Development of High-efficiency Turbocharger MET-MA Series for Large-Bore Diesel Engine

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1. Introduction

A turbocharger is a machine that recovers exhaust gas energy using a turbine and drives an axial compressor to feed air required for combustion. To respond to high output of recent large-bore diesel engines, the turbocharger must have a high pressure ratio of compressor and enhanced turbocharger efficiency.

Further, the turbo compound system that partially recovers exhaust gas energy as driving force is recently attracting attention, with the need for high-efficiency turbocharger increasing.

This paper presents a report on the development of the latest high-efficiency MET-MA turbocharger.

2. MET turbocharger overview

2.1 History of MET turbocharger

The MET turbocharger was first developed in 1965 for the Mitsubishi UE 2-cycle low speed diesel engine. To respond to the need for higher engine output, the turbocharger has undergone the model changes as shown in **Fig. 1** to improve performance mainly by improving the compressor impeller and turbine blade.

Fig. 2 shows the changes of aerodynamic designs.

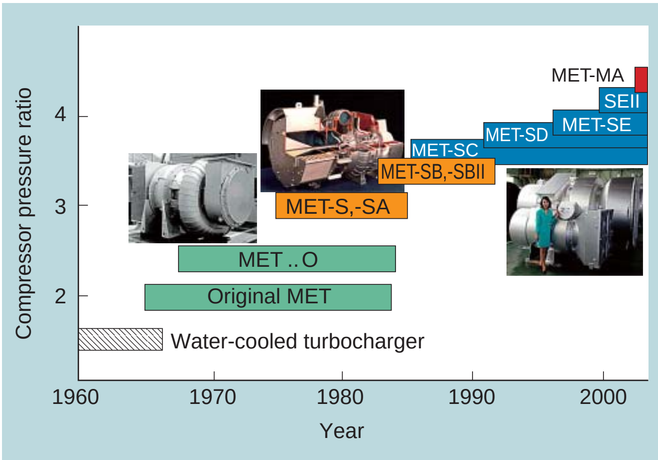

Fig. 1 History of Mitsubishi MET turbocharger

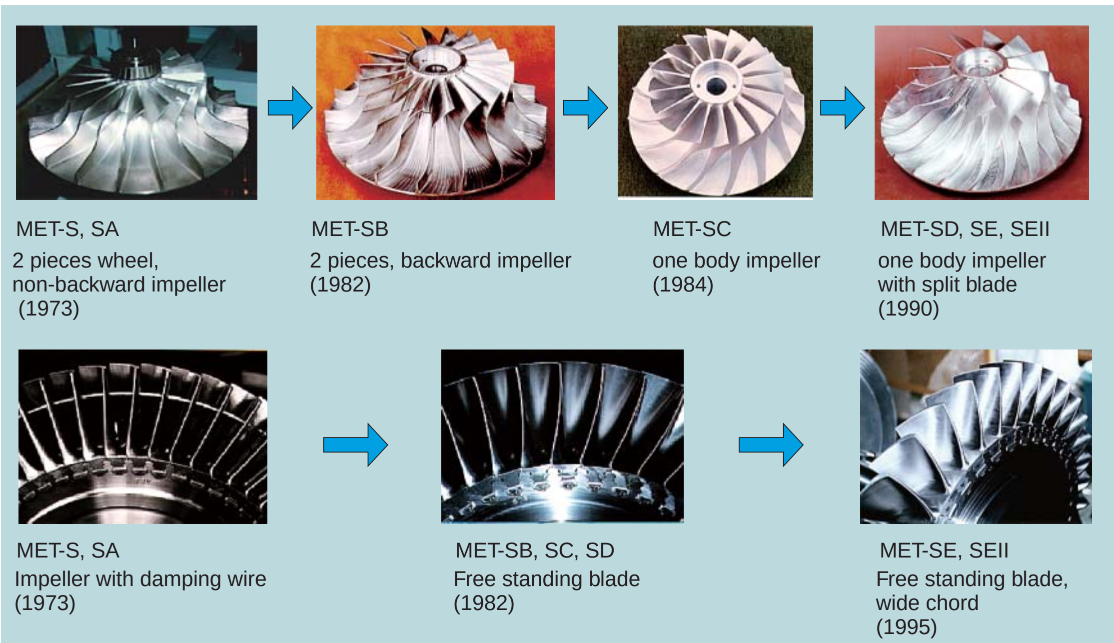

Fig. 2 Changes in Mitsubishi MET turbocharger compressor impellers and turbine blades

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2.2 MET turbocharger features

The MET turbocharger features a bearing on the inner side of the impeller and turbine blade and a rotor supported by a pedestal with less thermal deformation as shown in the sectional drawing of turbocharger in **Fig. 3**. Because of this, rotor support is not affected by thermal expansion of the turbine casing.

Furthermore, the bearing pedestal has an integrated head tank to enable supply lubricating oil even after the engine comes to an emergency shut down. In addition, the double wall structure of the gas inlet casing enables removal of the inner casing without removing the pipe connected to the engine, making it easy to check the turbine and nozzle.

3. Purpose of MET-MA turbocharger development

For high engine output, high-efficiency supply of high-density, i.e. high-pressure combustion air is needed, and this is why the turbocharger requires high compressor pressure ratio and high turbocharger efficiency. Further, for effective use of energy, the turbo compound system is drawing attention, where the exhaust gas supplied to the turbocharger is partially extracted and recovered as driving force.

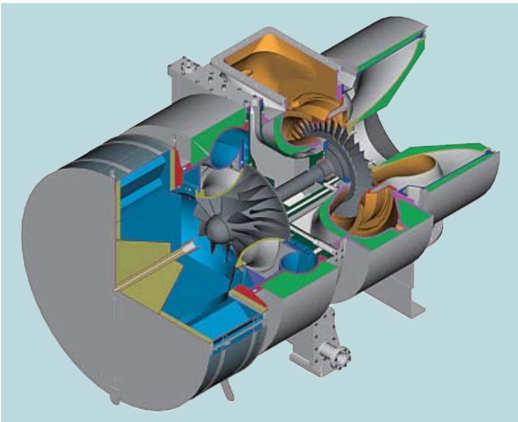

Fig. 3 Section of MET83SE II turbocharger

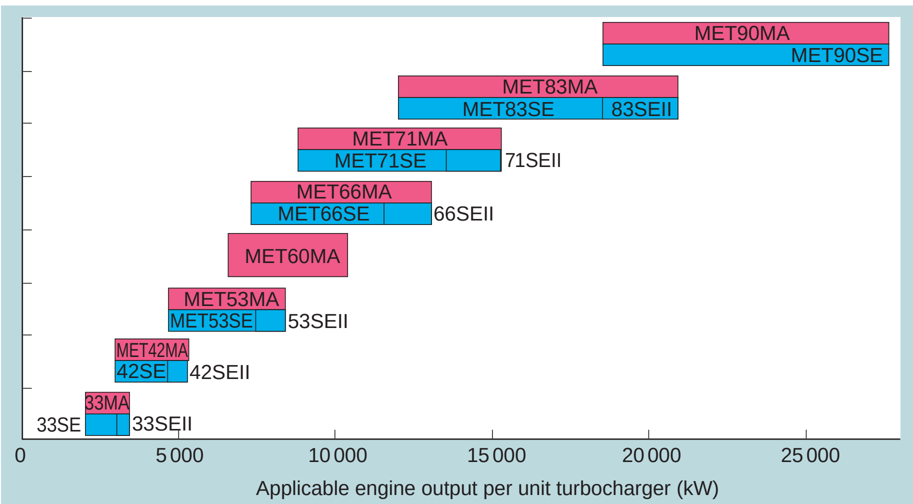

Fig. 4 Applicable engine output for MET-MA turbocharger

Since the higher the turbocharger efficiency in the turbo compound system, the higher the energy yield, the turbocharger must have efficiency improved. To improve turbocharger performances, MET-MA was developed as the new MET turbocharger series.

In developing MET-MA, the following items were taken into consideration:

(1) To respond to needs for high turbocharger performance, the turbine blade shape and exhaust gas passage were reviewed to improve performance.

(2) A new series MET60 was added between MET53 and MET66 series as shown in **Fig. 4**, and MET60MA with a frame smaller than MET66 was applied to an engine with output of approximately 10 000 kW, contributing to the reduction of turbocharger size.

(3) The external dimensions were approximated with the conventional turbochargers to enable interchangeability.

Detailed below is turbine blade and gas casing design closely linked to improved performance.

4. MET-MA Design

4.1 Turbine blade design

A new turbine blade is adopted to improve MET-MA turbocharger efficiency. **Fig. 5** shows the external views of the turbine blades of MET-SE II and MET-MA turbochargers. Compared to the MET-SE II turbocharger turbine blade where the leading and trailing edges of blade are designed linearly, the MET-MA turbocharger turbine blade adopts a three-dimensional curved form to optimize the flow pattern in the direction of blade height.

Fig. 5 External views of MET-MA and MET-SE II turbine blades

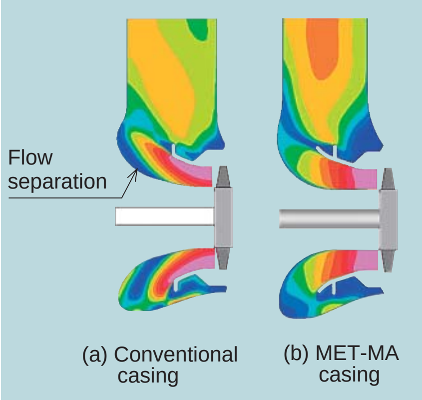

Fig. 6 Analytical result of flow velocity distribution in gas outlet casing

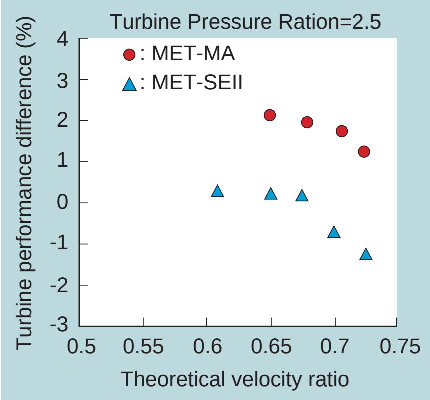

Fig. 7 Efficiency of MET-MA turbine

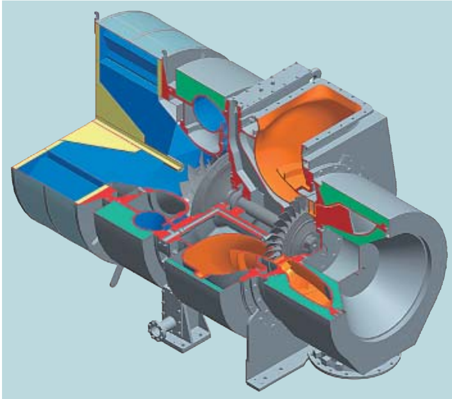
Fig. 8 Section of MET83MA turbocharger

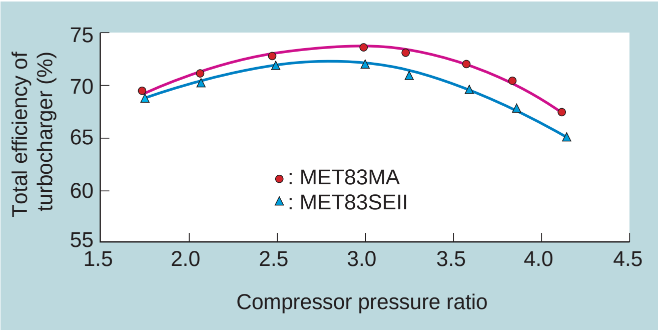

Fig. 9 Comparison of overall efficiency of MET83MA turbocharger and MET83SE II turbocharger

4.2 Aerodynamic design of gas casing

Progress in calculation technology in recent years has enabled analysis of large-scale flow fields comparatively in a short time, making it an effective tool for design. This tool was effectively used to optimize gas outlet casing and exhaust diffuser of the turbine.

Fig. 6 shows the analytical result of inner flow as compared to the conventional MET-SE II gas outlet casing. In conventional design, flow was partial separated (Fig. 6-a), corrected by improving the gas outlet casing shape (Fig. 6-b).

5. Performance test results

5.1 Independent turbine test

Fig. 7 shows the result of performance tests of an independent turbine, with the turbine efficiency in MET-MA confirmed to be improved approximately by 2% at turbine pressure ratio 2.5 compared to the conventional MET-SE II.

5.2 Turbocharger performance test

A MET83MA prototype was manufactured for turbocharger. performance tests. **Fig. 8** shows the sectional view of the MET83MA turbocharger.

Fig. 9 shows MET83MA turbocharger efficiency compared to the conventional MET83SE II, with MET83MA turbocharger efficiency indicating 70% or over at pressure ratio 3.8 (equivalent to scavenging air pressure 0.38 MPa), approximately 2% higher than the conventional type. The improved efficiency is considered to lead to a high-efficiency turbo compound system.

6. Conclusion

Based on the achievements of conventional turbochargers, the turbocharger turbine was improved to ensure a drastic improvement in efficiency. It is expected that the newly developed high-efficiency MET-MA turbocharger will be applied to the new high-output engine and exhaust heat recovery system, contributing largely to the further improvement in the diesel plant efficiency.


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