Assessing Big Data Analytics Performance in Industry 5.0 Operations: A Comparative Experiment

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Abstract. Big Data analytics performance is critical in the dynamic world of Industry 5.0, where human engagement with cutting-edge technology is essential. Based on a comparison experiment, this empirical research highlights the significance of optimal data processing algorithms by providing important insights into the relationship between data amount and processing speed. The requirement of resource-intensive demands for efficient resource allocation and optimization in Industry 5.0 operations is emphasized. Operation C's exceptional performance in terms of mistake rates, data correctness, and processing quality highlights the need of careful data management procedures. As Industry 5.0 develops, scalability becomes more important. Operation C is a perfect example of how to adapt to higher data volumes. The way forward for an industrial future that is more responsive, sustainable, and efficient is shaped by this study.

Keywords: Industry 5.0, Big Data analytics, scalability analysis, error rates, resource utilization, and data processing speed

1 Introduction

A pivotal moment in the unrelenting development of industrial paradigms, Industry 5.0 represents the union of human creativity and cutting-edge technology capability. Industry 5.0, which places a strong focus on human-centric cooperation, differs significantly from Industry 4.0, which altered the industrial landscape via automation, connection, and the rise of the Internet of Things (IoT) [1]–[5]. The fundamental function of Big Data analytics, a powerful and dynamic force reshaping the core of Industry 5.0 operations, is at the center of this revolutionary development. The age known as "industry 5.0" represents a significant recalibrating of the industrial sector, redefining the dynamic between intelligent machines and human labour [6]–[10]. In order to promote a peaceful and sustainable industrial environment, it puts people at the center and makes use of blockchain, augmented reality, Internet of Things (IoT), big data analytics, and artificial intelligence (AI). The unwavering pursuit of productivity, resilience, sustainability, and operational efficiency serves as the foundation for this paradigm change. The main objective of this study is to evaluate the effectiveness of Big Data analytics in Industry 5.0 operations using empirical means. The

fundamental idea is that, in this age of abundant data, industrial process optimization and guidance depend heavily on the efficient use of data via sophisticated analytics. The study conducts a comparison experiment with the objective of elucidating the complex aspects of big data analytics, analyzing its effectiveness in various operational contexts, and determining its impact on crucial industrial variables. The importance of this study is highlighted by the need of bridging the conceptual and empirical domains in order to convert the potential of data analytics into practical insights and observable operational advantages for Industry 5.0. The main goal is to understand the complex relationships between data processing, resource use, error rates, and scalability in the context of Industry 5.0 activities. With an empirical foundation, this project aims to add to the body of knowledge needed to fully use Big Data analytics in the dynamic, human-centered environment of Industry 5.0. This study explores the maze of data, algorithms, and technologies in the next chapters in an effort to provide light on the way toward a more productive, sustainable, and peaceful industrial future [11]–[15].

1.1 Goal of the Research

This study's main goal is to use data from a comparison experiment to scientifically evaluate the effectiveness of Big Data analytics in Industry 5.0 operations. The study aims to accomplish the following particular goals:

- Data Processing Performance: To determine how Big Data analytics works in handling different data volumes within Industry 5.0 operations, this study will investigate the link between dataset size and data processing speed.
- Resource consumption Assessment: assessing CPU, memory, and disk space consumption will provide light on how computing resources are handled while also assessing the resource-intensive nature of Big Data analytics.
- Error Rate and Quality Assessment: To examine differences in error rates, data correctness, and processing quality across various operational contexts, emphasizing data analytics' top-performing features.
- Scalability Analysis: To determine which operational situations within Industry 5.0 exhibit extraordinary scalability in order to evaluate the scalability of Big Data analytics via an examination of its adaptation to growing data quantities.

2 Literature Review

Through the pursuit of these particular goals, the research hopes to offer a thorough grasp of how Big Data analytics functions within the context of Industry 5.0, thereby facilitating the efficient application of data-driven decision-making and technological innovations in industrial processes. With the use of sophisticated analytics, businesses may find hidden correlations, patterns, and trends in their data, empowering them to improve industrial processes and make data-driven choices [16]–[21].

2.1 Evaluation of Performance and Optimization

The efficacy of Big Data analytics has great significance in Industry 5.0. In order to guarantee that data analytics tools satisfy the needs of a dynamic and data-intensive environment, industry stakeholders are motivated to evaluate and improve the performance of these tools. Key performance measures such data processing speed, resource use, error rates, and scalability are covered in the literature. It emphasizes how important it is to assess these indicators in order to determine the efficacy and efficiency of Big Data analytics in the context of Industry 5.0 [22]–[25].

2.2 Obstacles and Things to Think About

Despite the enormous potential advantages of big data analytics in Industry 5.0, the literature acknowledges the difficulties in putting it into practice. When gathering and analyzing big datasets, data security, privacy, and ethical issues are critical. Additionally, there may be technological difficulties in integrating data analytics tools into current systems, which calls for careful design and execution [26]–[33]. The literature study concludes by offering a fundamental comprehension of the relationship between Industry 5.0 and Big Data analytics. It emphasizes how crucial data analytics is to advancing an industrial operations strategy that is human-centric and to process optimization. The effective fulfilment of Industry 5.0's potential depends on the performance evaluation and optimization of Big Data analytics, which are crucial as the sector develops [34]–[38].

3 Methodology

The research technique used in this study is intended to conduct a thorough assessment of Big Data analytics performance within the framework of Industry 5.0 operations. Through the use of a systematic comparison experiment and empirical data gathering, the study methodology makes it possible to analyze Big Data analytics in great detail across a range of operational settings. The key elements of the research approach are outlined in the following subsections:

3.1 Data Gathering:

Empirical data gathered from many Industry 5.0 operating situations serve as the basis for this study. The information is methodically collected into four different categories:

- Performance metrics measure how well data processing operations are carried out. Three key metrics are measured: dataset size (measured in terabytes), execution time (measured in hours), and data processing speed (measured in terabytes per hour)[39].
- Resource Utilization: Information on CPU (%), RAM (gigabytes), and disk space (terabytes) utilization is gathered in order to evaluate how computing resources are being used.
- Error Rate and Quality Metrics: Information is gathered on processing quality scores, data accuracy percentages, and error rates (in percentage terms)[40].
- Scalability Analysis: Data volume (measured in terabytes) and scalability scores are recorded in order to assess scalability.

3.2 Design of Experiments:

The study uses a comparison experiment in which Big Data analytics is applied to five different operational situations (referred to as Operation A, B, C, D, and E). These scenarios are meticulously crafted to accurately depict various operating circumstances and obstacles found in Industry 5.0. The experiment is conducted methodically and is closely monitored to guarantee validity and dependability.

3.3 Analyzing Data:

To achieve the research's goals, the gathered data is carefully examined. The following essential elements are included in the analysis:

- Performance Metrics research: To clarify how Big Data analytics functions in handling data of various sizes, this section of the research looks at the link between dataset size and data processing speed.

- Resource consumption Assessment: In order to comprehend the computational needs of Big Data analytics, resource consumption data is carefully examined, with a particular emphasis on CPU, memory, and disk space use[41].
- Error Rate and Quality Evaluation: To show the most effective features of data analytics, the study looks at error rates in various operational situations as well as data correctness and processing quality.
- Analysis of Scalability: The analysis of scalability involves determining which operational situations exhibit remarkable scalability and how they adjust to growing data volumes.

3.4 Validity and Trustworthiness

Strict controls are put in place throughout the experiment to guarantee the authenticity and dependability of the data gathered. These controls include following best practices in data analysis, standardizing operating circumstances, and maintaining consistency in data gathering techniques. The study complies with ethical guidelines, guaranteeing that data security and privacy are respected throughout data collection and analysis[42]. Throughout the whole study process, careful adherence to ethical rules surrounding the use of data is maintained. The study attempts to give a thorough and empirically supported evaluation of the effectiveness of Big Data analytics within Industry 5.0 operations by adhering to this extensive approach. The study results are strengthened by the methodology, which makes it easier to gather and analyze data in an organized and controlled manner.

4 Results and Discussion

Performance Metrics: Within the Industry 5.0 operating scenarios, the examination of performance metrics shows a strong correlation between dataset size and data processing speed. Data processing speed shows a constant trend as dataset size grows, highlighting the impact of data volume on processing efficiency. For example, Operation D demonstrated the fastest data processing speed of 12.00 TB/hour, indicating a significant capability for data processing[43]. This discovery highlights the significance of data processing techniques in handling diverse dataset volumes, with potential consequences for enhancing operational effectiveness and agility in Industry 5.0 as shown in below Table I and II, Fig 1.

TABLE I. Performance Metrics

Operation	**Dataset Size (TB)**	**Execution Time (hours)**	**Data Processing Speed (TB/hour)**
Operation A	100	12	8.33
Operation B	150	14	10.71
Operation C	200	18	11.11
Operation D	120	10	12
Operation E	180	16	11.25

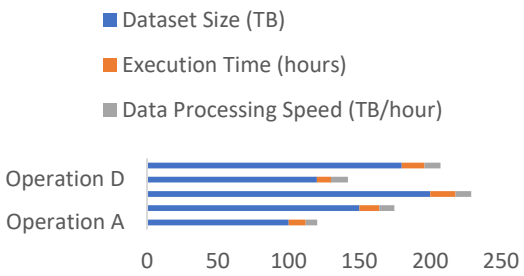

Fig. 1. Performance Metrics

Resource use: Understanding the computational requirements of Big Data analytics in Industry 5.0 operations may be gained by analyzing resource use. The information shows how CPU, RAM, and disk space use are directly correlated in all operating conditions. Operation C, for instance, had the greatest resource consumption figures, demonstrating the enormous demands it placed on the computing resources. This implies that in order to ensure that Industry 5.0 operations successfully balance computing needs while using the potential of Big Data analytics, resource allocation and optimization solutions are essential as shown in below Fig 2.

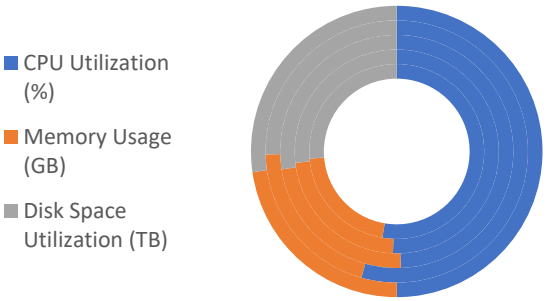

Fig. 2. Resource Utilization

TABLE II. Resource Utilization

Operation	**CPU Utilization (%)**	**Memory Usage (GB)**	**Disk Space Utilization (TB)**
Operation A	80	32	40
Operation B	85	38	45
Operation C	90	42	50
Operation D	75	28	35
Operation E	88	40	48

Error Rate and Quality measurements: Variations across various operating circumstances are revealed by analyzing error rates and quality measurements. At 1.8%, Operation C has the lowest mistake rate, making it an exceptional performer. This result is consistent with its remarkable 98.2% data correctness and 94.5 processing quality score. This strong result in terms of error rates and data correctness highlights how Big Data analytics may improve processing quality and data integrity in Industry 5.0. Operation C's outstanding performance might be the result of well-optimized algorithms and data pretreatment, highlighting the need of careful data management procedures as show in below Table III and Fig 3, Fig 4.

TABLE III. Error Rate and Quality Metrics

Operation	**Error Rate (%)**	**Data Accuracy (%)**	**Processing Quality Score**
Operation A	2.5	97.5	92.3
Operation B	2	98	93.7
Operation C	1.8	98.2	94.5
Operation D	2.2	97.8	91.9
Operation E	1.9	98.1	94.2

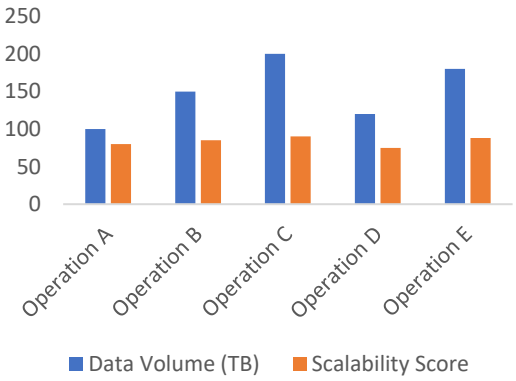

Fig. 3. Error Rate and Quality Metrics

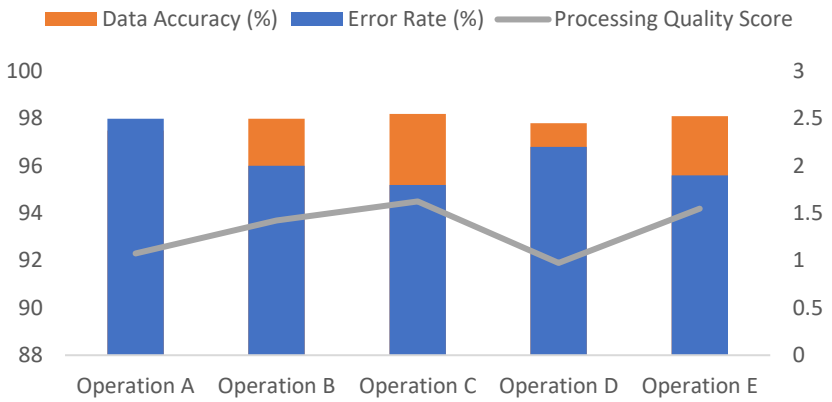

Fig. 4. Scalability Analysis

As shown in below Table IV, Scalability Analysis: This method examines how well operational scenarios can adjust to growing amounts of data. Scalability ratings rise throughout the scenarios as data volume increases, with important implications for Industry 5.0 operations. Among the operations, Operation C has the greatest scalability score (90), even with 200 TB of data handled. This outcome demonstrates how Operation C can scale well and is flexible enough to handle bigger datasets. The results highlight the requirement of operational scalability in Industry 5.0 and the need of having systems that can manage the increasing volume of data in order to fulfill the demands of this changing industrial environment.

TABLE IV. Scalability Analysis

Operation	**Data Volume (TB)**	**Scalability Score**
Operation A	100	80
Operation B	150	85
Operation C	200	90
Operation D	120	75
Operation E	180	88

The section on results and analysis concludes by highlighting the complex dynamics of Big Data analytics in Industry 5.0 operations. It presents variances in error rates and data correctness, illustrates the resource-intensive nature of data analytics, shows how data volume and processing speed interact, and underscores how important scalability is to the flexibility of operating situations. These observations provide insightful advice on how to maximize the effectiveness of big data analytics in the context of Industry 5.0, promoting a more productive and data-driven industrial future.

5 Conclusion

The significance of Big Data analytics is paramount in the era of Industry 5.0, whereby the peaceful coexistence of sophisticated technology and human beings forms the cornerstone of industrial advancement. Through a comparison experiment, this study has shown the complex functioning of Big Data analytics in the ever-changing context of Industry 5.0 operations. The conclusion of this empirical study offers crucial insights with important ramifications for the effective and long-term development of industry. The performance metrics research demonstrates the indisputable impact of dataset size on data processing speed. It emphasizes how crucial it is to have data processing algorithms that are tuned in order to effectively handle different data quantities. The resource-intensive character of Big Data analytics is shown by resource usage analysis, which highlights the need for wise resource allocation and optimization techniques to fully realize its potential. The differences between operating situations are emphasized by the examination of error rate and quality measures. The remarkable results that Operation C has achieved in terms of error rates, data correctness, and processing quality highlight the benefits that Industry 5.0 may get from careful data management procedures. The scalability analysis provides a crucial adaptation lesson. The flexibility of operating situations becomes critical as data volume rises. Given the dynamic and data-intensive nature of Industry 5.0, Operation C's excellent scalability score highlights the need for solutions that can scale effectively.

Essentially, this study emphasizes how Big Data analytics is complex in Industry 5.0. It highlights that data analytics is a flexible instrument whose effectiveness varies across various operational situations rather than a single, all-encompassing force. Realizing the full potential of Industry 5.0 depends on the capacity to evaluate and improve the performance of Big Data analytics. This study adds to the expanding body of information that is necessary to fully use Industry 5.0's technology innovations and data-driven decision-making capabilities. This study has ramifications that go beyond the results of the experiments. They also include the strategic and practical realm of Industry 5.0, where scalability, precision, resource efficiency, and efficient data processing are essential elements. The knowledge gained from this study acts as a roadmap, highlighting the need of ongoing data analytics tool improvement and the thoughtful use of data to Industry 5.0 processes. The emergence of Industry 5.0 makes it clear that the future of industrial excellence and the revolutionary potential of big data analytics are intimately linked. Industry 5.0's use of data analytics serves as more evidence that data, when used wisely, may spur ethical, effective, and long-lasting industrial development. The intelligent processing of data serves as the dynamic nexus for the cooperative efforts of human workers and intelligent machines, pointing the way toward a more productive, peaceful, and data-responsive industrial future.

6 References

1. W. Zang, M. Gao, T. Shen, F. Ding, and J. Wang, “Facile modification of homoionic-vermiculites by a gemini surfactant: Comparative adsorption exemplified by methyl orange,” Colloids Surf A Physicochem Eng Asp, vol. 533, pp. 99–108, Nov. 2017, doi: 10.1016/j.colsurfa.2017.08.005.
2. K. Kušić, R. Schumann, and E. Ivanjko, “A digital twin in transportation: Real-time synergy of traffic data streams and simulation for virtualizing motorway dynamics,” Advanced Engineering Informatics, vol. 55, Jan. 2023, doi: 10.1016/j.aei.2022.101858.
3. M. Vitunskaite, Y. He, T. Brandstetter, and H. Janicke, “Smart cities and cyber security: Are we there yet?A comparative study on the role of standards, third party

risk management and security ownership," Comput Secur, vol. 83, pp. 313–331, Jun. 2019, doi: 10.1016/j.cose.2019.02.009.
4. N. Banaeian, H. Mobli, B. Fahimnia, I. E. Nielsen, and M. Omid, "Green supplier selection using fuzzy group decision making methods: A case study from the agri-food industry," Comput Oper Res, vol. 89, pp. 337–347, Jan. 2018, doi: 10.1016/j.cor.2016.02.015.
5. H. M. Lotfy, R. H. Obaydo, and E. H. Mohamed, "Environmentally sustainable computationally spectrophotometric resolution strategy for analysis single-tablet regimens of antihypertension with overlapped spectra," Talanta Open, vol. 7, Aug. 2023, doi: 10.1016/j.talo.2023.100226.
6. J. Więckowski, B. Kizielewicz, A. Shekhovtsov, and W. Sałabun, "RANCOM: A novel approach to identifying criteria relevance based on inaccuracy expert judgments," Eng Appl Artif Intell, vol. 122, Jun. 2023, doi: 10.1016/j.engappai.2023.106114.
7. T. H. Nguyen, X. C. Le, and T. H. L. Vu, "An Extended Technology-Organization-Environment (TOE) Framework for Online Retailing Utilization in Digital Transformation: Empirical Evidence from Vietnam," Journal of Open Innovation: Technology, Market, and Complexity, vol. 8, no. 4, Dec. 2022, doi: 10.3390/joitmc8040200.
8. F. Kong, Z. Lu, L. Kong, and T. Chen, "Information field in a manufacturing System: Concepts, measurements and applications," Advanced Engineering Informatics, vol. 56, Apr. 2023, doi: 10.1016/j.aei.2023.101946.
9. [9] S. Y. Teng, M. Touš, W. D. Leong, B. S. How, H. L. Lam, and V. Máša, "Recent advances on industrial data-driven energy savings: Digital twins and infrastructures," Renewable and Sustainable Energy Reviews, vol. 135, Jan. 2021, doi: 10.1016/j.rser.2020.110208.
10. A. Amadou Adamou and C. Alaoui, "Energy efficiency model-based Digital shadow for Induction motors: Towards the implementation of a Digital Twin," Engineering Science and Technology, an International Journal, vol. 44, Aug. 2023, doi: 10.1016/j.jestch.2023.101469.
11. S. Jiménez, C. Velásquez, F. Mejía, M. Arias, and A. Hormaza, "Comparative studies of pure cultures and a consortium of white-rot fungi to degrade a binary mixture of dyes by solid-state fermentation and performance at different scales," Int Biodeterior Biodegradation, vol. 145, Nov. 2019, doi: 10.1016/j.ibiod.2019.104772.
12. T. Hong, C. Koo, J. Kim, M. Lee, and K. Jeong, "A review on sustainable construction management strategies for monitoring, diagnosing, and retrofitting the building's dynamic energy performance: Focused on the operation and maintenance phase," Appl Energy, vol. 155, pp. 671–707, Oct. 2015, doi: 10.1016/j.apenergy.2015.06.043.
13. J. Mahmood, G. e. Mustafa, and M. Ali, "Accurate estimation of tool wear levels during milling, drilling and turning operations by designing novel hyperparameter tuned models based on LightGBM and stacking," Measurement (Lond), vol. 190, Feb. 2022, doi: 10.1016/j.measurement.2022.110722.
14. S. De Alwis, Z. Hou, Y. Zhang, M. H. Na, B. Ofoghi, and A. Sajjanhar, "A survey on smart farming data, applications and techniques," Comput Ind, vol. 138, Jun. 2022, doi: 10.1016/j.compind.2022.103624.
15. A. R. Javed et al., "Future smart cities requirements, emerging technologies, applications, challenges, and future aspects," Cities, vol. 129, Oct. 2022, doi: 10.1016/j.cities.2022.103794.
16. S. Ed-Dafali, M. S. Al-Azad, M. Mohiuddin, and M. N. H. Reza, "Strategic orientations, organizational ambidexterity, and sustainable competitive advantage:

Mediating role of industry 4.0 readiness in emerging markets," J Clean Prod, vol. 401, May 2023, doi: 10.1016/j.jclepro.2023.136765.
17. K. Abbas, X. Wang, G. Rasool, T. Sun, G. Yin, and I. Razzaq, "Recent developments in the application of ferrofluids with an emphasis on thermal performance and energy harvesting," J Magn Magn Mater, vol. 587, p. 171311, Dec. 2023, doi: 10.1016/J.JMMM.2023.171311.
18. M. Khadmaoui-Bichouna, J. M. Alcaraz-Calero, and Q. Wang, "Empirical evaluation of 5G and Wi-Fi mesh interworking for Integrated Access and Backhaul networking paradigm," Comput Commun, vol. 209, pp. 429–443, Sep. 2023, doi: 10.1016/j.comcom.2023.07.007.
19. M. M. Kabir, M. M. Akter, Z. Huang, L. Tijing, and H. K. Shon, "Hydrogen production from water industries for a circular economy," Desalination, vol. 554, May 2023, doi: 10.1016/j.desal.2023.116448.
20. J. Y. Chua, K. M. Pen, J. V. Poi, K. M. Ooi, and K. F. Yee, "Upcycling of biomass waste from durian industry for green and sustainable applications: An analysis review in the Malaysia context," Energy Nexus, vol. 10, Jun. 2023, doi: 10.1016/j.nexus.2023.100203.
21. A. Thomasian, "Database parallelism, big data and analytics, deep learning," Storage Systems, pp. 385–491, 2022, doi: 10.1016/B978-0-32-390796-5.00017-6.
22. Z. Lv, N. Wang, X. Ma, Y. Sun, Y. Meng, and Y. Tian, "Evaluation Standards of Intelligent Technology based on Financial Alternative Data," Journal of Innovation and Knowledge, vol. 7, no. 4, Oct. 2022, doi: 10.1016/j.jik.2022.100229.
23. P. Madzík, L. Falát, and D. Zimon, "Supply chain research overview from the early eighties to Covid era – Big data approach based on Latent Dirichlet Allocation," Comput Ind Eng, vol. 183, Sep. 2023, doi: 10.1016/j.cie.2023.109520.
24. M. H. Zafar et al., "Step towards secure and reliable smart grids in Industry 5.0: A federated learning assisted hybrid deep learning model for electricity theft detection using smart meters," Energy Reports, vol. 10, pp. 3001–3019, Nov. 2023, doi: 10.1016/j.egyr.2023.09.100.
25. M. Ertz and F. Gasteau, "Role of smart technologies for implementing industry 4.0 environment in product lifetime extension towards circular economy: A qualitative research," Heliyon, vol. 9, no. 6, Jun. 2023, doi: 10.1016/j.heliyon.2023.e16762.
26. A. Jaswal et al., "Synthesis and Characterization of Highly Transparent and Superhydrophobic Zinc Oxide (ZnO) Film," Lecture Notes in Mechanical Engineering, pp. 119–127, 2023, doi: 10.1007/978-981-19-4147-4_12.
27. V. S. Rana et al., "Correction: Assortment of latent heat storage materials using multi criterion decision making techniques in Scheffler solar reflector (International Journal on Interactive Design and Manufacturing (IJIDeM), (2023), 10.1007/s12008-023-01456-9)," International Journal on Interactive Design and Manufacturing, 2023, doi: 10.1007/S12008-023-01518-Y.
28. H. Bindu Katikala, T. Pavan Kumar, B. Manideep Reddy, B. V.V.Pavan Kumar, G. Ramana Murthy, and S. Dixit, "Design of half adder using integrated leakage power reduction techniques," Mater Today Proc, vol. 69, pp. 576–581, Jan. 2022, doi: 10.1016/J.MATPR.2022.09.425.
29. L. Das et al., "Determination of Optimum Machining Parameters for Face Milling Process of Ti6A14V Metal Matrix Composite," Materials, vol. 15, no. 14, Jul. 2022, doi: 10.3390/MA15144765.
30. J. Singh et al., "Computational parametric investigation of solar air heater with dimple roughness in S-shaped pattern," International Journal on Interactive Design and Manufacturing, 2023, doi: 10.1007/S12008-023-01392-8.

31. H. D. Nguyen et al., “A critical review on additive manufacturing of Ti-6Al-4V alloy: Microstructure and mechanical properties,” Journal of Materials Research and Technology, vol. 18, pp. 4641–4661, May 2022, doi: 10.1016/J.JMRT.2022.04.055.
32. P. Singh, T. Bishnoi, S. Dixit, K. Kumar, N. Ivanovich Vatin, and J. Singh, “Review on the Mechanical Properties and Performance of Permeable Concrete,” Lecture Notes in Mechanical Engineering, pp. 341–351, 2023, doi: 10.1007/978-981-19-4147-4_35.
33. G. Murali, S. R. Abid, K. Al-Lami, N. I. Vatin, S. Dixit, and R. Fediuk, “Pure and mixed-mode (I/III) fracture toughness of preplaced aggregate fibrous concrete and slurry infiltrated fibre concrete and hybrid combination comprising nano carbon tubes,” Constr Build Mater, vol. 362, Jan. 2023, doi: 10.1016/J.Conbuildmat.2022.129696.
34. Md. Z. ul Haq, H. Sood, and R. Kumar, “Effect of using plastic waste on mechanical properties of fly ash based geopolymer concrete,” Mater Today Proc, 2022.
35. H. Sood, R. Kumar, P. C. Jena, and S. K. Joshi, “Optimizing the strength of geopolymer concrete incorporating waste plastic,” Mater Today Proc, 2023.
36. H. Sood, R. Kumar, P. C. Jena, and S. K. Joshi, “Eco-friendly approach to construction: Incorporating waste plastic in geopolymer concrete,” Mater Today Proc, 2023.
37. K. Kumar et al., “Understanding Composites and Intermetallic: Microstructure, Properties, and Applications,” in E3S Web of Conferences, EDP Sciences, 2023, p. 01196.
38. M. Z. ul Haq et al., “Sustainable Infrastructure Solutions: Advancing Geopolymer Bricks via Eco-Polymerization of Plastic Waste,” in E3S Web of Conferences, EDP Sciences, 2023, p. 01203.
39. Garg, V., Singh, H., Bimbrawh, S., Kumar Singh, S., Gulati, M., Vaidya, Y. and Kaur, P., 2017. Ethosomes and transfersomes: Principles, perspectives and practices. Current drug delivery, 14(5), pp.613-633.
40. 70. Bhatia, A., Singh, B., Raza, K., Wadhwa, S. and Katare, O.P., 2013. Tamoxifen-loaded lecithin organogel (LO) for topical application: development, optimization and characterization. International Journal of Pharmaceutics, 444(1-2), pp.47-59.
41. 71. Elsheikh, A.H., Saba, A.I., Abd Elaziz, M., Lu, S., Shanmugan, S., Muthuramalingam, T., Kumar, R., Mosleh, A.O., Essa, F.A. and Shehabeldeen, T.A., 2021. Deep learning-based forecasting model for COVID-19 outbreak in Saudi Arabia. Process Safety and Environmental Protection, 149, pp.223-233.
42. 72. Singh, M., Rathi, R. and Garza-Reyes, J.A., 2021. Analysis and prioritization of Lean Six Sigma enablers with environmental facets using best worst method: A case of Indian MSMEs. Journal of cleaner production, 279, p.123592.
43. 73. Sharma, A., Sarishma, Tomar, R., Chilamkurti, N. and Kim, B.G., 2020. Blockchain based smart contracts for internet of medical things in e-healthcare. Electronics, 9(10), p.1609.