International Conference on Mechanical, Industrial and Materials Engineering 2015 (ICMIME2015)
11-13 December, 2015, RUET, Rajshahi, Bangladesh

Paper ID: ET-11

Experimental Study of a Low Temperature Organic Rankine Cycle for Small Scale Power Generation

Md. Arafat Islam[1], Ashfaq Ahmad Shoaib[1], Mohammad Asaduzzaman Asif[1], Mir Sakib Mustashin[1]and Tahmidur Rahman[1]
[1]Military Institute of Science and Technology
Dhaka-1216, Bangladesh
E-mail: ashfaqahmadshoaib@gmail.com

Abstract

The Rankine cycle (ORC) is an Ideal and mathematical model which is mainly used to prognosticate the efficiency of steam engines. It's a thermodynamic cycle of a heat engine that converts heat into mechanical work. In Organic Rankine Cycle, organic substances are used rather than water as a working fluid. Organic working fluids are better than water because of having more turbine efficiency due to higher mass flow rate and low temperature heat source can be used to operate the cycle. In this research an experimentalsetup was locally fabricated to justify the usability of Dichloromethane as a working fluid of ORC power plant. The turbine of this set up was capable ofdriving a DC generator and it was able to produce up to 10 volts and .09A current while continuously operatingthe ORC. This preliminary concept was taken to further analyze the properties of Dichloromethane as a working fluid of ORC power plant at various load conditions. Temperatures, pressures,mass flow rates, fuel consumptions, vapor generation rates, condensation ratesetc.were measured. The plant runs at three different operating pressures of approximately 137. 206 *and* 275 Kpa. *The plant had shown its best performance at the operating pressure of 40 psi using R-30 as a working fluid. Not only that, butfor all operating pressure it was experimentally proven that, the efficiency of ORC plant is always higher than the conventional power plant.*

Keywords: *ORC, organic working fluid -dichloromethane, inorganic working fluid - water, impulse turbine*

1. Introduction

Many industrial processes produce waste heat that is typically rejected to lower temperature heat sinks. There are number of ways in which such waste heat can be recovered to produce useful energy. Recovery of waste heat offers the benefit of increasing overall efficiency in case of power generation or provides auxiliary power in other waste heat application. A standard Rankine cycle uses steam as a working fluid for primary power generation and it operates at relatively higher temperatures (523.15-873.15K) in order to maximize the Carnot efficiency. That's why low temperature heat sources are unsuitable for it. However Organic Rankine Cycle (ORC), which uses organic fluids rather than water and can operate at low temperatures to utilize the waste heat sources. It is the specialty of the organic fluids which can evaporate at low temperature and exert high pressure as compared tosteam. That's why organic fluids make the cycle more efficient. But the main challenge is to condense theorganic fluids. Here in this experiment dichloromethane was used as an organic fluid. The aim was to investigateORC plant operating character compared to conventional steam turbine power plant.

2. Experimental Setup

Model A

An experimentalsetup was locally fabricatedto justify the usability of Dichloromethane as a working fluid of ORC power plant. The turbine of this set up was capable of drivinga DCgenerator and it was able to produce maximum 10 volts and .09A current while continuously operating the ORC. The plant was consisting of boiler, burner, turbine, DC generator and condenser. Figure 1 demonstrates the experimental set up of locally fabricated ORC plant.

Fig. 1. Experimental setup of Model A

Model B

The P7669T is a miniature steam turbine power plant consists of furnace, boiler, micro steam turbine, condenser, fluid storage tank and a control panel. It is a total closed loop system.Control panel consists of different measuring instruments like ammeter, voltmeter, vortex shading meters, temperature meter, pressure meter and load switch. The plant consists of total four bulbs as loads. The maximum load of each bulb is 0.8 watt. Therefore thetotal plant capacity is 3.2 W.

Fig. 2. Experimental setup of Model B

3. Experimental Result

Table 1. Turbine inlet temperatures at different pressures

Operating Pressure(KPa)	Turbine Inlet Temperature Steam Turbine Power Plant (K)Fluid H_2O	Turbine Inlet Temperature ORC Power Plant (K)Fluid CH_2Cl_2
206	384.15	327.15
275	393.15	341.15

Table 2. Turbine exhausts temperatures at different pressures

Operating Pressure 206KPa				
For H_2O				
Parameters	Load Conditions			
	Load 1	Load 2	Load 3	Load 4
Dynamometer Voltage (Volts)	6	4	2.5	1.5
Dynamometer Current (Amps)	0.03	0.06	0.07	0.085
Power (W)	0.18	0.24	0.175	0.1275
Generator Speed (rad/s)	363	224	175	140
For CH_2Cl_2				
Parameters	Load Conditions			
	Load 1	Load 2	Load 3	Load 4
Dynamometer Voltage (Volts)	6.5	4	3	1.5
Dynamometer Current (Amps)	0.03	0.06	0.08	0.09
Power (W)	0.195	0.24	0.18	0.135
Generator Speed (rad/s)	371	234	187	142
Operating Pressure 275KPa				
For H_2O				
Parameters	Load Conditions			
	Load 1	Load 2	Load 3	Load 4
Dynamometer Voltage (Volts)	12	10	9	6
Dynamometer Current (Amps)	0.06	0.11	0.14	0.15
Power (W)	0.72	1.1	1.26	0.9
Generator Speed (rad/s)	911	735	545	361
For CH_2Cl_2				
Parameters	Load Conditions			
	Load 1	Load 2	Load 3	Load 4
Dynamometer Voltage (Volts)	12	11	9	7
Dynamometer Current (Amps)	0.06	0.11	0.14	0.17
Power (W)	0.72	1.21	1.26	1.19
Generator Speed (rad/s)	915	754	586	380