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Effects of DME's Temperature on Power Performance of a Turbocharged DME Engine

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Abstract: The present paper investigates into the effect of dimethyl ether (DME) temperature on a turbocharged DME engine that is used as a research object. The research results show that the DME temperature rises gradually in fuel tank during the engine running, and the system temperature is balanced after a period of time. When the DME temperature rises from 28°C to 40°C, the engine power decreases by 8.0% from 132.2 kW to 121.6 kW in 1400 r/min; it decreases by 12.0% from 192.1 kW to 168 kW in 2200 r/min. At the rated working conditions, the DME engine power decreases by averagely 1.0% when the DME's temperature rises by 1°C.

Keywords: DME temperature, turbocharged, DME engine, power performance, CLC number: TK464 literature code: A.

1. INTRODUCTION

Recently, DME has been highlighted increasingly as it can realize high-efficiency and low-pollution combustion and improve the energy structure in China thanks to its special properties. Foreign and Chinese researches have show that the DME can achieve highly efficiently and ultra-low emissions, mild combustion, zero smoke test value and low combustion noise [1-4]. In recent years, the technical center for combustion and environment in Shanghai Jiao Tong University has developed urban DME bus. Its power exceeds the level of the original diesel engine. The emission based on the mechanical pump reaches the national Level III emission standard. The noise decreases drastically by comparing to the diesel prototype engine [5-7]. Moreover, the center has been also committed to the development of DME engine industrialization application. During the experiment, it found that the DME engine power reduced by more 20kW under the rated working condition than the initial cold start up state when the engine operates continuously for more than an hour. The instability of output power affects the massive promotion and application inevitably. The present paper intensively investigates into the temperature characteristics of DME supply system in DME engine and the effect of DME temperature on the engine performance.

2. THE TEST EQUIPMENT AND METHODOLOGY

The DME engine under the experiment is developed by Shanghai Jiao Tong University based on the D6114ZLQB diesel engine manufactured by Shanghai Diesel Co., Ltd. D6114ZLQB engine is a turbocharged inter-cooled directly-injected diesel engine. The engine's main technical parameters are listed in Table **1**. With modification of the engine, the DME engine is better than the original diesel in the power performance (see Fig. **1**) [8].

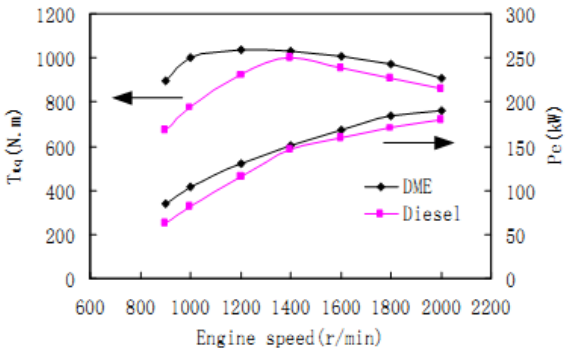


Fig. (1). Comparison of torque and power of DME engine and diesel engine at full load.

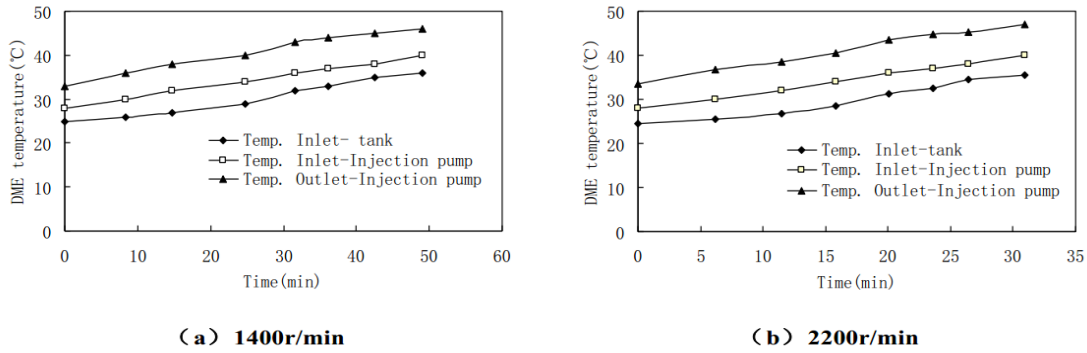
To reveal the effect law of DME temperature on DME engine power, the present paper investigates the temperature variation rule of DME supply system at steady engine running state. 50 kg MDE is stored in the tank. The MDE engine runs respectively at both 132.2 kW in 1400 r/min and 192.1 kW in 2200 r/min. During the experiment, the throttle position is kept unchanged. The temperature of each test point in the DME supply system is tested. The test points include DME tank outlet, high pressure oil pump inlet and outlet. The output power of engine is measured at each temperature test point.

3. TEST RESULTS AND ANALYSIS

Fig. (**2**) shows the variation of temperature with time in DME system. The initial temperature at DME tank outlet is

Table 1. The Specifications of Diesel Engine and DME engine.

	Diesel Engine	DME Engine
Model	D6114ZLQB	D6114ZKQB
Cylinder diameter x range	114 × 135 mm × mm	114 × 135 mm × mm
Displacement	8.27 L	8.27 L
Compression ratio	18:1	18:1
Injection advance angle	9/(ºCA BTDC)	9/(ºCA BTDC)
Max. torque/rpm	1000 N.m/1400 r/min	1000N.m/1400 r/min
Injection pump	P7100	P8500
Piston diameter	12 mm	13 mm
Nozzle number x nozzle diameter	6 × 0.24 mm	6 × 0. 4 mm



（a） 1400r/min （b） 2200r/min

Fig. (2). Variation of DME temperature with time (injection advance angle 8°CA BTDC, P8500 Pump, 12 mm Piston, 6 × 0.43 mm Nozzle).

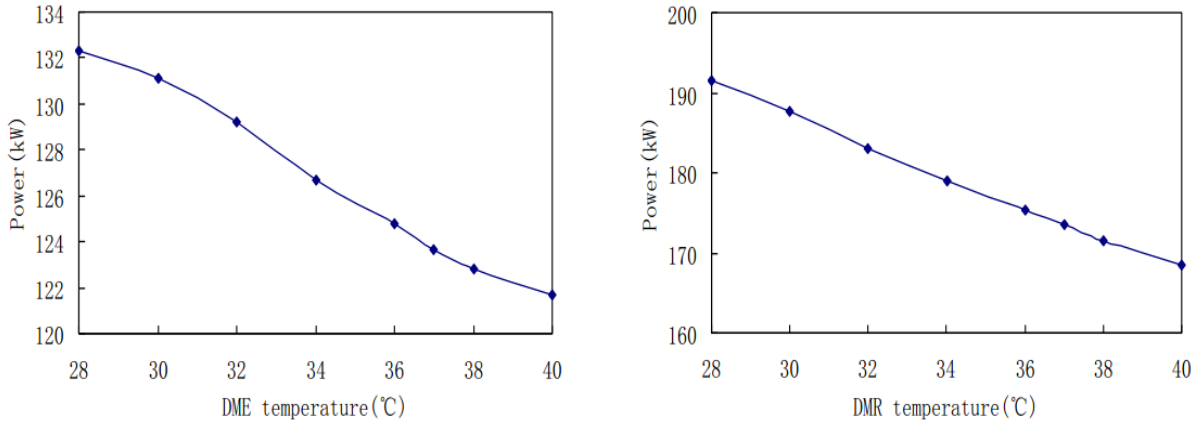
25°C, and the temperature at the high pressure oil pump inlet is 28°C. The DME temperature rises after passing through the high pressure oil pump. The initial temperature at high pressure oil pump outlet is 32°C. In the working condition of 132.2 kW in 1400 r/min, the temperature of DME supply system in DME engine is basically balanced. The temperature at the DME tank outlet is 37°C, the temperature at the high pressure oil pump inlet is 40°C and the temperature at the high pressure pump outlet is 46°C. In the working condition of 192.1 kW in 2200 r/min, the initial temperature in the DME tank outlet is 24.6°C, the temperature at the high pressure oil pump inlet is 28°C and the temperature at the high pressure pump outlet is 33.6°C. The DME supply system reaches a balance state in a shorter time by 30 min as the engine consumes more DME and the high pressure oil pump produces more heat at running. The temperature at the DME tank outlet is 37°C, the temperature at the high pressure oil pump inlet is 40°C and the temperature at the high pressure oil pump is 46.9°C.

Fig. (**3**) shows the effect of DME temperature on DME engine power. It can be known from Fig. (**3**) that the engine power is reduced from 132.2 kW to 121.6 kW, downturned by 8% in 1400 r/min; the engine power is reduced from 192.1 kW to 168 kW, downturned by 12.0%, in 220 r/min when the DME temperature at the high-pressure pump inlet rises from 28°C to 40°C. In the rated working condition, the DME engine power averagely reduces by 1.0% when the DME temperature rises by 1°C.

The elevated DME temperature causes a higher engine power. We can expound in following aspects:

(1) The rising temperature causes the decrease of temperature. In the same throttle position, the actual DME injection amount reduces and leads to the decrease of DME engine power

When the liquid-phase DME temperature rises, the DME volume and the density will change. AT atmospheric pressure, DME volume variation with temperature is shown in Tables **2** to **4** [9]. The DME density variation with the temperature can be reckoned as per the data given in Table **2** (Fig. **3**). At liquid-phase DME temperature 28°C, its density is 0.645 g/ml. When the liquid-phase DME temperature is



(a) 1400 r/min (b) 2200 r/min

Fig. (3). Effect of DME temperature on power of DME engine (injection advance angle 8°CA BTDC, P8500 Pump, 12 mm piston, 6 × 0.43 mm nozzle).

40°C, its density is 0.628 g/ml; the DME temperature rises from 28°C to 40°C, its density decreased by 2.6%.

The rising temperature leads to the increase of saturated DME vapor pressure. The increased vapor pressure is easier to cause the air resistance, the large tendency of generating cavitation when the delivery valve at oil pump is seated, and the decrease of engine power.

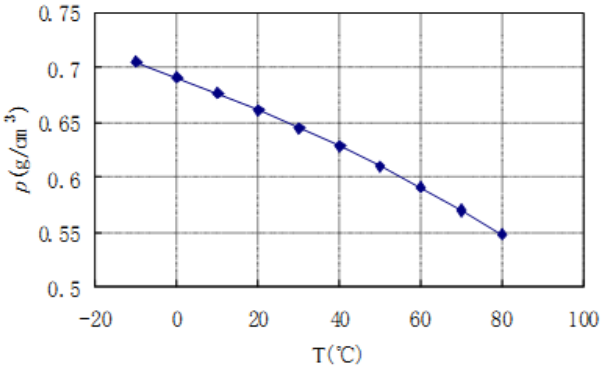


Fig. (4). Effect of temperature on Density of DME.

Fig. (**5**) shows the effect of temperature on the saturated vapor pressure. When the liquid-phase DME temperature is 20°C, its saturated vapor pressure is 0.51 MPa; when the liquid-phase DME temperature is 50°C, the saturated vapor pressure is 1.16 MPa, and the DME supply system pressure in DME engine is 1.2 MPa. After the DME temperature rises, the saturated vapor pressure is close to the oil supply system pressure, the system's air resistance is serious and the engine power is resultantly reduced.

When the rising temperature causes the decrease of DME elastic modulus, the DME is easily compressed. The decreased DME acoustic speed in high-pressure oil tubing and less actual DME amount into the nozzle at the same throttle positions lead the decrease of DME engine power as well.

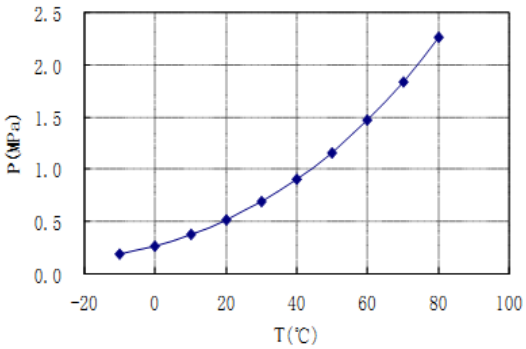


Fig. (5). Effect of temperature on vapor pressure of DM.

Table 2. Volume change of DME with temperature.

T/	-10	0	10	20	30	40	50	60
V/(cm³/mol)	65.235	66.583	68.049	69.633	71.358	73.238	75.424	77.845

CONCLUSION

(1). DME temperature has a significant effect on the engine power performance. At the rated working points, the DME engine power declines averagely by 1.0% when the DME temperature rises by 1°C.

(2). To ensure the stability of DME engine power, the DME temperature must be controlled in application. The special constant-temperature system can be used for temperature control. The DME temperature range should be specified in the nominal power of the DME engine.

CONFLICT OF INTEREST

The author confirms that this article content has no conflict of interest.

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