# Major Project

## Dissertation on

# "THERMODYNAMIC ANALYSIS OF A MODIFIED RANKINE CYCLE USED FOR POWER GENERATION"

Submitted to Delhi Technological University in partial fulfillment of the requirement for the award of Degree of

**Master of Technology**

**In**

**Thermal Engineering**

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**2K13/THE/20**

**UNDER THE SUPERVISION OF**

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# CERTIFICATE

**DELHI TECHNOLOGICAL UNIVERSITY**
(Formerly DELHI COLLEGE OF ENGINEERING)

Date:-__________

This is to certify that report entitled **“THERMODYNAMIC ANALYSIS OF A MODIFIED RANKINE CYCLE USED FOR POWER GENERATION”** by **ROHIT SINGH** is in partial fulfillment for the award of Degree of **Master of Technology (M.Tech)** in **Thermal Engineering** at **Delhi Technological University**. This work was completed under my supervision and guidance. He has completed his work with utmost sincerity and diligence. The work embodied in this project has not been submitted for the award of any other degree to the best of my knowledge.

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# ABSTRACT

In this study the modified Organic Rankine Cycle focuses the performances of IHE (Internal Heat Exchanger) in ORC (Organic Rankine Cycle) systems. Although previous studies hold multitudinous opinions, this study gives clear statements of IHE in both subcritical and supercritical ORC systems by setting a new model taking pressure drop in loops and pinch point into consideration. Commonly used working fluids R123 and R600 are chosen for subcritical and supercritical cases separately. The temperature of the heat source applied is 200 $^{0}$C and the mass flow rate of it is 1 kg/s. The analysis is accomplished by the software Engineering Equation Solver (EES). A modified method of calculating maximum heat exchange in IHE is given when modelling a supercritical cycle, because of the momentously changing specific heat near the critical point. Besides, a new approach is put forward to calculate the outlet temperature of the heat source and find the location of pinch point in supercritical cases. The results provide that IHE is beneficial to a subcritical case, but it improves system performance only in part of the low pressure stage in a supercritical case. Moreover, after the temperature Tad is taken into account, it is found that IHE is able to enlarge the maximum system net output in a subcritical case. And in a supercritical case, the original evaporation pressure which does not conform to the rule $T_{h,out} > T_{ad}$ is available now. It is revealed that the utilization of IHE will strengthen the applicability of the system. In subcritical cycle, it is observed that power output is not affected by IHE and maximum power obtained is 11.3 KW at an evaporator pressure of 1374 KPa and the thermal efficiency is 40.15% at $P_{evap}$ = 2350 KPa. In supercritical cycle, the maximum power output is 11.55 KW at an evaporator pressure of 5080 KPa and an thermal effiency of 45% .

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# NOMENCLATURE

| | |
|---|---|
| $dP_{cf}$ | Total resistance at condenser cooling water side, kPa |
| $\varepsilon$ | Heat exchanger effectiveness |
| $dP_{rf}$ | flow resistance in the working fluid circulation loop, kPa |
| e | specific flow exergy, kJ/kg |
| $\dot{E}_d$ | exergy destruction rate, Kw |
| h | specific enthalpy, kJ/kg |
| $\dot{m}$ | mass flow rate, kg/s |
| P | Pressure, kPa |
| s | specific entropy, kJ/(kg K) |
| T | temperature, $^0$C |
| v | specific volume, m3/kg |
| $\dot{W}$ | power output, kJ/s |
| w | specific power, kJ/kg |
| $\eta_{cpump}$ | overall efficiency of the cooling cycle pump |
| $\eta_{ex}$ | exergy efficiency |
| $\eta_P$ | overall efficiency of the working fluid pump |
| $\eta_{P,i}$ | isentropic compression efficiency of the working fluid isentropic compression efficiency of the working fluid pump |
| $\eta_{P,m}$ | mechanical efficiency of the working fluid pump |
| $\eta_{th}$ | thermal efficiency |
| $\eta_{T,i}$ | internal efficiency of the expander |
| $\eta_{T,m}$ | mechanical efficiency of the expander |

## Subscripts :

| | |
|---|---|
| 0 | Environment |
| 1-22 | state points of the cycle |
| ad | acid dew point |
| bp | boiling point |
| C | cold stream |
| cpump | cooling cycle pump |
| cond | Condensation |
| Cr | Critical |
| evap | Evaporation |
| Fp | fusing point |
| H | hot stream |
| IHE | internal heat exchanger |
| In | flow into the system |
| out | flow out of the system |
| P | Pump |
| pp | pinch point |
| r | working fluid |
| sub | Subcooling |
| sup | Superheating |
| T | Expander |