Performance analysis of different working fluids properties using ORC (Organic Rankine Cycle)

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Abstract

There are many recovery methods that are used using the low-grade energy. Among those methods ORC (Organic Rankine Cycle) is proved to be best. Various applications like waste heat, solar thermal andgeothermal make use of the ORC. Though, for the better performance of ORC in the above mentioned applications there is a need of selecting the suitable or appropriate working fluid for the ORC. There exists no specific fluid for any specific application and therefore, several researchers examined around more than 600 natural as well as zeotropiccombinations so that a best suitable fluid can be discovered for particular application depending upon their performance characteristics like environmental impacts, cost and efficiency on some operating conditions. This study provides a brief review for the working fluids selection for various applications for different parameters.

Keywords:ORC (Organic Rankine Cycle), Working fluids, Waste heat, Energy

1. INTRODUCTION

Today, world development was attained by a wide and effective use of different energy forms. Throughout the past years, the consumption of energy growth across the world was shown that the only energy of fossil fuel is incapable of fulfilling the demands of energy in the future. Because of increases in activities of industries, the waste heat amount also rises and it also rises in the consumption of fossil fuel. Industrial waste heat is basically the energy create by the activities of the industry which are not useful or cannot apply for some important purposes. It was shown in many studies that the specific amount for waste heat of industrial is badly calculated. Nearly 25% to 55% of industrial energy is useful for many reasons whereas the residual energy is called as industrial waste heat [1].Although, it is not possible to prevent the losses of waste heat in industrial areas.

There are few techniques like recovery of heat technology that is used to decrease the waste heat through the utilization of energy as well as refining efficiency of equipment. Many industries generate alternative sources of energy extraction from the exhaust of turbine, biomass energy, solar energy as well as waste heat. ORC system is used to convert heat resources of low grade into electrical power. ORCs principle is also same as the Conventional Ranking Cycle system. Still, they have some differences like working fluid of organic is used by ORC that has a low boiling point as compared to the boiling point of water and high vapor pressure. ORCs

properties compare with Conventional Rankine Cycle and it was shown that fluid of organic boost the efficiency of ORCs cycle. In the whole world, there were many ORCs installations as well as many researched are also done to improve the quality of ORCs.

1.1 History

In 1960 Harry Zvi was the first who developed the ORC system [9]. This particular prototype was primarily used to recover very low-quality high temperature which happens to be akin to the solar power used-to turn lower heat resources to electric power. Harry Zvi also discovered that the turbine was also capable to operate and work at low temperature. An Israeli company in 1965 privatized this invention [10].

1.2 Low-grade temperature heat recovery cycles

Low-grade heat source is not a useful method to convert thermal energy to electrical energy even at a low temperature. To utilize the energy of low-grade heat source many cycles were developed. ORC, trilateral flash, Kalina cycle, Goswami cycle are some main cycles thatuse organic working fluids in place of water. Hence they give higher benefit for the components at a low price [13].

Organic Rankine Cycle (ORC)

Conventional Rankine cycle and ORC has the same principle of working as discussed earlier. Turbine (expander), Boiler (evaporator), pump and condenser are the same components of Conventional Rankine cycle and ORC. On the other hand, only the working fluid is different in these cycles. As compared to CRC (conventional Rankine cycle) the ORCs is more efficient to produce electrical power with using the heat of low grade.

1.3 Worldwide ORC installation

Today, ORC installation has been done in several countries. ORC is used in many countries to utilize the waste heat. ORCs exist in the most countries like USA, Canada, Italy, and Germany whereas in other countries they installed a ORCs single unit for example India, Morocco, Swaziland, Finland, Russia, Romania, Austria, and Belgium [11].

Turboden, Ormat, as well as Tas Energy are the main companies which supply equipments of ORC [12]. Cement, glass as well as gas industries are the major industries in various companies which use the ORCs to recover waste heat.

1.4 ORC Applications

Waste heat recovery

Solar thermal power

Geothermal power plants

Biomass power plant

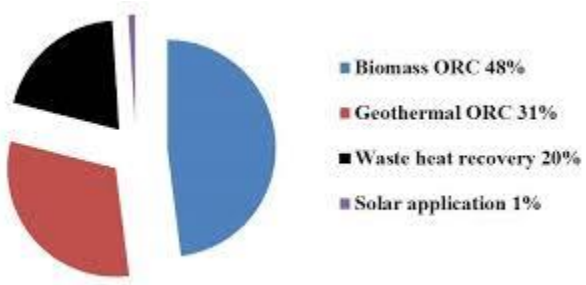

Fig. 1.10: The ORC market share for different heat sources

1.5 Working fluid selection

In ORC system selection of working fluid is very important and depends upon the temperature of heat sink along with a source of heat. For various operating parameters, there are various organic fluids which have a great match among temperature of heat source along with heat sink. It is not an easy job to choose an appropriate ORC working fluid. Properties of environmental, safety, thermodynamic of working fluids also depends while choosing working fluid. A number of requirements must be looked at when choosing good ORCs working fluid.

2. LITERATURE REVIEW

According to Lee et al., 2014; Yu et al., 2016, due to ORCs low evaporation temperature as well as simple design, everyone has more interest in the recovery of low-grade heat for power cogeneration/ generation. For a system of small scale, the ORC performs well as compared to the steam turbine at the temperature of 150°C to 200°C (Tsoukpoe et al., 2016).

As compare to conventional Rankine cycle, ORC use organic working fluid in place of water in the energy sources at low temperature (Uusitalo et al., 2016), like solar thermal (Desai and Bandyopadhyay, 2016), waste heat (Liu et al., 2016), biomass combustion (Al-Sulaiman et al., 2012), geothermal (Coskun et al., 2012), ocean thermal energy (Yang and Yeh, 2014). ORC is better than steam Rankine cycle when ORC has <1 MWe scale low-temperature.

Big energy sectors make use of traditional energy sources as well as throwing away overwhelming power. With this regard, scientists have already been attempting to utilize the heat of waste as renewable energy supply to create helpful commodities (Javan et al., 2016). Hybrid methods make it possible for the recuperation on the heat of waste within the thermal methods as well as enhance the effectiveness and also build methods economical. Hybrid methods which create cooling,heating and also energy at the same time have grown to be a possible substitute for conquering atmosphere issue.

Dai et al. (2009) analyzed heat of waste (composed with N_2 of 96.16 %, O_2 with 3.59 %, H_2O with 0.23 %, $NO+NO_2$with 0.02 % by volume) power driven ORC integrated ejector refrigeration cycle and then found energy and thermal effectiveness approximately 13% as well as 22%, respectively. Javan et al. (2016) used

heat of waste of diesel motor to operate the ORC dependent ejector refrigeration cycle and then completed substance choice optimization for noncommercial uses. Yang et al. (2016) examined ORC incorporated ejector cycle utilizing zeotropic combination isobutane/pentane with 0.4 %, 0.7 % as well as 0.8 % mass tiny proportion.

Al Sulaiman et al. (2011a) incorporated VARS, ORC as well as PTC to come up with combine power, heating, and cooling. Al-Sulaiman et al. (2011) noted OCR efficiency general dependent upon hybrid methods driven by solar thermal energy (90 %), solid oxide fuel cell (76 %), as well as biomass (90 %). Suleman et al. (2014) examined incorporated solar geothermal cycle in which ORC solar powered incorporated with VARS for cooling along with all the drying out progression as well as geothermal powered ORC for energy development. The energy as well as exergy advantages of the system/cycle are discovered to be 54.7 % as well as 76.4 %.

It is found by Al-Sulaiman et al. (2012) that 500 kW ORC combined with power,heating and cooling applications and it is noted that it has efficiency of energy near about 89% to 90% and efficiency of energy near about 28% to 30%.Huang et al. (2013) completed techno economic evaluation associated with the ORC small scale biomass incorporated cooling system of absorption. The perturbation contained effectiveness is to the assortment of 1 % for energy function, 5 % for consolidated high temperature as well as strength mode, along with 4 % for trigeneration setting (Huang et al., 2013).

3. CONCLUSION

This study provides a brief review for the working fluids selection for various applications for different parameters.There exists no specific fluid for any specific application and therefore, several researchers examined around more than 600 natural as well as zeotropiccombinations so that a best suitable fluid can be discovered for particular application depending upon their performance characteristics like environmental impacts, cost and efficiency on some operating conditions. The future focus will be on experimental evaluation of working fluid properties using the ORC.

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