

CHAPTER – V

CONCLUSION

Thermodynamic analysis of R-600a, R-290 & R-170, three stage cascade refrigeration system have been presented to optimize the operating parameter of the system and following inference are drawn.

1. The COP of the system decreases from 1.16 to 1.0477, the 2nd law efficiency of stage-I and full system decrease from 87.35% and 70.96% respectively to 80.64% and 69.66% respectively and exergy destruction for the system 8.8049 KW to 10.1833 KW as the high temperature circuit condenser temperature ($T_{C,HT}$ or T_1) is raised from 30°C to 40°C keeping other parameters constant.
2. COP of the system deteriorated from 1.16 to 0.9917, 2nd law efficiency of Stage-I decreases from 87.35% to 81.43%, 2nd law efficiency of system decreases 70.96% to 60.66% and exergy destruction increases for stage-I from 0.9256 KW to 2.313 KW and for overall system from 8.8049 KW to 13.9495 KW when the high temperature circuit evaporator temperature ($T_{E,HT}$ or T_3) decrease from 0°C to -15°C keeping other parameters constant.
3. The COP of the system decreases from 1.228 to 1.035, the 2nd law efficiency of system decreases 75.12% to 64.53% and 2nd law efficiency of stage-II decreases 85.16% to 78.18%, while the exergy destruction for the system increases from 7.1224 KW to 12.052 KW, as the medium temperature circuit condenser temperature (T_7 or $T_{C,MT}$) increases from 0°C to 15°C keeping other parameters constant.

4. The COP of the system decreased from 1.16 to 1.023, the $\eta_{II\text{-system}}$ & $\eta_{II\text{ stage-II}}$ decreases. From 70.96% to 62.58% & 82.73% to 79.44% respectively and the exergy destruction for the system increases from 8.8049 KW to 12.8623 KW as the medium temperature circuit evaporator temperature (T_5 or $T_{E,MT}$) decreases from -40°C to -50°C keeping other parameters constant.
5. The COP of the system decreases from 1.16 to 1.004, the $\eta_{II\text{stage-III}}$ changes from 77.95 to 72.95% and $\eta_{II\text{ system}}$ 70.96% to 61.41% when the condenser temperature change from -35°C to -25°C . The exergy destruction for stage-I change from 0.9256 KW to 0.992 KW for stage-II from 1.9018 KW to 2.0375 KW, for stage-III from 2.6449 KW to 4.1603 KW and Exergy destruction for full system increase from 8.8049 KW to 13.5412 KW (Fig. 4.5.7) as the low temperature circuit condenser temperature (T_{11}) increases from -35°C to -25°C keeping other parameters constant.
6. The COP of the system decreased from 1.369 to 1.089, The $\eta_{II\text{ stage-III}}$ and $\eta_{II\text{ system}}$ decrease from 81.96% to 76.37% and 72.59% to 70.23%, the II law efficiency for stage-I & II remains constant at 87.35% and 82.73 at the above temperature variation from -75°C to -88.8°C of evaporator of stage-III. (fig. 4.6.6). The exergy destruction for all the three stages and system increases when the evaporator temperature falls. At $T_9 = -88.8^\circ\text{C}$ the $E_{x\text{-dest}}$ for stage-I, stage-II, stage-III and system is 0.9557 KW 1.9536 KW, 3.1735 KW and 9.6151 KW respectively. Where as at $T_9 = -75^\circ\text{C}$, exergy destruction for stage-I, stage - II, stage-III & system is 0.8612 KW, 1.720 KW, 1.5615 KW and 7.038 KW respectively as the low

temperature circuit evaporator temperature (T_9) decreases from -75°C to -88.8°C keeping other parameters constant.

The storage temperature of around -80°C is required for long term storage of biological material. Therefore, the set of temperature at $T_3=30^\circ\text{C}$, $T_1=0^\circ\text{C}$, $T_7=5^\circ\text{C}$, $T_9=-40^\circ\text{C}$, $T_{11}=-35^\circ\text{C}$ and $T_9=-85^\circ\text{C}$ is recommended for the optimum utilization of system. By this set of temperatures the vapour pressure of refrigerant i.e. R-600a, R-290 and R-270, will remain above atmospheric pressure, So the air cannot ingress inside the system. In this set of temperature, the pressure ratio of HT circuit, MT circuit and LT circuit is 2.585, 4.964 and 7.454 respectively, so the lighter reciprocating compressors can be used. By lower compressor ratio the volumetric efficiency of compressors will increase and total work done will be reduced further from 30.32 KW. At this set of temperature the 2nd law efficiency of the system is 70.96% which is quite high and exergy destruction for the system is 8.8049 KW which is increasing with the variation in temperature of condensers and evaporators fitted in three stage cascade system.