International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-9 Issue-2, December 2019

# Thermal Prospective Estimations of COP and TR for R12 and HR12 Vapour Compression Refrigeration Systems

**Amruta Panda, N. K. Kund**

***Abstract:*** ***Experimentations got executed for investigating influence of R12 and HR12 refrigerants on system performance evaluation in terms of COP and TR. Temperature and pressure got measured by different temperature and pressure gauges mounted at several predetermined locations. Additionally, power consumption by refrigeration system also got measured from the installed energy meter readings. Altogether, it summarizes the tabular inscriptions of the variations of $COP_{th}$, $COP_{act}$ and $COP_{rel}$ with TR for R12 and HR12 refrigerants. Besides, it also demonstrates the graphical representation of the corresponding variations of $COP_{th}$, $COP_{act}$ and $COP_{rel}$ with TR for R12 and HR12 refrigerants. As expected, it stands observed (from both the stated table and figure) that both $COP_{th}$ and $COP_{act}$ increase with TR, however, the $COP_{rel}$ decreases with the same for said R12 and HR12 refrigerants. Furthermore, the stated variations of $COP_{th}$, $COP_{act}$ and $COP_{rel}$ with TR remain observed as approximately linear, independently. That's why, both $COP_{th}$ and $COP_{act}$ stay directly proportional to TR, however, the $COP_{rel}$ stays inversely proportional to the same because of approximately linear relationship between the $COP_{th}$, $COP_{act}$ and $COP_{rel}$ with TR, individually. Additionally, $COP_{act}$ decreases with the increase of $W_{i/p}$ for both R12 and HR12 refrigerants. However, $Q_{ext}$ increases with $W_{i/p}$ for both R12 and HR12 refrigerants.***

***Index Terms:*** ***R12 and HR12 Refrigerants, COP, TR, Experiment, Performance, Refrigeration System.***

## I. INTRODUCTION

VCR occupies the absolute momentous practice for removal of heat in chilling of any kind of items/goods. It is a cooling practice where coefficient of performance (COP) and tons of refrigeration (TR) of preferred pressure and temperature gets produced through removal of heat using refrigerants. Refrigeration practices remain influenced through external power supply to the unit. Here, chilling happens due to gross heat removal from refrigeration system.

Fundamental objective of refrigeration practices stand to keep things cold of desired COP and TR using R12 and HR12 refrigerants throughout its epoch.

**Revised Manuscript Received on December 30, 2019.**
***** Correspondence Author
**Amruta Panda**, Ph.D., Department of Mechanical Engineering,VSS University of Technology, Sambalpur, India.
**N. K. Kund***, M.Tech., Manufacturing System Engineering (MSE) Specialization, Department of Production Engineering, VSS University of Technology, Sambalpur, India.



In refrigeration practices, the major concern of customer requirements is coldness. COP and TR remain primarily outcomes of process parameters pressure and temperature. Numerical or experimental evaluations on COP with TR remain extant in collected works [1-7]. Computational and experimental researches stand also pronounced [8-44].

Contemporary research remains as examining the effect of R12 and HR12 refrigerants on COP and TR for the stated refrigeration system. Study includes determination of best levels of thermal parameters for getting ideal the COP and TR using first principle. In addition, thermal variables (i.e. P and T) got correlated with recital aftermaths (COP with TR).

## II. EXPERIMENTAL PREPARATION

Procedure illuminates strongly about the basics of modern refrigeration system block diagram along with experimental setup components.

### A. Portrayal of Block Diagram of Refrigeration System

Figure 1 shows the colorful block diagram of refrigeration system. It involves compressor, condenser, expansion device and evaporator, sequentially.

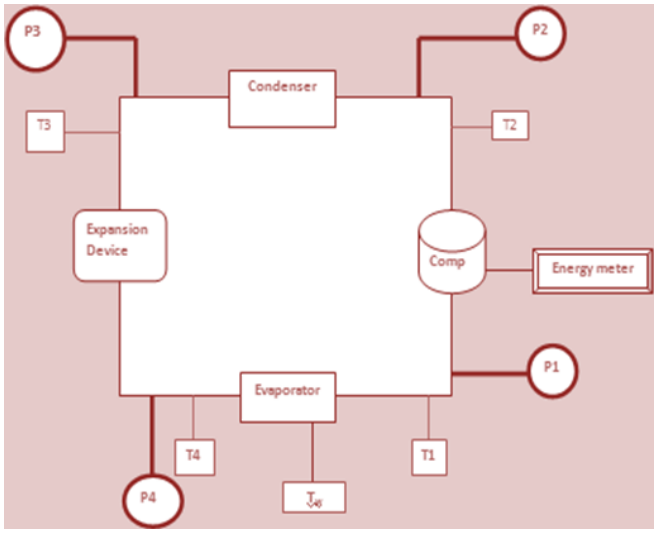


**Figure 1. Schematic of refrigeration system block diagram**

### B. Depiction of Components of Experimental Setup

It embroils descriptions of the colorful components of the experimental setup.

The exploded colorful photos of compressor, condenser, dryer and capillary tube are illustrated in figures 2 to 5, respectively. These components are fabricated and assembled to produce the desired experimental setup relating to the refrigeration system.

**Figure 2. Exploded photo of compressor**

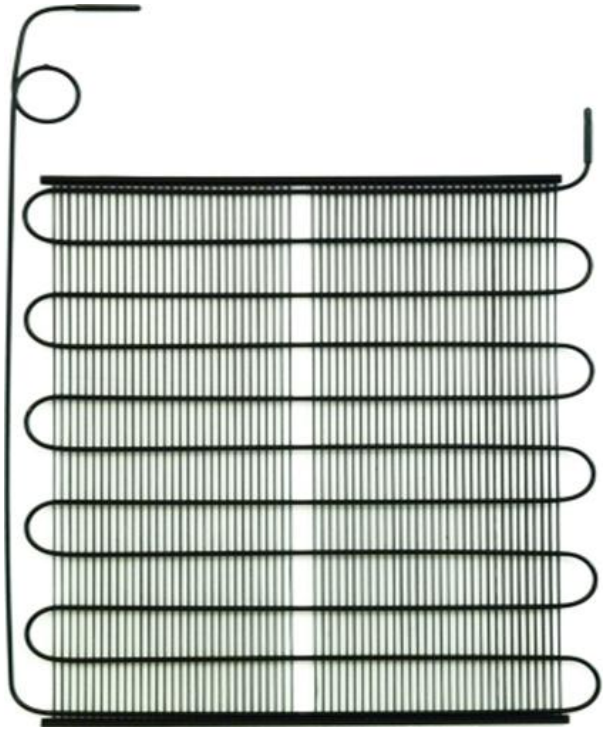

**Figure 3. Exploded photo of condenser**

**Figure 4. Exploded photo of dryer**

**Figure 5. Exploded photo of capillary tube**

## III. EXPERIMENTAL TECHNIQUES

It ensnares the apparatus readings of under declared variables.

### A. Measurement of Pressure

Pressure got measured by both high pressure (0 to 35 kg/cm$^2$) and low pressure (-2 to -10 kg/cm$^2$) gauges (mounted at different predetermined locations) as depicted in figures 6 and 7, respectively.

**Figure 6. Exploded photo of high pressure gauge**

**Figure 7. Exploded photo of low pressure gauge**

### B. Measurement of Temperature

Temperature got measured by different mercury thermometers (-50ºC to 360ºC) mounted at several predetermined locations.

## IV. RESULTS AND DISCUSSIONS

Experimentations stay accomplished for probing impacts of both R12 and HR12 refrigerants on system performances evaluations in terms of COP and TR. Temperature and pressure got measured by different temperature and pressure gauges mounted at several predetermined locations. Additionally, power consumption by refrigeration system also got measured from the installed energy meter readings. Like this 5 such observations got obtained with half an hour time interval between the 2 consecutive intervals. After finishing all such observations and noting down related data, power supply to refrigeration system got switched off. Subsequently, the stated refrigerant got discharged from the compressor for making the system once again ready to perform experiments by filling or introducing another refrigerant and so on.

### Effects of R12 and HR12 Refrigerants on Performances of Refrigeration Systems

As already described both R12 and HR12 refrigerants got introduced into the compressors of the stated refrigeration systems. It is aimed at critically examining the influences of both R12 and HR12 on performances of the said refrigeration systems in terms of COP and TR.

### A. Variations of $COP_{th}$ with TR for R12 and HR12 Refrigerants

Table 1 summarizes the tabular inscriptions of the variations of $COP_{th}$ with TR for R12 and HR12 refrigerants. Figure 8 also demonstrates the graphical representation of the corresponding variations of $COP_{th}$ with TR for R12 and HR12 refrigerants. As expected, it stands observed (from both the stated table and figure) that the $COP_{th}$ increases with TR for said R12 and HR12 refrigerants. Furthermore, the stated variations remain observed as approximately linear. In other words the $COP_{th}$ stays directly proportional to TR because of approximately linear relationship between the $COP_{th}$ and TR.

**Table 1. $COP_{th}$ of R12 and HR12 refrigerants at different TR**

| | | | | | |
|---|---|---|---|---|---|
| $COP_{th}$ of HR12 | 9.33 | 7.9 | 7.8 | 6.3 | 5.12 |
| $COP_{th}$ of R12 | 6.21 | 5.9 | 5.62 | 4.83 | 4.72 |
| TR | 0.2 | 0.17 | 0.16 | 0.14 | 0.11 |

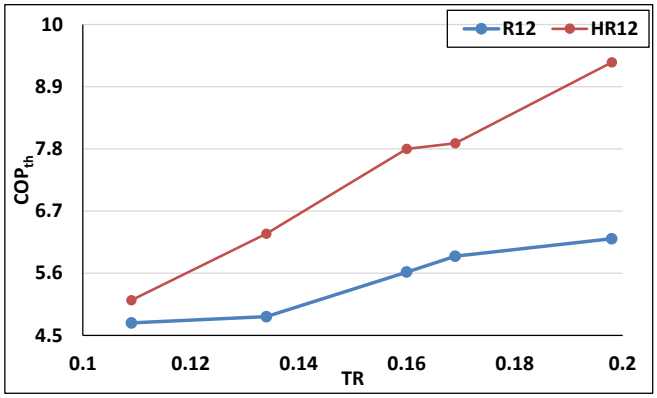


**Figure 8. $COP_{th}$ vs. TR for R12 and HR12 refrigerants**

### B. Variations of $COP_{act}$ with TR for R12 and HR12 Refrigerants

Table 2 summarizes the tabular inscriptions of the variations of $COP_{act}$ with TR for R12 and HR12 refrigerants. Figure 9 also demonstrates the graphical representation of the corresponding variations of $COP_{act}$ with TR for R12 and HR12 refrigerants. As expected, it stands observed (from both the stated table and figure) that the $COP_{act}$ increases with TR for said R12 and HR12 refrigerants. Furthermore, the stated variations remain observed as approximately linear. In other words the $COP_{act}$ stays directly proportional to TR because of approximately linear relationship between the $COP_{act}$ and TR.

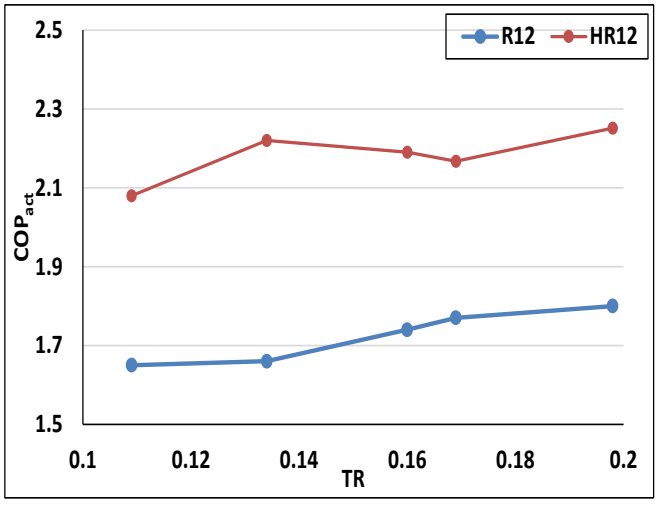


**Figure 9. $COP_{act}$ vs. TR for R12 and HR12 refrigerants**

**Table 2. $COP_{act}$ of R12 and HR12 refrigerants at different TR**

| $COP_{act}$ of HR12 | 2.25 | 2.17 | 2.2 | 2.22 | 2.1 |
|---|---|---|---|---|---|
| $COP_{act}$ of R12 | 1.8 | 1.77 | 1.74 | 1.66 | 1.64 |
| TR | 0.2 | 0.17 | 0.16 | 0.14 | 0.11 |

### C. Variations of $COP_{rel}$ with TR for R12 and HR12 Refrigerants

Table 3 summarizes the tabular inscriptions of the variations of $COP_{rel}$ with TR for R12 and HR12 refrigerants. Figure 10 also demonstrates the graphical representation of the corresponding variations of $COP_{rel}$ with TR for R12 and HR12 refrigerants. As expected, it stands observed (from both the stated table and figure) that the $COP_{rel}$ decreases with the increase of TR for said R12 and HR12 refrigerants. Furthermore, the stated variations remain observed as approximately linear. In other words the $COP_{rel}$ stays inversely proportional to TR because of approximately linear relationship between the $COP_{rel}$ and TR.

**Table 3. $COP_{rel}$ of R12 and HR12 refrigerants at different TR**

| $COP_{rel}$ of HR12 | 0.24 | 0.27 | 0.28 | 0.35 | 0.41 |
|---|---|---|---|---|---|
| $COP_{rel}$ of R12 | 0.29 | 0.3 | 0.31 | 0.34 | 0.35 |
| TR | 0.2 | 0.17 | 0.16 | 0.14 | 0.11 |

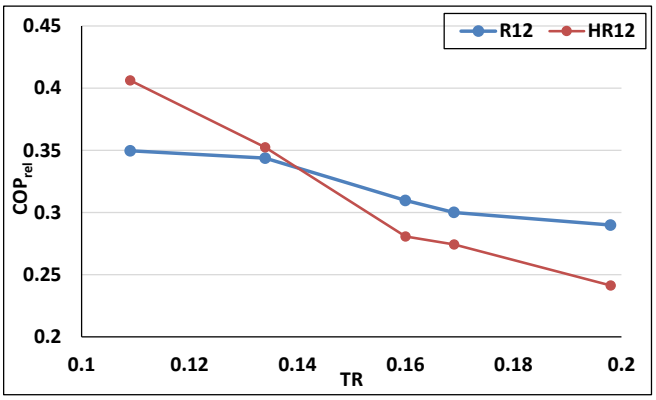


**Figure 10. $COP_{rel}$ vs. TR for R12 and HR12 refrigerants**

### D. Variations of $COP_{act}$ with $W_{i/p}$ for R12 and HR12 Refrigerants

Figure 11 demonstrates the graphical representation of the variations of $COP_{act}$ with $W_{i/p}$ for R12 and HR12 refrigerants. As expected, it stands observed that the $COP_{act}$ decreases with the increase of $W_{i/p}$ for said R12 and HR12 refrigerants. Furthermore, the stated variations remain observed as approximately linear. In other words the $COP_{act}$ stays inversely proportional to $W_{i/p}$ because of approximately linear relationship between the $COP_{act}$ and $W_{i/p}$.

### E. Variations of $Q_{ext}$ with $W_{i/p}$ for R12 and HR12 Refrigerants

Figure 12 demonstrates the graphical representation of the variations of $Q_{ext}$ with $W_{i/p}$ for R12 and HR12 refrigerants. As expected, it stands observed that the $Q_{ext}$ increases with $W_{i/p}$ for said R12 and HR12 refrigerants. Furthermore, the stated variations remain observed as approximately linear. In other words the $Q_{ext}$ stays directly proportional to $W_{i/p}$ because of approximately linear relationship between the $Q_{ext}$ and $W_{i/p}$.

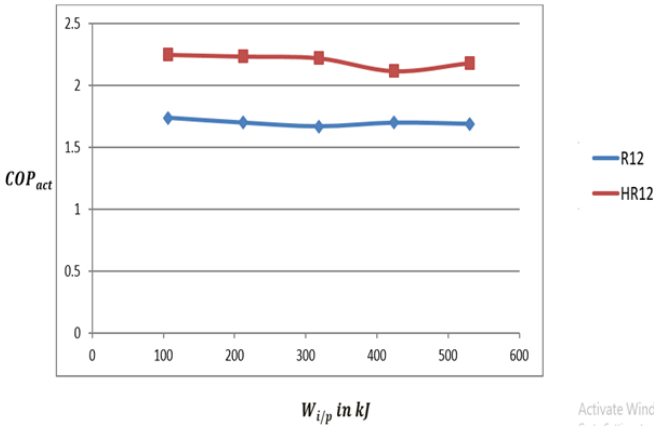


**Figure 11. $COP_{act}$ vs. $W_{i/p}$ for R12 and HR12 Refrigerants**

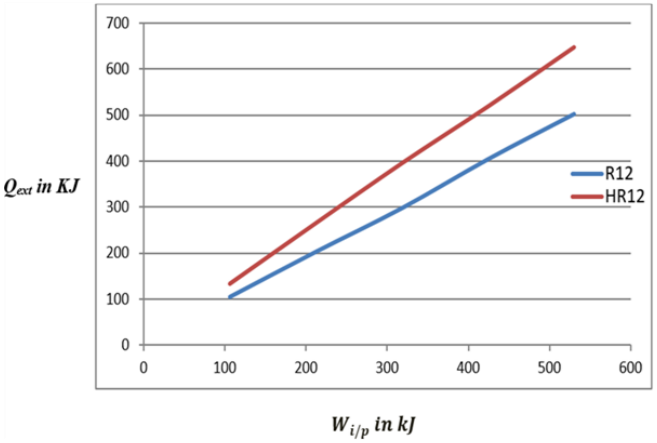


**Figure 12. $Q_{ext}$ vs. $W_{i/p}$ for R12 and HR12 Refrigerants**

## V. CONCLUSION

Experiments got performed for examining effect of R12 and HR12 refrigerants on system performance evaluation in terms of COP and TR. Temperature and pressure got measured by different temperature and pressure gauges mounted at several predetermined locations. Additionally, power consumption by refrigeration system also got measured from the installed energy meter readings. Altogether, it summarizes the tabular inscriptions of the variations of $COP_{th}$, $COP_{act}$ and $COP_{rel}$ with TR for R12 and HR12 refrigerants. Besides, it also demonstrates the graphical representation of the corresponding variations of $COP_{th}$, $COP_{act}$ and $COP_{rel}$ with TR for R12 and HR12 refrigerants. As expected, it stands observed (from both the stated table and figure) that both $COP_{th}$ and $COP_{act}$ increase with TR, however, the $COP_{rel}$ decreases with the same for said R12 and HR12 refrigerants. Furthermore, the stated variations of $COP_{th}$, $COP_{act}$ and $COP_{rel}$ with TR remain observed as approximately linear, individually. That's why, both $COP_{th}$ and $COP_{act}$ stay directly proportional to TR, however, the $COP_{rel}$ stays inversely proportional to the same because of approximately linear relationship between the $COP_{th}$, $COP_{act}$ and $COP_{rel}$ with TR, separately. Additionally, $COP_{act}$ decreases with the increase of $W_{i/p}$ for both R12 and HR12 refrigerants. However, $Q_{ext}$ increases with $W_{i/p}$ for both R12 and HR12 refrigerants.

## ACKNOWLEDGMENT

The authors gratefully acknowledge the vital supports and means from VSSUT Burla for performing this research work. The authors also wish to thank the reviewers and journal editors for their constructive and critical comments for improving the text.

## REFERENCES

1. N. K. Kund, P. Dutta, 2010, Numerical simulation of solidification of liquid aluminium alloy flowing on cooling slope, Trans. Nonferrous Met. Soc. China, Vol. 20, pp. s898-s905.
2. N. K. Kund, P. Dutta, 2012, Scaling analysis of solidification of liquid aluminium alloy flowing on cooling slope, Trans. Indian Institute of Metals, Vol. 65, pp. 587-594.
3. N. K. Kund, 2014, Influence of melt pouring temperature and plate inclination on solidification and microstructure of A356 aluminum alloy produced using oblique plate, Trans. Nonferrous Met. Soc. China, Vol. 24, pp. 3465−3476.
4. N. K. Kund, 2015, Influence of plate length and plate cooling rate on solidification and microstructure of A356 alloy produced by oblique plate, Trans. Nonferrous Met. Soc. China, Vol. 25, pp. 61−71.
5. N. K. Kund, P. Dutta, 2015. Numerical study of solidification of A356 aluminum alloy flowing on an oblique plate with experimental validation, J Taiwan Inst. Chem. Ers., Vol. 51, pp. 159−170.
6. N. K. Kund, P. Dutta, 2016, Numerical study of influence of oblique plate length and cooling rate on solidification and macrosegregation of A356 aluminum alloy melt with experimental comparison, J. Alloys Compd., Vol. 678, pp. 343−354.
7. N. K. Kund, 2018, Effect of tilted plate vibration on solidification and microstructural and mechanical properties of semisolid cast and heat-treated A356 Al alloy, Int. J. Adv. Manufacturing Technol., Vol. 97, pp. 1617−1626.
8. N. K. Kund, 2019, EMS route designed for SSM processing, International Journal of Engineering and Advanced Technology, Vol. 8, pp. 382−384.
9. N. K. Kund, 2019, Cooling slope practice for SSF technology, International Journal of Engineering and Advanced Technology, Vol. 8, pp. 410−413.
10. N. K. Kund, 2019, Comparative ways and means for production of nondendritic microstructures, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 534−537.
11. N. K. Kund, 2019, Simulation of electronics cooling deploying water-zinc oxide nanofluid, International Journal of Recent Technology and Engineering, Vol. 7, pp. 1076−1078.
12. N. K. Kund, 2019, Numerical studies on fuel cell cooling introducing water-copper nanofluid, International Journal of Recent Technology and Engineering, Vol. 7, pp. 1079−1081.
13. N. K. Kund, 2019, Computational modeling of fuel cell expending water-zinc oxide nanofluid, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 424−426.
14. N. K. Kund, 2019, Investigations on modeling and simulation of electronics cooling exhausting water-aluminum nanofluid, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 660−663.
15. N. K. Kund, 2019, Numerical study on effect of nozzle size for jet impingement cooling with water-$Al_2O_3$ nanofluid, International Journal of Engineering and Advanced Technology, Vol. 8, pp. 736−739.
16. N. K. Kund, 2019, Experimental investigations on impacts of nozzle diameter on heat transfer behaviors with water jet impingement, International Journal of Engineering and Advanced Technology, Vol. 8, pp. 745−748.
17. N. K. Kund, 2019, Comparative CFD studies on jet impingement cooling using water and water-$Al_2O_3$ nanofluid as coolants, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 545−548.
18. N. K. Kund, 2019, Experimental studies on effects of jet Reynolds number on thermal performances with striking water jets, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 2195−2198.
19. N. K. Kund, D. Singh, 2019, CFD studies on heat transfer and solidification progress of A356 al alloy matrix and $Al_2O_3$ nanoparticles melt for engineering usages, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 2043−2046.
20. N. K. Kund, S. Patra, 2019, Simulation of thermal and solidification evolution of molten aluminum alloy and SiC nanoparticles for engineering practices, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 2047−2050.
21. N. K. Kund, 2019, Numerical modeling on heat dissipation from electronics through water-titanium carbide nanofluid, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 1772−1775.
22. N. K. Kund, 2019, CFD modeling on influence of impinging spout strength for device cooling with water-$Al_2O_3$ nanofluid, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 1776−1779.
23. N. K. Kund, 2019, Computational modeling on fuel cell cooling with water based copper oxide nanofluid, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 1967−1970.
24. N. K. Kund, 2019, Modeling and simulation on IC cooling using water centered $SiO_2$, TiC and MgO nanofluids, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 1971−1975.
25. N. K. Kund, 2019, CFD simulation on IC thermal cooling through water involved $TiO_2$, AlN and CuO nanofluids, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 1976−1980.
26. N. K. Kund, 2019, CFD simulation with modeling on fuel cell thermal management using water based $SiO_2$, TIC and SIC nanofluids, International Journal of Engineering and Advanced Technology, Vol. 8, pp. 1291−1295.
27. N. K. Kund, 2019, CFD modeling on thermal management of IC using water based Fe, Cu and Al nanofluids, International Journal of Engineering and Advanced Technology, Vol. 8, pp. 1666−1670.
28. N. K. Kund, 2019, Numerical simulation and modeling on thermal cooling of fuel cell using water based $Al_2O_3$, SiC and CuO nanofluids, International Journal of Engineering and Advanced Technology, Vol. 8, pp. 2047−2051.
29. N. K. Kund, 2019, Computational modeling and simulation on thermal management of fuel cell with water based ZnO, TiC and AlN nanofluids, International Journal of Engineering and Advanced Technology, Vol. 8, pp. 2052−2056.
30. N. K. Kund, 2019, Numerical modeling and simulation on fuel cell thermal cooling with water based $TiO_2$, AlN and CuO nanofluids, International Journal of Engineering and Advanced Technology, Vol. 8, pp. 2272−2276.
31. N. K. Kund, 2019, Computational modeling on thermal control of electronics using water-silicon carbide nanofluid, International Journal of Recent Technology and Engineering, Vol. 8, pp. 644−647.
32. N. K. Kund, 2019, Numerical simulation on influence of nozzle to plate distance for spout impact cooling with water-$Al_2O_3$ nanofluid, International Journal of Recent Technology and Engineering, Vol. 8, pp. 1290−1293.
33. N. K. Kund, 2019, Numerical modeling on fuel cell cooling using water based aluminum nitride nanofluid, International Journal of Recent Technology and Engineering, Vol. 8, pp. 1294−1297.
34. N. K. Kund, 2019, Numerical simulation on IC cooling with water based TiN, TiC and SiC nanofluids, International Journal of Recent Technology and Engineering, Vol. 8, pp. 1351−1355.
35. N. K. Kund, 2019, Computational simulation on IC cooling using water based ZnO, AlN and $Al_2O_3$ nanofluids, International Journal of Recent Technology and Engineering, Vol. 8, pp. 2280−2283.
36. Pabak Mohapatra, N.K. Kund, 2019, Experimental and numerical examinations of temperature distributions along SSF pin fins cast through semisolid materials processing, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 500−503.
37. Pabak Mohapatra, N.K. Kund, 2019, Numerical research on thermal variations along SSF pin fins shaped with SSM processing, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 504−507.
38. N.K. Kund, 2019, Experimental work on influences of Reynolds number on cooling behaviors with water jet impingement, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 1867−1870.
39. N.K. Kund, 2019, Experimental research on effects of nozzle size intended for water jet impingement cooling, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 1871−1874.

40. N.K. Kund, 2019, Experimental exploration on influences of nozzle to plate spacing on cooling performances using impinging water jets, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 1989−1992.
41. N.K. Kund, 2019, Experimental examination on impacts of jet inclination on cooling performances using striking water jets, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 1993−1996.
42. N.K. Kund, 2019, Forced convection experimentation designed for cooling behaviors encompassing water jet impingement, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 2222−2225.
43. S.K. Sahu, N.K. Kund, 2019, Microstructural characterization and evaluation of sliding wear of Hastelloy C276 under different loading conditions, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 2841−2845.
44. S.K. Sahu, N.K. Kund, 2019, Hardness along with electrochemical corrosion performance examination of Hastelloy C276, International Journal of Innovative Technology and Exploring Engineering, Vol. 8, pp. 3251−3254.

## AUTHORS PROFILE

**Amruta Panda** obtained her B.Tech. in Mechanical Engineering from Biju Patnaik University of Technology Rourkela. Right now, she is pursuing her M.Tech. in Manufacturing System Engineering (MSE) Specialization in the Department of Production Engineering, VSS University of Technology Burla, Sambalpur, India (A Government Technical University).

**N. K. Kund** obtained both M.Tech. & Ph.D. in Mechanical Engineering from IISc Bangalore. He has also obtained B.Tech.(Hons) in Mechanical Engineering from IGIT Sarang, Utkal University Bhubaneswar. He has published several research papers in international journals and also guided many research scholars, besides, wide teaching and research experience. He is presently working as Associate Professor in the Department of Production Engineering, VSS University of Technology Burla, Sambalpur (A Government Technical University).