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# Thermal Analysis of Radiator Using Sustainable Graphene oxide Nanofluid Mixture of Ethylene Glycol and Water

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**Abstract.** The purpose of the research is to determine if adding grapheme oxide (GO) fluids combined with EG (ethylene glycol) or water might boost the transfer of heat in automobile radiators. Radiators are essential parts of car cooling systems; they dissipate extra heat that the engine produces. The capacity of conventional coolants to transport temperature is limited, including Glycol and water. The ability to conduct heat may be improved with the use of nanoparticles fluids, which are basically solutions of particles in a base liquidize. This technique uses ethylene glycol and water to create a nanoparticles fluid by dispersing GO particles. Using experiments, the resilience or thermal features of the nanoparticle fluids are described. Next, utilizing an early version radiators arrangement, many heat transfer tests are carried out. In comparison to traditional coolants, the radiator's ability to dissipate heat in various functioning circumstances has been assessed while utilizing the GO nanoparticles fluids together. Comparing the radiator's heat transfer efficiency with plain ethylene glycol (or water, initial results indicate the addition with GO nanoparticles fluids improves it. Increased thermal conductivity in the nanoparticles fluids combination results in more efficient heat dissipation. For the purpose of to ensure the efficient utilization of the nanoparticles fluids on car cooling mechanisms, it is further evaluated for durability during extended exposure to elevated temperatures. The continued attempts to provide cutting-edge cooling systems for automotive applications are aided by this study. The results indicate that the use of GO nanoparticles fluids in conjunction with conventional coolants has a chance to improve car radiator thermal transfer or general efficiency.

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It is advised to carry out greater refinement and calibration research to fully realize the potential advantages of this unique coolant composition.

**Keyword-:** Radiator, grapheme oxide (GO), nanoparticle fluids.

# 1 Introduction

Heat exchangers known as radiators are used to transfer thermal energy from one medium to another for heating and cooling [1]. A radiator constantly generates heat to its surroundings, however this heat can be used to both heat the air around well as reduce the water and liquid that is fed to it, like in the case of conditioning the engine of a car [2-3]. Most radiators use convective rather than warmth to convey the majority of their heat. The study in [4] examines the heat transfer characteristics of an oriented square-shaped pins fins warmth sink utilizing a graphene oxide (GO) tiny fluids in the laminar-flow mode. The results indicate enhanced thermal stability for all concentrations of GO tiny fluids evaluated versus a base fluid, with a wall temp and a maximum improvement in Nusselt number associated to a level of 0.009 vol %. Given that GO tiny fluids [5] displays better thermal enhancement trends than EG/water base fluid, heat sink performance might be improved by it [6-8]. Researchers examined graphene oxide (GO tiny sheets—60:40) ionized water/ethylene glycol (GONs-DW/EG) in terms of electrical conductivity, weight, specific heat stability, thermal conductivity, and stickiness. The tiny liquids were demonstrated to be durable for over a month, exhibiting superior the thermal conductivity at both mass percent and temperature of 0.10%. Their behavior was strain thin at low shear rates and Classical at higher strain rates [9]. Correlations were employed to predict the thermophysical characteristics and electricity conductivity of the tiny fluids [10-13]. The performance of a car radiator using reduced graphene oxide (RGO) nanocoolant is examined in [14]. The efficiency of the radiator is being investigated in relation to ultralow nanoparticle concentration, air Reynolds ratio, temperature of the inlet, or Reynolds number. Based on the results, RGO nanocoolant may increase CHTC and efficacy by 111% and 100.5%, respectively, at a concentration of 0.006 vol% [15]. The study uses nanoplatelets of graphene to assess the specific heat capacity and thermal conductivity of water-ethylene glycol blends. The investigation found that the specific heat capacity dropped as nanoplatelet loading increased while thermal conductivity increased. A reduction in specific heat capacity of 8% was observed with the greatest enhancement at 0.45 vol% of nanoplatelet loading [16]. In [17], a study is conducted on the thermal properties of nanocoolant doped with graphite for use in automotive radiators. In [18-23], efficacy and temperature reduction over the whole length heating up the tube are studied using GO nanoparticles in water. The temperature drop shows a significant change with GO nanoparticles volume fraction which has maximum increase at 10% volume fraction (97.49%). By enhancing heat transfer, this coolant could reduce radiator bulk and increase their weight; hence it might find applications in other sectors of economy [24].With the goal to enhance performance and heat transmission in thermal systems, the study looks into graphite-based tiny fluids, notably graphite (G) and graphite oxide (GO) [25-28]. After being scattered in a base fluid composed of water and ethylene glycol in a 60 to 40 ratio, the nanoparticles are placed within a radiator model. Inserting louvered strip improves heat by 58–60% and stiffness by 1.8%, according to simulations. Moreover, Graphene and GO show a rise in the heat transfer efficiency of 236% and 320%, respectively [29-31]. This work investigates the rheological characteristics of graphite oxide and particles of magnesium oxide in a water-ethylene peg base liquid with the goal of developing a novel hybrid tiny fluids. According to the study, thermal conductivity rises with temperature fraction and volume, reaching a maximum improvement of 8.8% at 60°C and 0.2%. The findings show a big difference between the test and idea results [32]. The research looks at how tiny bits in coolants, which affect fuel use, change radiator size. Different amounts of Al2O3 were put in a mix of water and ethylene glycol to make the tiny coolant. The results say adding 0.2% Al2O3 increased heat transfer by 43% and made the radiator 65% smaller which led to less drag and power use [33]. This study sees coolant and heat for car engines using SiC nan fluids. The temp and volume of the fluids got better heat. The biggest improvement was 53.81% at 50°C for 0.5 vol. % fluids. Overall, the fluids did better than usual coolants showing they are better [34]. This research looks at the possibility of using nanofluid coolant to improve the fuel tank's thermal performance using a polymer electrolyte membrane (PEM). The study measured the Al2O3 concentrations of 0.1 and 0.5% in mixtures of water and acetic ethanol. The results show that, in comparison to the foundation fluid, there is a positive 23% and 21% rise in thermal transportation, respectively. However, a larger drop in pressure was seen. Based on the study results, 0.1% Al2O3 in 60:40 is the most advantageous tiny fluids choice, with benefit ratios that are greater than 1.

## 2 Methodology

The development of a radiator utilizing a graphene oxide nanofluid mixture of ethylene glycol and water entails a multifaceted methodology as depicted in Fig. 1. Commencing with an extensive review of existing literature, researchers delve into the synthesis of the nanofluid, ensuring the uniform dispersion and stability of graphene oxide nanoparticles within the base fluid. Characterization follows suit, wherein the properties of the synthesized nanofluid—thermal conductivity, viscosity, density, and stability—are meticulously analyzed. Thermal performance analysis consists mainly of experimental measurements to investigate heat rise coefficients, dissipation rates and temperature profiles in radiators under different conditions Building radiator systems to optimize the enhanced heat transfer properties of graphene oxide nanofluid blends with careful design and optimization process Being Experimental validation of the prototype confirms the performance claims; Modeling and simulation work provides insight into system behavior and contributes to further development.

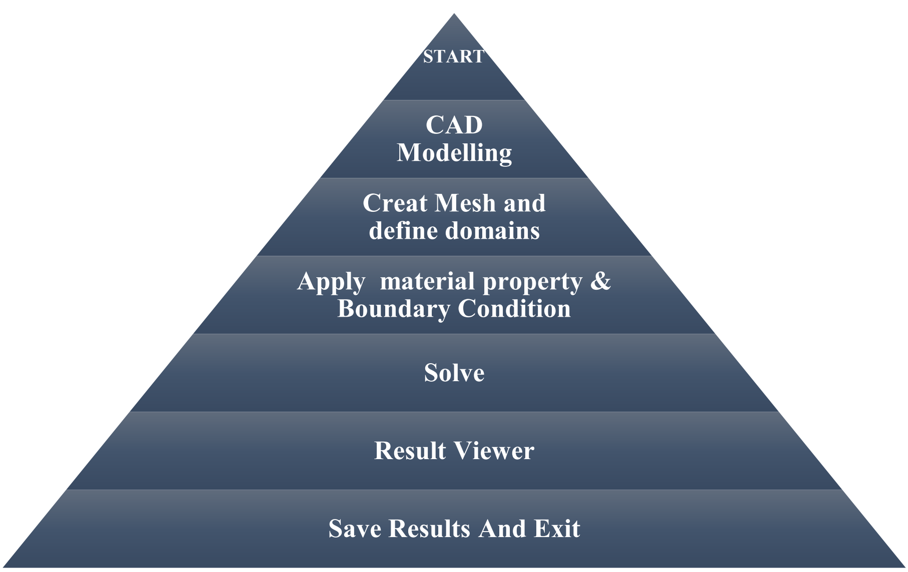


**Fig. 1:** Steps of conducting CFD analysis

Cost-benefit analysis balances financial considerations with the benefits of operational efficiency; Environmental assessment makes it sustainable and safe. In summary, there are thorough papers and reports with conclusions, implications, and future research directions. Through this radical approach, researchers are trying to fully utilize graphene-oxide nanofluids in the manufacture of radiators for the improvement of heat management technology.

Properties of EG: W/GO (60:40) mixed with 60% ethylene glycol (EG) and 40% water (W) exhibits the required properties in various thermal applications at 1157.4 constant kg/m3 mass and specific heat revealed 3527.71 J/kg. This mixture exhibits significant heat capacity, which is essential for good thermal conductivity With a thermal conductivity of up to 0.55 W/mK establishes the ability to conduct heat in media efficiency and strength. Moreover, the dynamic viscosity of 0.0026 Ns/m2 indicates its flow behaviour, which is important to understand its motion in different systems. The Prandtl number of 18 reflects the ratio between kinetic diffusivity and thermal diffusivity, which is an important parameter in fluid dynamics. These features combine to make EG:W/GO (60:40) blends a promising candidate for a wide range of thermal applications, from cooling systems to heat exchangers, where the efficient heat transfer agent is water functional is of the utmost importance This study investigates the heat transfer of a refrigerated mixture of ethylene glycol-water/glycerol oil (60:40), comparing the findings from the original paper with those in the present work mass flow rates from 180 LPH up to 420 LPH was observed, and the corresponding heat transfer rate was measured.

## 3 Result and Discussion

The main objective of the present work to investigate the heat transfer performance of the radiator at different flow rate of the heat transfer fluid by using various coolants such as mixture of ethylene glycol and water (60:40) mixed with graphene oxide GO nanofluid. Mass flow inlet of heat transfer fluid ranging from 180 LPH, 240 PH, 300 LPH, 360 LPH and 420 LPH has been used.

**Table 1:** Analyzing different mass flow rates of a radiator and comparing thermal performance parameters

| **Mass flow rate [LPH]** | **Inlet Temperature [°C]** | **Outlet temp [°C]** | **Temperature Difference $\Delta T$** | **Heat transfer rate [W]** | **Nusselt number [Nu]** | **Convective heat transfer coefficient [W/m$^2$K]** |
|---|---|---|---|---|---|---|
| 180 | 90 | 60.23 | 29.77 | 5253.97 | 82.60 | 15143.47 |
| 240 | 90 | 62.82 | 27.18 | 6715.63 | 108.12 | 19821.11 |
| 300 | 90 | 62.97 | 27.03 | 7632.64 | 120.30 | 22055.73 |
| 360 | 90 | 65.08 | 24.92 | 8796.04 | 143.82 | 26366.32 |
| 420 | 90 | 67.21 | 22.79 | 9653.05 | 166.40 | 30506.64 |

Based on various flow rates between 180 and 420 liters per hour (LPH), table 1 provides a detailed analysis of radiator performance metrics. Heat transfer rate in Watts, Nusselt number, and convective heat transfer coefficient (W/m2K) are all included in the data. A simple increase in the flow rate, in other words, raises the outlet temperature slightly, while the temperature difference is reduced. This could suggest that higher flow rates reduce the amount of heat transferred per unit of fluid, in spite of an increased overall heat transfer.

Convective heat transfer coefficients and Nusselt numbers increase with flow rate, indicating enhanced convective heat transfer capabilities.

## 4 Comparative Results

The following study delivers a comparative analysis of temperature difference and heat transfer rate for graphene oxide/ethylene glycol-water (60:40) mixture. Fig. 2 illustrates the outlet temperature data of this mixture, and the comparative results are illustrated further in Fig. 3, 4, and 5, showing the Reynolds number, Nusselt number, and heat transfer coefficient, respectively. This comprehensive examination sheds light on the thermal performance of the graphene oxide/ethylene glycol-water blend, offering insights into its heat transfer characteristics and potential applications.

### 4.1 Comparative results of temperature difference & heat transfer rate for EG: W/GO

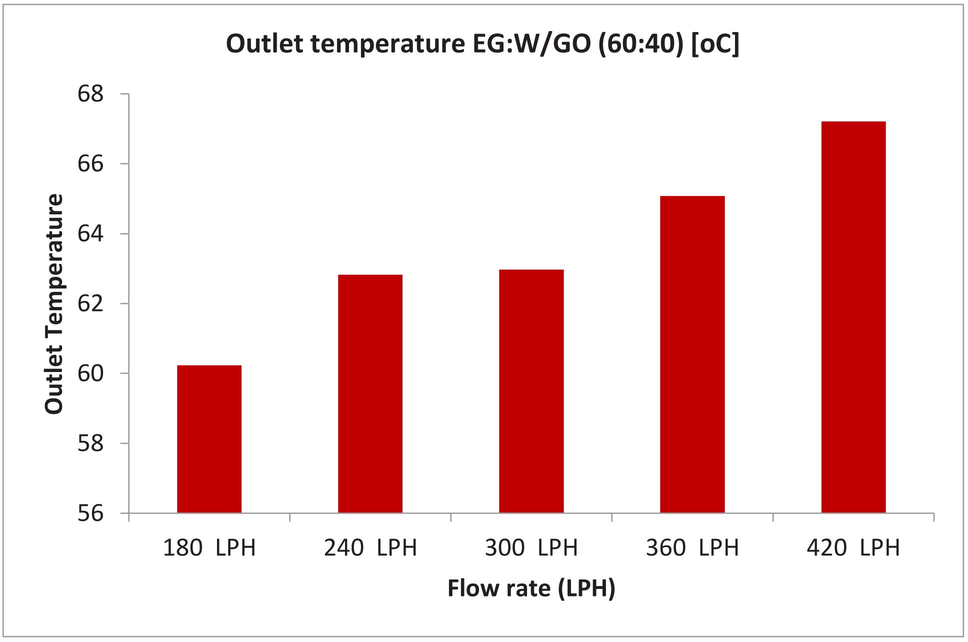


**Fig. 2:** Outlet temperature of EG: W/GO (60:40)

Based on Figure 2, it is evident that the outlet temperature increases with increasing flow rate. Temperatures at 180 LPH have been recorded as low as 58°C. When 240 LPH is reached, it rises to approximately 62°C, followed by 64°C at 300 LPH and slightly declining at 360 LPH. When 420 LPH is applied, the temperature increases sharply to about 68°C.

### 4.2 Comparative results of Reynolds number, Nusselt number & heat transfer coefficient for EG: W/GO (60:40)

It can be seen from the Fig. 3 that the rate of heat transfer increases with the flow rate. Starting at around 4500W at 180LPH, the rate rises to around 6500W at 240LPH, remains relatively stable until 300LPH and 360LPH with a slight increase, and then jumps significantly to around 9500W at 420LPH. This pattern suggests that higher flow rates increase the ability of the fluid mixture to transfer heat, which can be advantageous in applications requiring efficient heat dissipation or management.

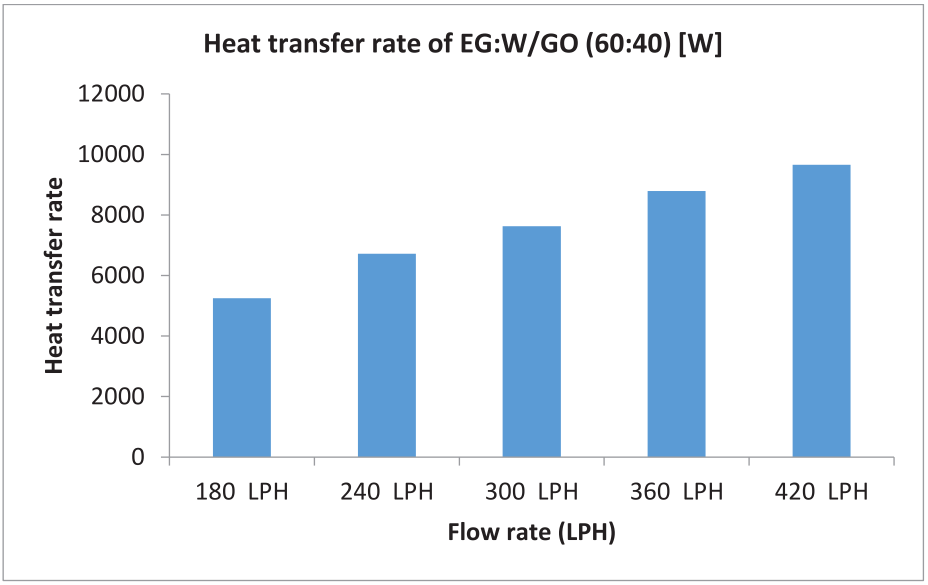


**Fig. 3:** Heat transfer rate of EG:W/GO (60:40)

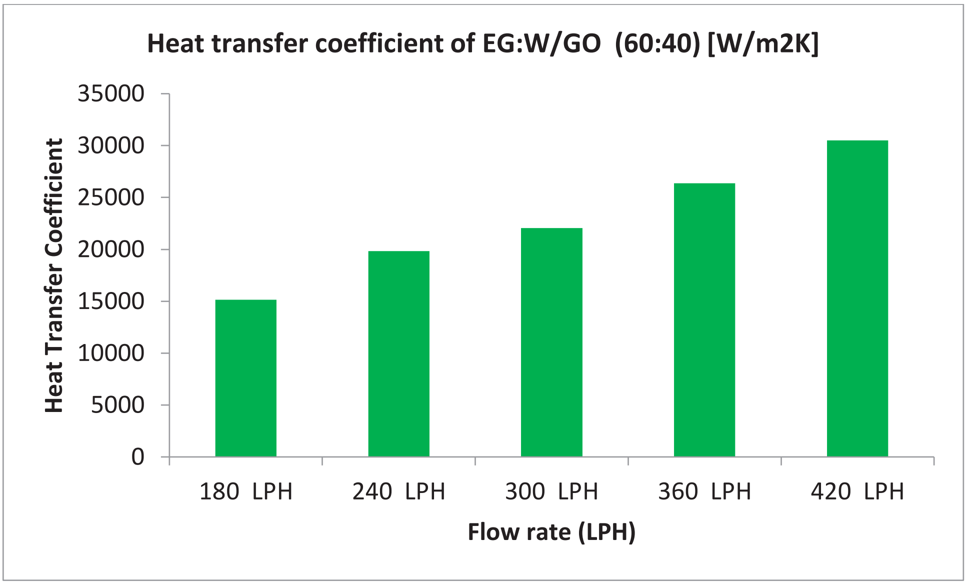


**Fig. 4:** Heat transfer coefficient of EG: W/GO (60:40)

Indeed, from the graph presented in Fig. 4, it is clear that the heat transfer coefficient increases with flow rate, meaning that better heat transfer occurs at higher flow rates. The coefficient starts at about 10,000 $W/m^2K$ at 180 LPH and increases and stabilizes slightly at 240 LPH and increases more quickly at higher flow rates, with the most considerable increase occurring at 420 LPH, which nearly exceeds 30,000 W/m²K. From the trend, it could be concluded that the mixture gets better at transferring heat with higher flow rates, which could be attributed to a more enhanced turbulence and thinner boundary layer at higher flow rates.

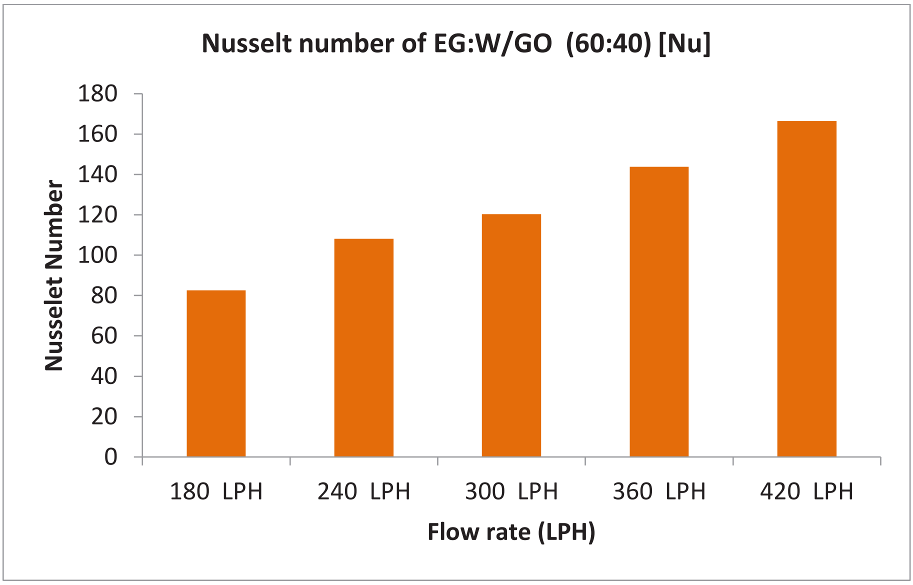


**Fig. 5:** Nusselt number of EG: W/GO (60:40)

The Nusselt number is dimensionless and gives an impression of the effectiveness of the convective heat transfer compared with conductive heat transfer across the boundary. The graph presented at Fig. 5: it can be seen that the Nusselt number increases with increasing flow rate—that's, better heat transfer is achieved at higher flow rates. The values start at around 70 for 180 LPH and increase in sequence, surpassing 160 at 420 LPH. This trend upward means the increasing flow rate improves the convective heat transfer most probably due to increased turbulence flow and larger disturbance of the thermal boundary layer.

## 5 Conclusion

In the present work mathematical and computational fluid dynamic analysis have been performed for radiator in order to investigate the thermal performance of the radiator at different flow rate of the heat transfer fluid by using various coolants such as mixture of ethylene glycol and water (60:40) mixed with graphene oxide nanofluid. For that three dimensional CAD model of radiator has been created in design modular of ANSYS workbench and perform CFD analysis by defining the Steady state pressure based absolute velocity formulation analysis where Energy equation is used for thermal analysis, K-epsilon RNG viscous model with standard wall function has been used for turbulent flow. Mass flow inlet of heat transfer fluid ranging from 180 LPH to 420 LPH has been used.

- Utilized graphene oxide/ethylene glycol: water (60:40) at 180 LPH with 90ºC inlet temperature. Output temperature: 60.23ºC with a temperature difference of 29.77 degrees.
- Maximum velocity: 15.28 m/s near the bend section. Heat transfer: 5253.97 W, coefficient of heat transfer: 15143.47 W/m2K, Nusselt number: 82.6.

- Exhaust temperature: 62.82ºC with a temperature difference of 27.18 degrees. Maximum velocity: 21.45 m/s at the bending section.
- Maximum heat transfer coefficient: 83.7%. Maximum heat transfer coefficient and Nusselt number increased by 1.015 times at 420 LPH compared to 180 LPH.

## References

1. Nawaz, Sonia, Hamza Babar, Hafiz Muhammad Ali, Muhammad Usman Sajid, Muhammad Mansoor Janjua, Zafar Said, Arun Kumar Tiwari, L. Syam Sundar, and Changhe Li. "Oriented square shaped pin-fin heat sink: performance evaluation employing mixture based on ethylene glycol/water graphene oxide nanofluid." Applied Thermal Engineering 206 (2022): 118085.
2. Ijam, Ali, R. Saidur, Poobalan Ganesan, and A. Moradi Golsheikh. "Stability, thermo-physical properties, and electrical conductivity of graphene oxide-deionized water/ethylene glycol based nanofluid." International Journal of Heat and Mass Transfer 87 (2015): 92-103.
3. Ponangi, Babu Rao, V. Krishna, and K. N. Seetharamu. "Effect of ultralow concentrated reduced graphene oxide nanofluid on radiator performance." Journal of Heat Transfer 143, 8 (2021): 082501.
4. Selvam, C., D. Mohan Lal, and Sivasankaran Harish. "Thermal conductivity and specific heat capacity of water–ethylene glycol mixture-based nanofluids with graphene nanoplatelets." Journal of Thermal Analysis and Calorimetry 129 (2017): 947-955.
5. Ijaz, Hamdoon, Hassan Raza, Ghulam Abbas Gohar, Sana Ullah, Awais Akhtar, and Muhammad Imran. "Effect of graphene oxide doped nano coolant on temperature drop across the tube length and effectiveness of car radiator–A CFD study." Thermal Science and Engineering Progress 20 (2020): 100689.
6. MADDERLA, Sandhya, Devarajan RAMASAMY, K. Sudhakar, Kumaran KADİRGAMA, and Wan Sharuzi WAN HARUN. "Heat transfer performance of a radiator with and without louvered strip by using Graphene-based nanofluids." Journal of Thermal Engineering 7, 6 (2021): 1315-1328.
7. Roohani, Ebrahim, and DavoodToghraie. "Heat transfer improvement of antifreeze by changing it to hybrid nanofluid: effects of hybrid magnesium oxide–graphene oxide nanopowders." Journal of Thermal Analysis and Calorimetry 147, no. 12 (2022): 6777-6791.
8. Subhedar, Dattatraya G., Bharat M. Ramani, Kamlesh V. Chauhan, Hitesh Panchal, Sagar M. Prajapati, Ali Jawad Al-rubaie, and Mustafa Musa Jaber. "Experimental study on the variation of car radiator frontal area using Al2O3/water-ethylene glycol nano coolant." Proceedings of the Institution of Mechanical Engineers, Part E: Journal of Process Mechanical Engineering (2023): 09544089231159994.
9. Li, Xiaoke, Changjun Zou, and Aihua Qi. "Experimental study on the thermo-physical properties of car engine coolant (water/ethylene glycol mixture type) based SiC nanofluids." International Communications in Heat and Mass Transfer 77 (2016): 159-164.
10. Zakaria, Irnie, W. H. Azmi, A. M. I. Mamat, RizalmanMamat, R. Saidur, SF Abu Talib, and W. A. N. W. Mohamed. "Thermal analysis of Al2O3–water ethylene glycol mixture nanofluid for single PEM fuel cell cooling plate: an experimental study." International Journal of Hydrogen Energy 41, 9 (2016): 5096-5112.
11. Sathish, T., R. V. Sabariraj, K. Muthukumar, and S. Karthick. "Experimental investigation of convective heat transfer coefficient on nano particles mixture used in automobile radiator based on mass flow rate." Materials Today: Proceedings 33 (2020): 2524-2529.

12. Azizi, Mehdi, and Bizhan Honarvar. "Synthesis of highly stable nanofluids including polyvinyl alcohol-treated graphene oxide for improved heat dissipation in a tubular heat exchanger." Journal of Thermal Analysis and Calorimetry 145, no. 1 (2021): 13-25.
13. Narayanasamy, Manikanda Prabu, Sureshkannan Gurusamy, Suresh Sivan, and A. P. Senthilkumar. "Heat transfer analysis of looped micro heat pipes with graphene oxide nanofluid for Li-ion battery." Thermal Science 25, no. 1 Part A (2021): 395-405.
14. Das, Nipu Kumar, Somtirtha Santra, Papu Kumar Naik, Maureen Shama Vasa, Rishi Raj, Suryasarathi Bose, and Tamal Banerjee. "Evaluation of thermophysical properties and thermal performance of amine-functionalized graphene oxide/deep eutectic solvent nanofluids as heat-transfer media for desalination systems." ACS Sustainable Chemistry & Engineering 11, no. 14 (2023): 5376-5389.
15. Suji Prasad, S. J., M. Thangatamilan, M. Suresh, Hitesh Panchal, Christober Asir Rajan, C. Sagana, B. Gunapriya, Aditi Sharma, Tusharkumar Panchal, and Kishor Kumar Sadasivuni. "An efficient LoRa-based smart agriculture management and monitoring system using wireless sensor networks." International Journal of Ambient Energy 43, no. 1 (2022): 5447-5450.
16. Joseph, Sudha, Kavitha Joseph, Trevor C. Lindley, and David Dye. "The role of dwell hold on the dislocation mechanisms of fatigue in a near alpha titanium alloy." International Journal of Plasticity 131 (2020): 102743.
17. Prasad, C. Durga, S. Kollur, M. Nusrathulla, G. Satheesh Babu, M. B. Hanamantraygouda, B. N. Prashanth, and N. Nagabhushana. "Characterisation and wear behaviour of SiC reinforced FeNiCrMo composite coating by HVOF process." Transactions of the IMF 102, no. 1 (2024): 22-28.
18. Meenal, R., D. Binu, K. C. Ramya, Prawin Angel Michael, K. Vinoth Kumar, E. Rajasekaran, and B. Sangeetha. "Weather forecasting for renewable energy system: a review." Archives of Computational Methods in Engineering 29, no. 5 (2022): 2875-2891.
19. Akshatha, S., S. Sreenivasa, L. Parashuram, Fahad A. Alharthi, and Tadimety Madhu Chakrapani Rao. "Microwave assisted green synthesis of p-type Co3O4@ Mesoporous carbon spheres for simultaneous degradation of dyes and photocatalytic hydrogen evolution reaction." Materials Science in Semiconductor Processing 121 (2021): 105432.
20. Akshatha, S., S. Sreenivasa, L. Parashuram, V. Udaya Kumar, S. C. Sharma, H. Nagabhushana, Sandeep Kumar, and T. Maiyalagan. "Synergistic effect of hybrid Ce3+/Ce4+ doped Bi2O3 nano-sphere photocatalyst for enhanced photocatalytic degradation of alizarin red S dye and its NUV excited photoluminescence studies." Journal of Environmental Chemical Engineering 7, no. 3 (2019): 103053.
21. Ramkumar, M., C. Ganesh Babu, K. Vinoth Kumar, D. Hepsiba, A. Manjunathan, and R. Sarath Kumar. "ECG cardiac arrhythmias classification using DWT, ICA and MLP neural networks." In Journal of Physics: Conference Series, vol. 1831, no. 1, p. 012015. IOP Publishing, 2021.
22. Kumar, CB Pradeep, B. S. Prathibha, K. N. N. Prasad, M. S. Raghu, M. K. Prashanth, B. K. Jayanna, Fahad A. Alharthi, S. Chandrasekhar, H. D. Revanasiddappa, and K. Yogesh Kumar. "Click synthesis of 1, 2, 3-triazole based imidazoles: Antitubercular evaluation, molecular docking and HSA binding studies." Bioorganic & Medicinal Chemistry Letters 36 (2021): 127810.
23. Rajesh, A., K. Gopal, B. Rajesh Kumar, A. P. Sathiyagnanam, and D. Damodharan. "Effect of anisole addition to waste cooking oil methyl ester on combustion, emission and performance characteristics of a DI diesel engine without any modifications." Fuel 278 (2020): 118315.

24. Naik, Ramachandra, S. C. Prashantha, H. Nagabhushana, S. C. Sharma, H. P. Nagaswarupa, and K. M. Girish. "Effect of fuel on auto ignition route, photoluminescence and photometric studies of tunable red emitting Mg2SiO4: Cr3+ nanophosphors for solid state lighting applications." Journal of Alloys and Compounds 682 (2016): 815-824.
25. Naveen Kumar, Rangaswamy, J. Suresh Goud, Pudhari Srilatha, Pattasale T. Manjunatha, S. Prasanna Rani, Raman Kumar, and S. Suresha. "Cattaneo–Christov heat flux model for nanofluid flow over a curved stretching sheet: An application of Stefan blowing." Heat Transfer 51, no. 6 (2022): 4977-4991.
26. Vallabhuni, Rajeev Ratna, G. Yamini, T. Vinitha, and S. Sanath Reddy. "Performance analysis: D-Latch modules designed using 18nm FinFET Technology." In 2020 International Conference on Smart Electronics and Communication (ICOSEC), pp. 1169-1174. IEEE, 2020.
27. Dhanalaxmi, B., and G. Apparao Naidu. "A survey on design and analysis of robust IoT architecture." In 2017 International Conference on Innovative Mechanisms for Industry Applications (ICIMIA), pp. 375-378. IEEE, 2017.
28. Nikam, Pritam B., Jayendra Kumar, V. Sivanagaraju, and Achinta Baidya. "Dual-band reconfigurable EBG loaded circular patch MIMO antenna using defected ground structure (DGS) and PIN diode integrated branch-lines (BLs)." Measurement 195 (2022): 111127.
29. Vallabhuni, Rajeev Ratna, Jujavarapu Sravana, Chandra Shaker Pittala, Mikkili Divya, B. M. S. Rani, and Vallabhuni Vijay. "Universal shift register designed at low supply voltages in 20 nm FinFET using multiplexer." In Intelligent Sustainable Systems: Proceedings of ICISS 2021, 203-212. Singapore: Springer Singapore, 2021.
30. Kishore, Somasundaram Chandra, Raji Atchudan, Thomas Nesakumar Jebakumar Immanuel Edison, Suguna Perumal, Muthulakshmi Alagan, Rajangam Vinodh, Mani Shanmugam, and Yong Rok Lee. "Solid waste-derived carbon fibers-trapped nickel oxide composite electrode for energy storage application." Energy & Fuels 34, no. 11 (2020): 14958-14967.
31. Malagavelli, Venu, Srinivas Angadi, J. S. R. Prasad, and Subodh Joshi. "Influence of metakaolin in concrete as partial replacement of cement." Int J Civil Eng Technol 9, no. 7 (2018): 105-111.
32. Ashok Babu, Puralasetty, Javanna Latheef Mazher Iqbal, S. Siva Priyanka, Machana Jithender Reddy, Gaddam Sunil Kumar, and Rajaram Ayyasamy. "Power control and optimization for power loss reduction using deep learning in microgrid systems." Electric Power Components and Systems 52, 2 (2024): 219-232.
33. Saritha, M., M. Lavanya, G. Ajitha, Mulinti Narendra Reddy, P. Annapurna, M. Sreevani, S. Swathi, S. Sushma, and Vallabhuni Vijay. "A VLSI design of clock gated technique based ADC lock-in amplifier." International Journal of System Assurance Engineering and Management 13, 5 (2022): 2743-2750.
34. Pittala, Chandra Shaker, Rajeev Ratna Vallabhuni, Vallabhuni Vijay, Usha Rani Anam, and Kancharapu Chaitanya. "Numerical analysis of various plasmonic MIM/MDM slot waveguide structures." International Journal of System Assurance Engineering and Management 13, 5 (2022): 2551-2558.