CHAPTER 5

Conclusion and Recommendation

5.1 Conclusions

This research objective was numerical simulation and testing for an ORC using low-temperature heat source with an organic substance as a working fluid in the system. The possibilities of an ORC working obtain both numerical and experimental results. The research conclusions are as follows

1. The numerical simulation analysis of the heat source temperature varied between 70 – 100°C and working fluid mass flow rate 112 – 372 kg/h. The heat rate of absorption at vapor generator is 4.0 – 27.1 kW and heat rate of rejection at condenser is 2.3 – 19.9 kW, whereas the experimental results the heat rate of absorption at vapor generator were 4.4 – 27.1 kW and heat rate of rejection at condenser is 2.3 – 19.9 kW.
2. The optimum condition of experiment on the system when heat source temperatures and working fluid mass flow rate between 69.7 – 97.1°C and 115 – 398 kg/h, respectively. The test rig performance on the rotation speed increase was 387 – 2,022 rpm, the optimum torque and power output reached between 0.02 – 0.11 N.m and 0.81 - 15.73 W, respectively. Consequence the experiment torque increasing caused by the pressure difference between the turbine inlet and outlet in the system.
3. The system performances for this research, the thermal efficiency for the experimental analysis are between 0.02 – 0.07%, while the theoretical thermal efficiency is 14.3 – 15.7%. It can be seen that the system must improvement and new system design development for increase thermal efficiency is nearly of the theoretical efficiency.
4. The characteristics of irreversibility and second law of the system. For experimental cases, there are optimum operating conditions in the relationship between the heat source temperature and the system performance. These operating conditions down to a second law efficiency and exergy destruction as

the irreversibility rises. In the system of a exergy destruction 2.94 – 29.26 kW and the second law efficiency is 1.2 – 5.4%.

The Key Conclusions Identified from This Research are as Follows

1. ORC is capable of being operated on low-temperature heat sources with little to modest vaporization pressure, and still attain a better performance than a steam cycle.
2. ORC necessitates bigger feed pumps, because of an elevated mass flow, which has a higher force on the net electric power.
3. The heating curves of ORC can be integrated to match the temperature profile of a low-temperature heat source, resulting in higher cycle effectiveness and in a higher recuperation ratio for the thermal power.

5.2 Recommendation for Further Studied

The ORC testing has been enhanced over the 16 sets of experiments. Those improvements resulted in more accurate measurements gathered and recorded, hence providing better control of the parameters, higher efficiency and output power source. Nevertheless, some innovative improvements on the test bench and on the models could still be executed to further develop these models. The following is a list of details identifying the most important achievable improvements that could be further developed. The research recommendations are as follows

1. The shell and tube vapor generator was found to be the most suitable technology for vaporizing since it illustrated a compact design, good heat transfer, coefficient and low-cost creation. In the power generating, the increased availability of energy efficiency for utilized use would be optimal in this construction.
2. The arrangement of the condenser in the construction, the asymmetry of the condenser resulted in a two phase flow at the pump supply and made for any adjustments difficult. The best design would be a parallel union for both sides, in order to keep the pressure drops as low as possible, and to eradicate the two phase flow at exhaust, and the condenser would have to be redesign when the

configuration of changes. An entirely parallel arrangement ought to result in a better harmony between the predicted and measured values.

3. Correct working fluid circumstances of the vapor generator and condenser, taking into relation the fluid properties, would make possible the design of the cycle with dissimilar working fluids, and would be a very exciting sign for the selection of the best performance fluid.
4. Increasing in the order to the heat sources in the vapor generator. The mean temperature of the heat source. The vapor generator would be better if the heat source was to be found on the large exchange of the vapor generator. The temperature profile would be improved, and the energy losses would lower significantly.
5. Enhancement of the turbine. This point is probably the most central. As mentioned before, the turbine is not optimized. It is this component of the cycle that shows the highest prospective for development. The internal leaks may be condensed, as well as the exterior leaks that cause fluid losses. The abrasion torque may also be simply reduced.
6. The most favorable would be a radial turbine, which shows compensation: No peripheral leaks and thus no working fluid losses. This would then permit the utilization of a flammable working fluid, which has not used because of the leakage possibility and decrease heat losses, the power generating device if integrated into the turbine, its inefficiencies could result in heat that may be transmitted to the fluid. It is nonetheless imperative to put into practice a generating device capable of performance in a high range of temperatures. The lubrication of the radial turbine would also be valuable, as the leakage area and the friction torque could be reduced.

5.3 Feasibility for Power Generation with ORC

An ORC with low-pressure turbine and low-temperature heat source was build for power generation. The total efficiency of ORC for power generation was between 0.01-0.67% and the micro-radial turbine is a generated for power generation by an ORC. An ORC is a low to medium speed turbine type. So, the generator should be generating the

electricity at low-medium rotation speed. The generator was tested to prove the relation between output of electricity, torque, and rotation speed. The generator should be proper with the characteristic of ORC.

5.2 Future Work

The future works on this system are to increase heat source temperature and change a new working fluid. Once this is complete the system will be extensively tested to allow research into the system behavior. The performance of the unit will then be analyzed and any necessary changes implemented. A custom made radial turbine will be tested within the system. Once all required testing is complete the system will be used to optimize control methods and test different working fluids at a small, manageable scale. This will aid system design as it will allow working fluid performance to be tested and control systems to be developed to control the dynamic behavior of the ORC system.