Journal of Mines, Metals and Fuels, *73(7): 1987-1994; 2025. DOI: 10.18311/jmmf/2025/49272*

Print ISSN : 0022-2755

Journal of Mines, Metals and Fuels

Contents available at: *www.informaticsjournals.co.in/index.php/jmmf*

Recent Advancements in the Field of Nanotechnology Using Artificial Intelligence, Data Science and Machine Learning

Suresh Chimkode[1], Jayant Mane[2], Mayur Jakhete[3], Umesh Moharil[4], Chetankumar Sedani[5], Nandkishore Rao[6], Rohit Garad[7], Shobha Rupanar[7], Nirmala Kakade[8], Ramakant Choudhari[9], Vijay Bhambere[10], Girish Modak[11], Roma Paliwal[13], Smita Desai[12], Kamalkishor Maniyar[12*], Ganesh Patil[12], Ekta Mishra[12], Prasad Ghodke[14], Swati Dixit[12] and Mahendra Yadav[15]

[1]*Geetanjali College of Engineering and Technology, Cheeryal (V), Keesara(M), Hyderabad - 501301, Telangana, India*
[2]*Finolex Academy of Management and Technology, Ratnagiri - 415639, Maharashtra, India*
[3]*PCET's Pimpri Chinchwad University, Maval (PMRDA) - 412106, Pune, Maharashtra, India*
[4]*Marathwada Mitramandal's Institute of Technology, (MMIT) Lohgaon, Pune - 411047, Maharashtra, India*
[5]*P K Technical Campus, Chakan, Pune - 410501, Maharashtra, India*
[6]*Guru Nanak Dev Engineering College Bidar - 585403, Karnataka, India*
[7]*Ajeenkya DY Patil School of Engineering, Lohegaon - 412105, Maharashtra, India*
[8]*Dada Patil Rajale Arts and Science College, Adinathnagar, Pathardi, Ahilyanagar - 414505, Maharashtra, India*
[9]*Padmashri Dr VB Kolte College of Engineering, Malkapur - 443101, Maharashtra, India*
[10]*Jagadambha College of Engineering and Technology, Yavatmal - 445105, Maharashtra, India*
[11]*PES Modern College of Engineering, Shivajinagar, Pune - 411005, Maharashtra, India*
[12]*Dr. D. Y. Patil Institute of Technology, Pimpri,Pune - 411018, Maharashtra, India; advancedresearch25@gmail.com*
[13]*International Institute of Information Technology, Rajiv Gandhi IT Park, Hinjewadi Phase 1, Pune - 411057, Maharashtra, India*
[14]*Modern Institute of Business Studies (Autonomous) Nigdi, Pune - 411044, Maharashtra, India*
[15]*Dr. D. Y. Patil Dnyan Prasad University's, School of Management and Research, Tathawade, Pune - 411033, Maharashtra, India*

Abstract

Rapidly developing technologies like nanotechnology and machine learning (ML) have many practical uses in data processing, computer engineering, materials research, and medicine. By making data processing easier in the synthesis of nanomaterials, characterisation, and optimization of nanoscale features, machine learning (ML) advances nanotechnology. ML algorithms, on the other hand, depend on faster and more efficient processing power, which nanotechnology enhances. A survey of the academic literature offers insights into the fascinating horizons of both nanotechnology and machine learning, despite the fact that both areas' capabilities are still in their infancy. It also suggests that their integration can have transformational effects. Creating instruments for working with nanomaterials and making sure that data collecting for ML models is impartial and moral are two areas of future research. Furthermore, nanochips can boost the performance and power of contemporary computers, which could cut down on the time and expense required to train intricate machine learning models. The goal is to draw attention to how important it is for these two domains to work together, since this can improve computing power, optimize model training, and hasten nanotechnology research and nanomachine development. It is anticipated that a deeper comprehension of this cross-collaboration will enhance computer capabilities to maximize model training, accelerate nanotechnology research, and guide future nanomachines.

**Author for correspondence*

Major Findings: *This information provides a broad overview of nanotechnology, emphasising both the worldwide concerns regarding their application and the importance of these fields in the development of new systems and technologies. These instances highlight machine learning's revolutionary potential in finding nanoparticles with desired characteristics and streamlining time-consuming procedures in nanotechnology*

Keywords: *Nanotechnology, Significance, Uses, machine learning, artificial intelligence, data science*

1.0 Introduction and Literature Review

Researching and working with materials at the nanoscale which is measured in relation to the nanometer is known as nanotechnology. By manipulating the basic building elements of matter at the nanoscale, scientists can reverse-engineer medicine delivery and agricultural solutions[1,2]. Nanotechnology has made significant contributions to the fields of semiconductors and microelectronics, including innovations such as silicon transistors. In machine learning, different algorithms are studied and trained to evaluate enormous datasets, find patterns, and generate predictions on their own[3,4]. A user refines a model a collection of algorithms through multiple trials to provide predictions that are more accurate[5,6]. In order to solve contemporary scientific and technical problems[7,8], these two disciplines nanotechnology and machine learning are increasingly being combined, utilizing each other's advantages to further both. ML can speed up advancements in the field by automating some of the steps involved in finding and creating nanoparticles using trained models[9,10], as shown schematically in Figure 1. Nanostructures and classifying nanoparticles with an accuracy of over 95% is another illustration of machine learning's influence in nanotechnology[11,12]. This degree of effectiveness made it feasible to carry out large-scale investigations more quickly and accurately by drastically cutting down on the time and effort required for characterisation[13,14]. The difficulties at this juncture and potential paths forward are also covered in this assessment. The difficulty of efficiently processing and producing nanoparticles is one of the biggest obstacles to their commercial adoption[15,16]. Nanotechnology advancements are frequently theoretical, and production is a time-consuming and expensive trial-and-error process. To completely automate the synthesis of nanoparticles, however, state-of-the-art machine learning techniques are being investigated[17,18]. These algorithms will determine the best synthesis settings and direct robotic devices to carry out the procedure effectively as shown in figure 1. Compared to conventional trial-and-error techniques, this clever fusion of machine learning and robotics has the potential to completely transform the production of nanomaterials by enabling more consistent quality and scalability[19,20].

2.0 Materials and Method

The production of nanomaterials is highly dependent on a number of chemical characteristics or factors that the machine can tolerate, including mass, volume, and temperature. Numerous jobs related to a particular process can be carried out by a mobile robotic chemist, while a model known as WANDA can map many of these characteristics to establish a synthesis process[21,22]. One of the system's main advantages is that it operates at a never-before-seen speed and reduces a significant

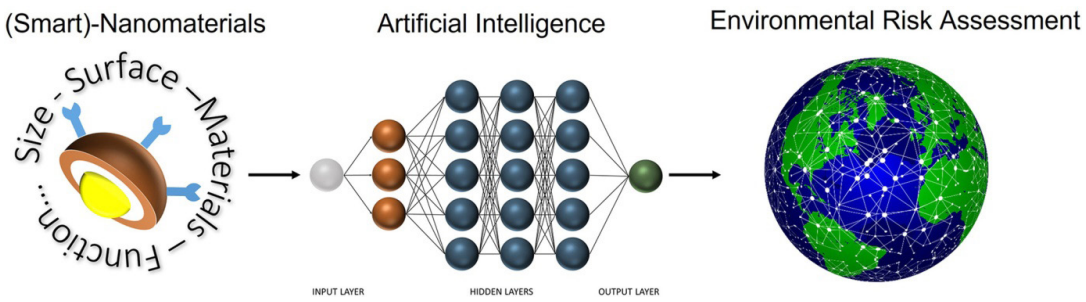


Figure 1. Collaborating Artificial Intelligence and Machine Learning In Nanotechnology[3]

amount of human mistake related to chemistry. It may be possible to transform nanotechnology and commercialize nanomaterials by combining robotic components with machine learning algorithms[23,24]. Antimicrobial peptide (AMP) discovery, for instance, may benefit from machine learning. AMPs are mostly employed as bactericides and are present in bacteria[25,26]. By making it easier to identify peptides with lengths between 8 and 12 amino acids, machine learning (ML) improves sequestration, or the storage of carbon, which increases yield and efficiency[27,28]. Researchers can more effectively fight drug-resistant bacteria in the body and get past AMPs' conventional problems with instability and toxicity by creating these novel AMPs with machine learning[29,30]. By employing machine learning to create these novel AMPs, scientists can overcome the conventional problems with AMPs, like instability and toxicity, and more effectively fight drug-resistant bacteria in the body[31,32]. Scalability concerns can be more successfully addressed through interdisciplinary collaboration, especially the incorporation of machine learning (ML), which can improve manufacturing procedures and increase the accuracy of nanomaterial fabrication[33,34]. The time and expense involved in experimental trials can be greatly decreased by employing interdisciplinary approaches, such as machine learning (ML) to evaluate enormous datasets of nanoparticle attributes. In addition to increasing efficiency, this synergy creates new opportunities for nanoscale innovation. The ability of machine learning (ML) to extract valuable insights from extraordinarily big data sets is especially helpful[35,36]. Similar to the creation of nanoparticles, automatic image classification is an effective technique that reduces the amount of time required to do an experiment. Nanomaterials will be examined more quickly and precisely than previously to the development of machine learning technology, which will speed up the engineering process[37,38]. As a result, ML is taking the lead in yield analysis, predictive metrology, and process flows for nanoscale characterisation. ML, which learns from simulated or experimental data, has emerged as a potent technique for predicting the properties of nanoparticles[39,40]. Predicting nanoparticle properties requires the use of three machine learning algorithms. SVMs may predict important attributes like tensile strength and Young's modulus with high accuracy by spotting hyperplanes in datasets, frequently outperforming traditional regression models[41,42]. Researchers may tailor mechanical properties for specific applications using this capacity, which also ensures robust generalization across several datasets, greatly improving the design process of nanocomposites. Thus, the development of nanocomposite materials has advanced significantly with the inclusion of ML, particularly SVMs[43,44]. Heavy metal and nanometal oxide combinations' toxicity can be predicted using this machine learning technique. Numerous applications, including as regression and classification, are made possible by these networks. Neural networks, which are made up of interconnected nodes for data processing, have applications in pharmacokinetics, drug testing as shown in Figure 2. In addition to classifying nanomaterials

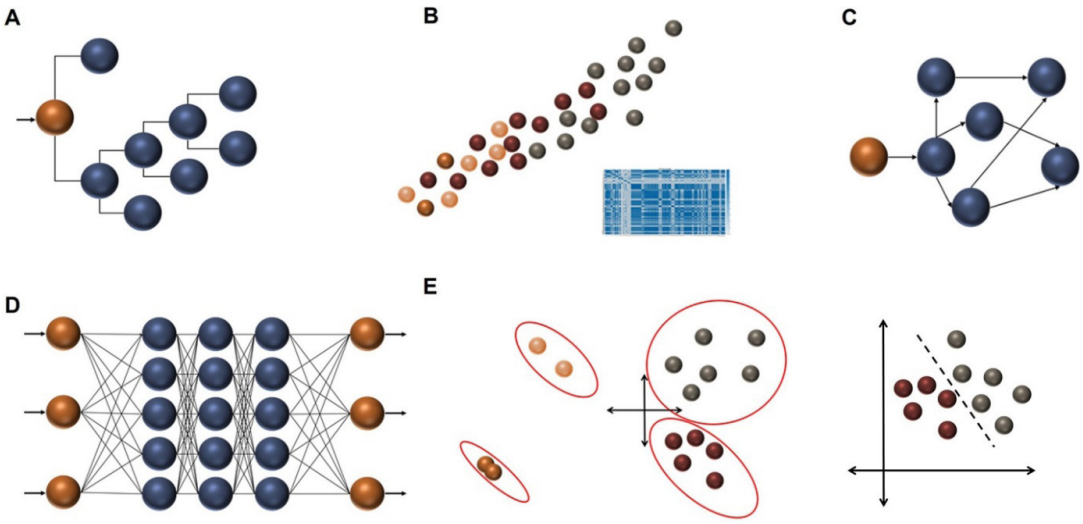


Figure 2. Nanostructures using AI & ML[5]

based on their structure, neural networks can also anticipate the attributes of individual nanomaterials by using extensive[45,46]. For instance, a recent study showed that, without knowing anything about the materials beforehand, a model could accurately predict the characteristics of combinations of four, five, and six elements in 18 out of 19 situations[47,48].

3.0 Application of Artificial Intelligence, Data Science and Machine learning in the various fields of Nanotechnology

Another real-world use of ML nanomaterial property prediction is in the treatment of cancer. With the use of MRI-sensitive nanoparticles that track the disease's growth in real time, nanotechnology makes it possible to treat cancer with combinations of chemotherapy, radiation, and immunotherapy[49,50]. With the development of machine learning (ML), these nanoparticles may now be deployed and directed specifically using predictive analysis. In one study, the success of treating different malignancies in mice with nanoparticles was predicted, in predicting responses to the nanoparticles using 376 distinct datasets[51,52]. Devices operating at the nanoscale must adhere to a set of regulations, which frequently deviate from accepted macro-engineering norms[53,54]. In addition to guiding the design and development of nanomachines that are impossible to replicate using conventional computational tools and ests, machine learning (ML) has shown that it can anticipate the properties of nanomaterials[55,56]. As shown in Figure 3, researchers may quickly retrieve data and predict the characteristics and operations of certain nanodevices by using an AI model. The development of tiny devices for a variety of applications is one instance of how machine learning has affected nanotechnology, especially in nanomanufacturing. By producing synthetic materials, nanomanufacturing makes a substantial contribution to civil engineering. By examining materials with exceptional qualities seen[47,48]. All things considered, machine learning not only supports the advancement of nanotechnology but also increases its ability to tackle problems in engineering and medical[57,58]. While the ways in which ML influences many facets of nanotechnology have been thoroughly studied and reviewed, the opposite that is, how nanotechnology supports ML has been less clear and is more of a recent development. New strategies, such as nanotechnology, are crucial to generating future performance advances as conventional ways of boosting computer power hit their physical limits. Notably, nanomaterials such as quantum dots and graphene-based transistors function more efficiently and at faster speeds[59,60]. It demonstrated precise RDF predictions. A

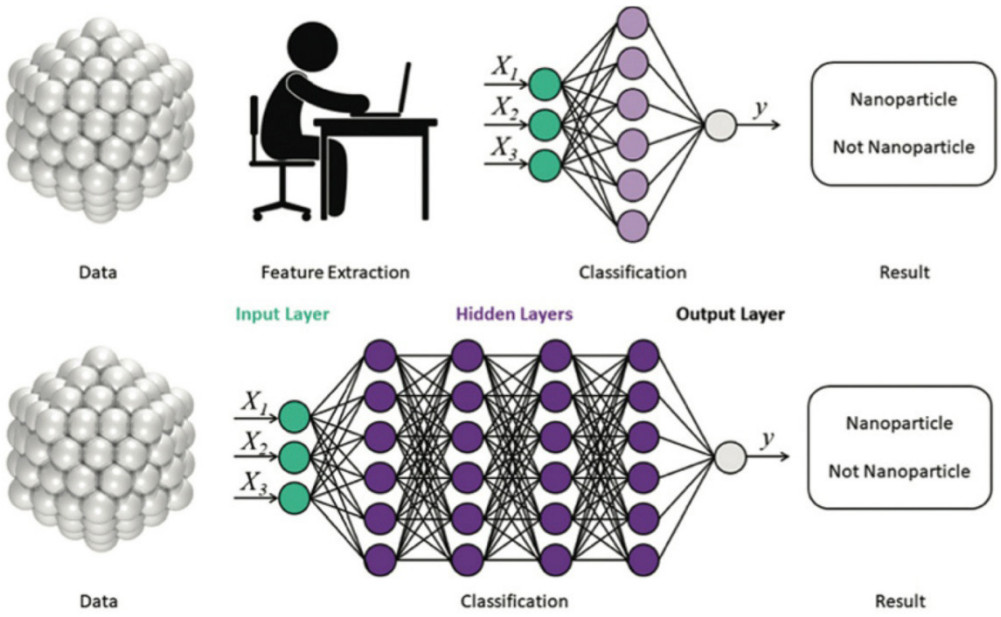


Figure 3. Uses of Machine learning and artificial intelligence in Nanotechnology[7]

polymer matrix and nanofillers combine to form polymer nanocomposites, which have remarkable multifunctional qualities. Design and optimization were aided by ML's ability to forecast nanocomposite properties based on composition and processing factors[61].

4.0 Conclusion

Both ML and nanotechnology are extremely helpful to each other's advancement and have the potential to completely transform medical technology, energy storage, and processing power. Chemical engineers can save a great deal of time and effort by using machine learning (ML) to speed up the development of nanotechnology by making it easier to discover and synthesize novel nanomaterials using previously learned information. Together, these two disciplines have the ability to automate medical, agricultural, and aviation technologies with previously unheard-of strength and efficiency, thereby bringing about a new era of scientific progress. In agriculture, sensors enabled by nanotechnology in conjunction with machine learning algorithms could maximize crop productivity and monitor soil health. Nanomaterials might be used to make lightweight parts for the aviation industry, and machine learning could forecast maintenance requirements, increasing efficiency and safety. Because of nanotechnology, ML hardware acceleration is entering a new phase that could revolutionize a number of industries by making ML faster, easier to use, and more energy-efficient. Significant obstacles still exist, though, such the complexity of production and the requirement for specialist software tools. Understanding these difficulties offers a fair assessment of these technologies' prospects. Notwithstanding these challenges, there is no denying the benefits of changing the AI environment. The potential of these tools is demonstrated by developments in nanomedicine in particular, and as nanotechnology develops. When nanotechnology and machine learning are combined, new possibilities for solving difficult problems and applications arise.

5.0 References

1. Alexis F, Rhee JW, Richie JP, Radovic-Moreno AF, Langer R, Farokhzad OC. New frontiers in nanotechnology for cancer treatment. Urol Oncol. 2008; 26(1):74-85 https://doi.org/10.1016/j.urolonc.2007.03.017 PMid:18190835
2. Bai C. Scanning tunnelling microscopy and its application. Springer Science and Business Media; 2000.
3. Bayda S, Adeel M, Tuccinardi T, Cordani M, Rizzolio F. The history of nanoscience and nanotechnology: From chemical–physical applications to nanomedicine. Molecules. 2019; 25(1):112. https://doi.org/10.3390/molecules25010112 PMid:31892180 PMCid:PMC6982820
4. Yao L, Chen Q. Machine learning in nanomaterial electron microscopy data analysis. In Intelligent Nanotechnology. Amsterdam, The Netherlands: Elsevier; 2023. p. 279–305
5. Binnig G, Rohrer H. Scanning tunneling microscopy. Surf Sci. 1983; 126(1-3):236-244 https://doi.org/10.1016/0039-6028(83)90716-1
6. Bronson B. The making and selling of wootz, a crucible steel of India; 1986. Available from: https://www.semanticscholar.org/paper/The-making-and-selling-of-wootz%2C-a-cruciblesteel-Bronson/6fbe75ffd29d29338808cf55ec430a11e0f5c013
7. Tulevski GS, Franklin AD, Frank D, Lobez JM, Cao Q, Park H, Afzali A, Han, S-J, Hannon JB, Haensch W. Toward high-performance digital logic technology with carbon nanotubes. ACS Nano. 2014; 8:8730–8745
8. Verhelst M, Murmann B. Machine learning at the edge. In NANO-CHIPS 2030: On-Chip AI for an Efficient Data-Driven World; Berlin/Heidelberg, Germany: Springer; 2020. p. 293–322.
9. Cheng HN, Doemeny LJ, Geraci CL, Grob Schmidt D. Nanotechnology overview: opportunities and challenges. ACS Symp Ser. 2016; 1-12. https://doi.org/10.1021/bk-2016-1220.ch001 PMid:27353003
10. Enrico A, Dubois V, Niklaus F, Stemme G. Scalable manufacturing of single nanowire devices using crack-defined shadow mask lithography. ACS Appl Mater Interfaces. 2019; 11(8):8217-8226. https://doi.org/10.1021/acsami.8b19410 PMid:30698940 PMCid:PMC6426283
11. Park J, Kim YM, Hong S, Han B, Nam KT, Jung Y. Closed-loop optimization of nanoparticle synthesis enabled by robotics and machine learning. Matter. 2023; 6:677–690
12. Ali MG. Diamondoids -The molecular lego of biomedicine, materials science and nanotechnology. J Bioanaly Biomed. 2013; 05(02). https://doi.org/10.4172/1948-593X.1000e116
13. Chan EM, Xu C, Mao AW, Han G, Owen JS, Cohen BE, Milliron DJ. Reproducible, high-throughput synthesis of colloidal nanocrystals for optimization in multidimensional parameter space. Nano Lett. 2010; 10:1874–1885.

14. Hochella Jr, MF. Nanoscience and technology: The next revolution in the Earth sciences. Earth Planet Sci Lett. 2002; 203(2):593-605. https://doi.org/10.1016/S0012-821X(02)00818-X
15. Hulla J, Sahu S, Hayes A. Nanotechnology. Hum Exp Toxicol. 2015; 34(12):1318-1321. https://doi.org/10.1177/0960327115603588 PMid:26614822
16. Garad RN, Hudgikar SRK, Maniyar K. An extensive study on the optimized piston bowl with spiral grooves for the CI engine. J Mines Met Fuels. 2025; 73(5):1389–1394. https://doi.org/10.18311/jmmf/2025/48016
17. Choudhari RM, Adhaye AM, Sulakhe VN, Warke PS, Maniyar KG. An analysis of tensile strength and performance of resistance spot welding parameters for HSLA 355 stainless steel. J Mines Met Fuels. 2025; 73(5):1409–1418. https://doi.org/10.18311/jmmf/2025/48684
18. Warke PS, Chaudhari DM, Naik VS, Patil DD, Dhokale SS, Maniyar KG, Patil GH.. Wet Scrubber System for Exhaust Gas Emission Reduction. J Mines Met Fuels. 2025; 73(5):1331–1341. https://doi.org/10.18311/jmmf/2025/48623
19. Maniyar K, Puri A, Suhane S, Deshmukh S, Modak G, Biradar R. An experimental performance of edm process parameters for aluminum composites. In: Joseph DPVJ, Thangaraju, K, editors. Proceedings of the International Conference on Emerging Multifunctional Materials and Devices for Sustainable Technologies. IEMDST 2024. Springer, Singapore; (2025). https://doi.org/10.1007/978-981-96-5863-3_44
20. Maniyar K, Saravade N, Suhane S, Deshmukh S, Modak G, Biradar R. Investing Experimental Effect of Welding Parameters in Friction Stir Welding on Aluminium Alloy. In: Joseph DPVJ, Thangaraju, K, editors. Proceedings of the International Conference on Emerging Multifunctional Materials and Devices for Sustainable Technologies. IEMDST 2024. Springer, Singapore; 2025. https://doi.org/10.1007/978-981-96-5863-3_45
21. Maniyar KG, Ingole DS. Multi response optimization of EDM process parameters for aluminium hybrid composites by GRA. Mater Today Proc. 2018; 5:1983643. https://doi.org/10.1016/j.matpr.2018.06.347
22. Maniyar KG, Ingole DS. Investigation of EDM process parameters for hybrid metal matrix composites. IOP Conf Ser Mater Sci Eng. 2018; 377:012204. https://doi.org/10.1088/1757-899X/377/1/012204
23. Maniyar KG, Ingole DS. Mathematical modeling and optimization of EDM process parameters for aluminium hybrid composites. Mater Today Proc. 2018; 5:27700-27709. https://doi.org/10.1016/j.matpr.2018.10.004
24. Maniyar KG, Ingole DS. Influence of EDM control factors for aluminium hybrid Composites. Lect Notes Multidiscipl Indust Eng. 2018; 275-284. https://doi.org/10.1007/978-3-319-76276-0_27
25. Maniyar KG. An experimental analysis of aluminium hybrid metal matrix composites, Mater Today Proc. 2024. In Press. https://doi.org/10.1016/j.matpr.2024.01.021
26. Maniyar KG, Marode RV, Chikalthankar SB. Optimization of EDM process parameters on MRR and TWR of Tungsten Carbide by Taguchi Method. Int J Eng Adv Technol. 2016; 5(3):112-116.
27. Maniyar KG. Analysis of EDM process parameters on material removal rate of WC. 2nd Nat Conf Recent Inno Sci Eng. 2017; 5(9):37-39.
28. Maniyar KG, Agrawal SK, Ingole DS. Optimization of multiple performance characteristics in EDM: A critical literature review. Int J Innov Technol Explor Eng. 2016; 5(10):27-33.
29. Maniyar KG, Deore HV. Design and testing of carbon fiber composite material with comparative analysis. Int Res J Eng Tech. 2020; 7(8):1120-1122.
30. Maniyar KG, Ingole DS. Current research development in machining of hybrid metal matrix composites: A review. Int J Recent Innov Trends Comput Commun. 2016; 4(7):150-154.
31. Jadhav PA, Maniyar K. Evaluation and characterization of aluminum silicon carbide Metal Matrix Composites. AIP Conf Proc. 2024; 3196:040002. https://doi.org/10.1063/5.0227945
32. Maniyar K, Jadhav P, Biradar R, Gawande J. An experimental study of process parameters for nano composites. NanoWorld J. 2024; 10(S1):S209-S211.
33. Maniyar K, Jadhav P, Biradar R, Gawande J. Effect of nano-lubricants on journal bearing for performance enhancement. NanoWorld J. 2024; 10(S1):S206-S208.
34. Maniyar K, Suhane S. Parametric analysis of electric discharge machining for nano composites. NanoWorld J. 2024; 10(S1):S63-S65.
35. Maniyar K, Puri A, Pawar P, Patil V, Jadhav P, Patil G, *et al*. The comprehensive study for machining of metal matrix composites. AIP Conf Proc. 2024; 3196:040005. https://doi.org/10.1063/5.0227955
36. Maniyar K, Warke P, Jadhav P, Waware S, Harsur S, Biradar R. An extensive study of mechanical properties and tribological characteristics for hybrid composites. AIP Conf Proc. 2024; 3203:030038. https://doi.org/10.1063/5.0224994
37. Maniyar K, Pawar P, Kolhe P, Ingale M, Patil P, Sarode G. The comprehensive study of synthesis and characterization of hybrid nano fluids. AIP Conf Proc. 2024; 3149:030048. https://doi.org/10.1063/5.0224988

38. Ghutepatil PR, Khapare S, Joshi RB, Maniyar KG. A critical review of nanotechnology in various fields of engineering. AIP Conf Proc. 2024; 3149:030002. https://doi.org/10.1063/5.0224984
39. Thamke V, Saravade N, Banarase S, Maniyar K. Seismic performance and cost analysis of AAC blocks vs. fly ash bricks: A comparative study utilizing STAAD pro. AIP Conf Proc. 2024; 3196:060006. https://doi.org/10.1063/5.0227895
40. Banarase S, Banarase M, Saravade N, Thamke V, Maniyar K. Evaluation of concrete building strengthening through non-destructive testing methods - A case study. AIP Conf Proc. 2024; 3196:040001. https://doi.org/10.1063/5.0227927
41. Maniyar K, Harsur S, Shinde SN, Shaaikh JA, Chandan MN, Rupanar S. An experimental investigation of machining parameters on aluminum composites. J Poly Comp. 2024; 12(06):8-13.
42. Maniyar K, Harsur S. Experimental findings of the EDM process parameters for metal matrix composites. J Poly Comp. 2024; 12(06):14-18.
43. Saravade N, Sedani C, Maniyar K, Nandkishore D, Deshmukh S, Rupanar S, *et al.* (2024). Study on heavy machinery utilizing the most recent technologies for excavation of road construction and mining. J Mine Metal Fuel. 2024; 72(7):667-673. https://doi.org/10.18311/jmmf/2024/45327
44. Patil GH, Mishra E, Maniyar K, Rawoot M, Satarkar MFAR. Study on prediction of lightning impulses on transmission line tower due to harsh field and variable working condition, environmental condition and tower footing resistances. J Mine Metal Fuel. 2024; 763-769. https://doi.org/10.18311/jmmf/2024/45322
45. Jathar A, Maniyar K, Nawghare B, Ansari S, Patil PG, Mali C, *et al.* An extensive study of nanomaterial and nanotechnology in the various fields of engineering. J Mine Metal Fuel. 2024; 1067-1074. https://doi.org/10.18311/jmmf/2024/45658
46. Nawghare B, Maniyar K, Jathar A, Mali C, Pawar D, Jadhav SP, *et al.* An extensive study of nano fluids and their applications in real life. J Mine Metal Fuel. 2024; 1119-1124. https://doi.org/10.18311/jmmf/2024/45407
47. Raut P, Maniyar K, Kakade S, Rupanar S, Bhalake S, Mali C, *et al.* A comprehensive analysis of the synthesis, properties and uses of nanofluid. J Mine Metal Fuel. 2024; 965-971. https://doi.org/10.18311/jmmf/2024/45524
48. Warghat S, Sedani C, Rasane A, Maniyar K, Dhanwate V, Jadhav SP, *et al.* An extensive study of metal matrix composites and their various properties for different uses. J Mine Metal Fuel. 2024; 949-955. https://doi.org/10.18311/jmmf/2024/45554
49. Mali C, Maniyar K, Rupanar S, Jathar A, Nawghare B, Kakade N, *et al.* An analysis of nanoparticles in composite materials. J Mine Metal Fuel. 2024; 1215-1223. https://doi.org/10.18311/jmmf/2024/45579
50. Patil G, Mishra E, Maniyar K, Warke P. Four quadrant operation of induction motor using h-bridge in harsh and noxious environment field with dust, voltage fluctuation and major load variations. J Mine Metal Fuel. 2024; 1225-1231. https://doi.org/10.18311/jmmf/2024/45557
51. Mhaske M, Gidhad B, Maniyar K, Ghuge G. The role of linear algebra in developing machine learning solutions. 2024 3rd International Conference for Advancement in Technology (ICONAT), GOA, India; 2024. p. 1-5, https://doi.org/10.1109/ICONAT61936.2024.10775140 PMid:38258445
52. Ansari S, Vaidya K, Kadu A, Rokade A, Maniyar K. A comprehensive study on modern electronic technologies in the field based engineering industry. J Mine Metal Fuel. 2025;455-465. https://doi.org/10.18311/jmmf/2025/47122
53. Bhavna, Ghodke S, Maniyar K. Using geogebra and sagemath to assist engineering students in tracing different curves and solving numerical methods. Commun Appl Nonlinear Anal. 2025; 32(6s). https://doi.org/10.52783/cana.v32.3310
54. Kakade N, Gaikwad D, Sayyad S, Sedani C, Sayyad F, Rupanar S, *et al.* Thermal analytical characterization of gymnema sylvestre using TGA-DTA technique. Comm Appl Nonlinear Analy. 2025; 32(7s). https://doi.org/10.52783/cana.v32.3492
55. Maniyar K, Rupanar S, Sayyad F, Sedani C, Gawande J, Pawar P. An analysis of machining parameters for metal matrix composite. J Poly Comp. 2025; 13(02):76-85.
56. Mishra E, Jog P, Bugade VS, Patil GH, Jarad RS, Kulkarni B, *et al.* Case study on role of solar energy in greenhouse gas emissions reduction in India. J Inform Sys Eng Manag. 2025; 10(19s):462-471. https://doi.org/10.52783/jisem.v10i19s.3058
57. Patil S, Kute U, Jakhete M, Ansari S, Maniyar K, Chimkode S, *et al.* The role of internet of things, cloud computing, artificial intelligence and robotics in the fourth industrial revolution. J Mine Metal Fuel. 2025; 1089-1095 https://doi.org/10.18311/jmmf/2025/47334
58. Mishra E, Patil GH, Chavan SD, Jarad RS, M.F.A.R. Satarkar, Mohan Thakare, et al. Analysis of impact of STATCOM on distance relay using MATLAB. J Mine Metal Fuel. 2025; 743-750. https://doi.org/10.18311/jmmf/2025/48052
59. Choudhari PM, Chopde PV, Kharche NA, Shekokar SR, Kharche YA, Warke P, *et al.* Determinant factors for

the development of rural entrepreneurship. J Inform Systems Eng Manag. 2025; 10(25s):111-118. https://doi.org/10.52783/jisem.v10i25s.3951

60. Patil G, Upasani S, Vaidya H, Desai K, Satarkar MFAR, Mishra E, *et al*. DTMF phone call control home appliance using Arduino and GSM module and home automation. J Inform Systems Eng. 2025; 10(25s):249-257. https://doi.org/10.52783/jisem.v10i25s.3976
61. Kadam J, Phadtare G, Pawar A, Maniyar K. Offline signature verification using siamese neural network. J Inform Sys Eng. 2025; 10(26s):431-439. https://doi.org/10.52783/jisem.v10i26s.4245