Experimental study of an ORC (Organic Rankine Cycle) system with thermal oil for Waste Heat Recovery of a diesel engine

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Introduction

An Organic Rankine Cycle (ORC) system with thermal oil onboard was constructed and preliminarily tested for Waste Heat Recovery (WHR) from exhaust gas of a 244kW diesel engine. The main purposes of this work is to show its ability against high temperature and variation of exhaust gas. The results show that thermal oil is effective to protect organic fluids from decomposing, as well as to bring a significant inertia to the response of system which could be positive.

Problems

Two main problems when recover waste heat from exhaust gas of a diesel engine for vehicle:

1. High temperature that may decompose most organic fluids;
2. Variation of engine condition that leads to the variation of recoverable heat in exhaust gas

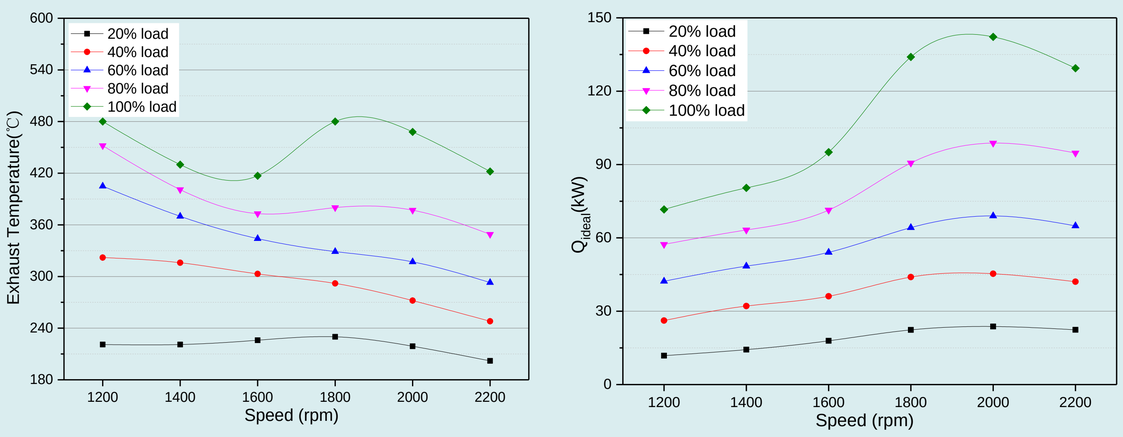

Fig.1 Exhaust temperature and recoverable waste heat when engine condition varies

Methods

1. Test Bench

Thermal oil serves as heat transfer medium between exhaust gas and ORC

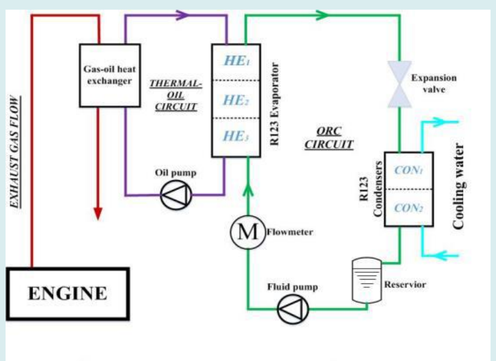

Fig.2 Structure and photo of ORC system with thermal oil

2. Ability against high temperature of exhaust gas

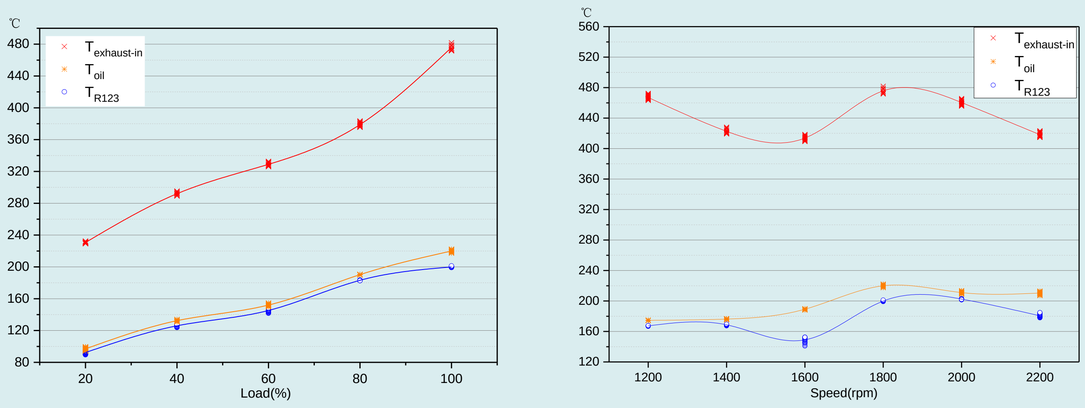

Fig.3 Highest temperature in exhaust gas, thermal oil cycle and ORC

The highest temperature of exhaust gas is around 480℃, while that of thermal oil is around 220℃, which effectively protect organic fluids from decomposing

3. Response against variation of engine condition

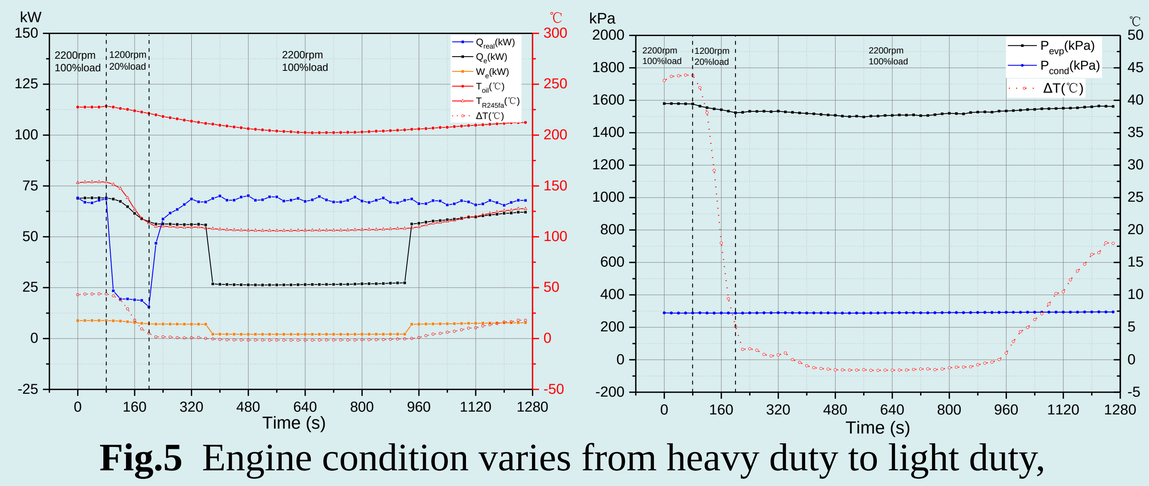

Fig.5 Engine condition varies from heavy duty to light duty, then back to heavy duty

The inertia of thermal oil is considerable. If properly adjusted to keep superheat degree of organic fluid above zero, the system could potentially keep outputting power when engine condition changes vastly.

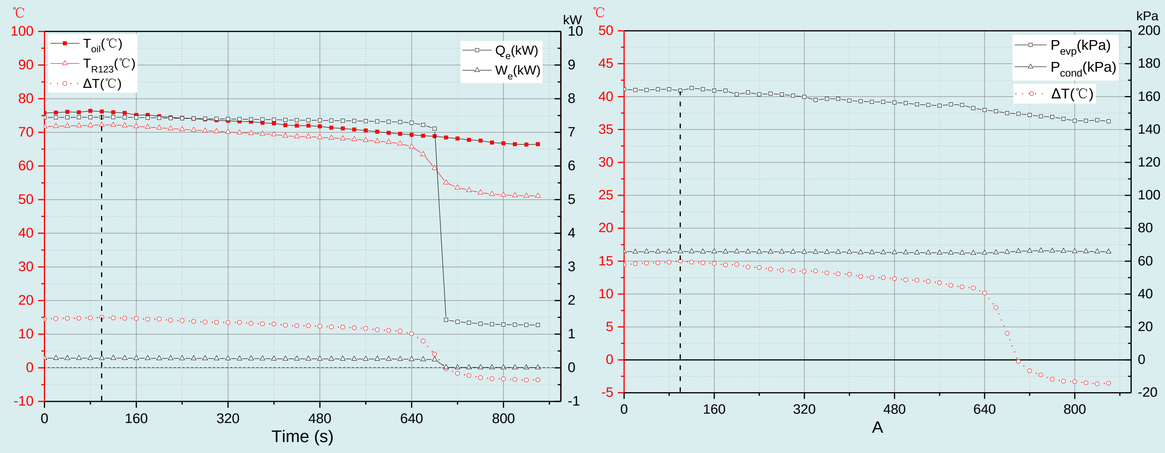

Fig.6 Engine suddenly shut down from light duty

Under this circumstance, the system have the potential to keep outputting power for nearly 10 minutes when engine shuts down.

Conclusions

1. The temperature range of exhaust gas is from 200℃ to 480℃, however that of thermal oil is from 81℃ to 222.5℃. It is way below the decomposition temperature of many organic working fluids, which ensures a longer working life.
2. The response test shows that, thanks to the inertia of thermal oil, the whole system is able to keep outputting power when the engine condition changes vastly even shuts down, which could be applied on the urban traffic. During this investigation, the superheat degree of working fluid after evaporator is proven to be a reliable indicator for safe operation. Evaporating and Condensing pressure are found almost unchanged during the variation of engine condition which is important to the system safety.

References

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