ISME2017-1709

The 25th Annual International Conference on Mechanical Engineering
ISME2017, 2-4 May 2017, Tarbiat Modares University, Tehran, Iran

# Waste Heat Recovery from Exhaust and Coolant of OM 352 Diesel Engine Using a Transcritical Dual Loop Organic Rankine Cycle

**Farzad Mohammadkhani[1], Faramarz Ranjbar[2], Mortaza Yari[3], Shahram Khalilarya[4]**
[1,2,3] Mechanical Engineering Faculty, University of Tabriz, Tabriz, Iran
[4] Department of Mechanical Engineering, Urmia University, Urmia, Iran

**Abstract**
A thermodynamic analysis is reported for Waste Heat Recovery (WHR) from exhaust gas and coolant of OM 352 Diesel engine using a transcritical dual loop Organic Rankine Cycle (ORC). To reach the best results, various working fluids are examined in the cycle. Also, a parametric study is performed to reveal the effects on system performance of lower pressure of high temperature loop. Results show that the dual cycle with toluene in high temperature loop and R143a in low temperature loop has the best performance so that employing the dual cycle increases the system produced power by 25%. The dual cycle energy and exergy efficiencies are calculated to be 20.63% and 55.86%, respectively. Also, the parametric study shows that the cycle produced power has a maximum value with respect to lower pressure of the high temperature loop.

**Keywords**: *waste heat recovery-Diesel engine-transcritical organic Rankine cycle-exergy analysis-parametric study*

## Introduction

Internal Combustion Engines (ICEs) are broadly used as the prime mover in power units. In industrial countries, about 60-70% of fossil fuels are consumed by these engines. Since it is difficult for the maximum efficiency of the engines to reach 42%, large amount of fuel is wasted. The converting of waste heat into useful power would not just bring advantages for improving fuel consumption, but also increase engine power output or downsizing and further reducing harmful exhaust emissions correspondingly [1,2].

Organic Rankine Cycle (ORC) has been proven as one of the most promising techniques for engine waste heat recovery, among all the existing technologies. The exhaust gas and coolant are two main sources of waste heat in an engine. Thus, the dual loop ORC is proposed for engine waste heat recovery, in which, the waste heat of the exhaust gas is recovered in the high temperature loop while the low temperature loop utilizes the waste heat of the coolant and residual heat of the high temperature loop [3]. Some studies have been conducted on the analysis of dual loop ORCs. Shu et al. [4] Proposed three regenerative dual loop organic Rankine cycles and reported that the maximum output power and exergy efficiency are obtained when water is used as the working fluid in the high temperature loop and no regenerator is adopted in the system.

In the present work, a transcritical dual loop ORC is proposed to recover the waste heat from the exhaust gas and coolant of the OM 352 Diesel engine. The performance of the cycle is examined using two working fluids for every loop: toluene and cyclohexane for high temperature loop and carbon dioxide and R143a for low temperature loop. Also, a parametric study is done to show effects of lower pressure of high temperature loop on the system performance.

## System description

Fig. 1 shows the schematic diagram of the system.

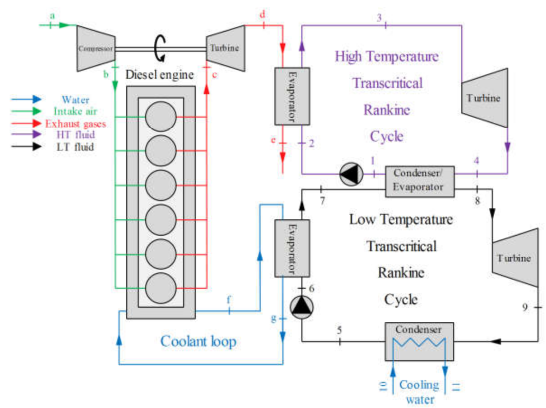


**Fig. 1: schematic diagram of the system**

As Fig. 1 shows, OM 352 is a turbocharged Diesel engine which its main parameters are shown in Table 1.

**Table 1: Main engine parameters**

| Parameter | Value |
|---|---|
| Engine power output (kW) | 98.9 |
| Exhaust temperature (°C) | 524.9 |
| Exhaust mass flow rate (kg/s) | 0.1769 |
| Coolant temperature (°C) | 86.8 |
| Coolant mass flow rate (kg/s) | 1.6 |

The High Temperature (HT) loop recovers the waste heat of the exhaust gas and the Low Temperature (LT) loop utilizes the waste heat of the coolant and residual heat of the high temperature loop. All the heat exchangers are analyzed using pinch point temperature difference method [4], and the location of pinch point in the condenser/evaporator depends on the lower pressure of the high temperature loop. The considered assumptions in the study are shown in Table 1.

**Table 2: The considered assumptions**

| Parameter | Value |
|---|---|
| $P_1$, $P_3$ and $P_7$ (kPa) | 100, 10500 and 7000 |
| $T_3$ (°C) | 425 |
| $\eta_P$ and $\eta_T$ | 0.85 and 0.8 |
| $\Delta T_{PP,Evap}$, $\Delta T_{PP,CE}$ and $\Delta T_{PP,Cond}$ (°C) | 30, 5 and 5 |

The last row of Table 2 gives considered values for the pinch point temperature differences in the heat exchangers.

1. Postdoctoral Research Fellow, f.mohammadkhani@tabrizu.ac.ir (Corresponding author)
2. Associate Professor
3. Professor
4. Professor