature and shaft vibration at high load with power turbine 100% rotating speed. The metal temperatures of thrust bearings and journal bearings at rated load were, respectively, about 97℃ and about 75℃, which fall within design allowable values, and reliability was confirmed. Shaft vibration at rated load was about 30 μm^{P-P}, which was also within design allowable values. At other points, measurements were normal, which reliability of the equipment was verified.

Fig. 10 shows the results of measurement of performance. It was confirmed that performances at the rated point and partial load were as planned. Thus, at the rated load, the high thermal efficiency of the original MFT-8 is maintained, and at partial load, sufficient practical performance could be confirmed.

5. Conclusions

MHI's 25 MW gas turbine MFT-8, in widespread use for marine propulsion and power generation purposes, has been modified for compressor driver.

The controllability and maintainability have been improved accordingly, and the installation space of gas turbine is reduced by about 40% as compared with gas turbines of the same class made by other manufacturers.

Reliability of the modified MFT-8 has been confirmed in shop load test. It was verified that the modified MFT-8 has the same high thermal efficiency as the original MFT-8 at rated load, and has sufficient practical performance at partial load.

In future, the product will be brought to the gas field market as a total package of Mitsubishi Advanced Compressor (MAC) and MFT-8 gas turbine.


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