



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 3, March 2024

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.423



9940 572 462



6381 907 438



ijirset@gmail.com



www.ijirset.com

A Study of Environmental Factors on the Discrete Performance of Workers in Manufacturing Plant

J.Prithith Kumar¹, S.Sanjiev Prasath¹, K.Paramasivan¹, M.AnanthaKumar¹, S.Periyasamy Prabhu¹

UG Scholar, Department of Mechanical Engineering, St.Mother Theresa Engineering College, Thoothukudi,
Tamil Nadu, India¹

ABSTRACT: Environmental factors such as lighting, temperature and relative humidity are important factors affecting the productivity of workers in the automotive industry. Therefore, the optimal parameters must be obtained to get the best productivity. Data collection were obtained by conducting the experiment in a simulated field is located in the UKM where the subject will perform the repetitive process of manually installing and productivity assessed for every 10 minutes. Environmental factors such as lighting, temperature and relative humidity are controlled and productivity levels will be recorded. From the data obtained, it will then be analyzed using the Taguchi method to obtain the optimum parameters. These results indicate that the optimum parameter for the temperature factor is 24 ° C, relative humidity factor of 40% and the brightness factor of 500 lux. Revenue contribution from this study will be used to help improve the country's automotive industry productivity.

KEYWORDS: humidity, illuminance, optimum, productivity

I. INTRODUCTION

The automotive industry is one industry that contributes significantly to the revenue of the national economy. Therefore, healthy competition and there should be competitive in the industry to compete in the global market. Time is a factor that is often an issue on the productivity of an industry. Various research methods have been discovered and applied to optimize the productivity of industry as well as high quality products. According to the study, several factors have been identified as the cause of the decline in labor productivity. Therefore, the parameters must be obtained for the workstation environment is not only aimed to increase productivity and even ensure the comfort, health and safety of workers involved [1-2]. Environment and a comfortable atmosphere is an important point because it can maintain focus and employee performance for a long time. If the focus of their impairment, this is what led to the decline in productivity, or worse, can result in accidents. Therefore, the values should be applied in ergonomic working environment for a comfortable environment and quality. The utility of ergonomics research is not limited to predicting and eliminating workplace injuries but can also be used to enhance productivity [3-9].

A study on impact of lighting level on productivity by [10-12] indicated that at higher illumination level (1200 lux as against 800 lux) shows increase in productivity. This study shows a change and improvement in lighting can have an effect on productivity. [13-20] also found that by increasing an illumination levels it is possible to increase a person's productivity. This result in line with finding by [21-25] who claimed that there was a general satisfaction with the environment at higher level of illuminance. Previous research done by [26-30] show that the human alertness increase directly proportional with the increase of illuminance. This research was done to define and quantify the dose (illuminance levels) of light needed to evoke alerting responses in humans and their temporal relationship to light-induced changes in endocrinological and electrophysiological sequelae of alertness.

Humans can attempt to maintain their internal (core) temperature within an optimum range at around 37°C and if the body is subjected to thermal stress the thermoregulatory system responds by changing its state in a way which is consistent with maintaining core temperature within this range. [31-42] had conducted the study of thermal comfort temperature range for factory workers in warm humid tropical climates. The results from this study showed that the ability to operate factory buildings as free running will be very useful in the context of saving energy needed from providing adequate thermal comfort for workers in warm humid tropical climatic conditions.

Relative humidity is a term used to describe the water vapor pressure of the air at given temperature [43-54]. It is one of the environmental factors that could give an influence towards workers' performance. Previous research done by [55-64] showed that the low relative humidity resulted in more discomfort and more frequent symptoms in facial skin and the mucous membranes such as dryness of the mouth and throat, facial skin, more frequent symptoms of the eyes, lips and running nose. According to the [65-71] Japanese people might be more sensitive to humidity than westerners and so different methods from those used in the western countries should be required for human thermal environmental studies with respect to the hot humid summer in Japan. [72-74] conducted a study to evaluate the effect of humidity on human comfort and productivity after step changes from warm and humid environment. The results of the study revealed that workers' performance was found to be at the same level under all conditions but to more tired at 70% RH after humidity step change meanwhile more evaporation of sweat from human body at lower humidity. The objective of this study was to determine the dominance effects of environmental factors such as illuminance, humidity and WBGT on the workers performance at Malaysian manufacturing plant.

II. METHODOLOGY

The experimental layout is shown in Figure 1. This study was conducted in a room which is about 4.91 x 3.53 m which is modeled as a field of work similar to the work environment in selected industries. Therefore, the study can be conducted in a controlled environment. This room can accommodate one subject at a time and can also put some observation equipment for research. Three male workers have been selected as subjects of study. Before the study began, a calibration of measurement equipment must be done. The aim is to determine the accuracy of a data device. Coordination calibration is done by using computer equipment to ensure that the calibration is done according to set standards. Subjects will perform the installation in the stands and on every 10 minute period, the total production will be recorded. At this frequency is every 10 minutes, observation equipment will be monitored so that the room is a controlled environment as a set at the beginning of the study. The same set of parameters to be repeated by two other employees to obtain a more accurate reading. The experimental was carried out for 8 days in order to achieve the L_8 Taguchi design of experiment.

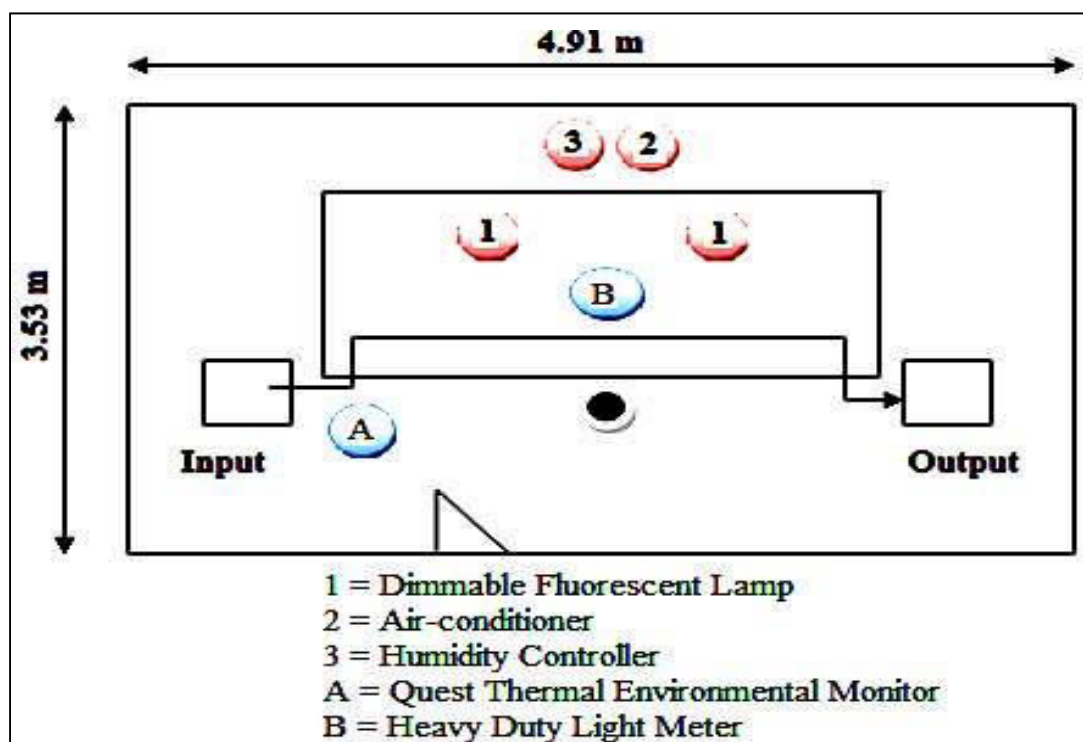


Figure 1: Experimental Layout

III. RESULTS AND DISCUSSION

From research and revenue data were collected, the results of the average productivity of three employees may be viewed as shown in Table 1. Minitab 15.0 software has been used for the purpose of the analysis the hypothesis. By using this software, it is able to get the value of optimization through Taguchi Method. Taguchi method is a good method to develop an experiment for the engineering process that involves a combination of several experimental parameters to obtain optimal results parameter. This method will then analyze the data using ANOVA analysis of the signal noise ratio (S/N ratio). Concept of signal noise ratio is a measurement of quality improvement. For the calculation of the data obtained, the signal noise ratio larger is better to be used. This is due to the productivity, the larger the better. This shows the growing production and the production of good quality. Table 2 below are the results of ratio S/N of productivity. Through mapping the data graph, it can show the difference between the average value of each level 1 and 2. The more significant difference means a greater influence on productivity. The difference ranges for each parameter level as shown in Figure 2. From Figure 2, the Y-axis for the graph represents as the value of S/N ratio while the X-axis represented the levels of these parameters. To such factors as temperature, level 1 indicates the value is greater than level 2. The value of level 1 is 0124, while level 2 is the -1765. The range of the two levels is of 1889. For the second factor is the relative humidity factor, the level 1 also shows a higher value than the level

2. Level 1 provides the ratio S / N of -0297 while level 2 is to provide a range of -1344 then the value of 1047. Further factor is the brightness factor, level 1 gives a value of - 1716 while level 2 is 0075. The range for the two levels is of 1791. Therefore, based on the range of S/N ratio is obtained, it can be concluded that the temperature factors are the most significant factors impact on productivity while the second biggest factor affecting productivity is followed by the brightness and relative humidity. This can be explained by taking into account the place of field studies in a private room where the three parameters to be studied will be controlled throughout the study was conducted. Thus, each parameter is fixed for a period of study. Thus, the factors involved are not influencing each other.

Table 1: Results of Average Worker Productivity Study

Experiment No.	Level of Parameters			Average Worker's Productivity, (unit)			Productivity (unit)
	WBGT	Relative	Illuminance	Worker	Worker	Worker	
	Temperature (°C)	Humidity (%)	(lux)	1	2	3	
1	24	40	200	0.899	0.852	0.854	0.870
2	24	40	500	1.244	1.126	1.326	1.232
3	24	70	200	0.877	0.862	0.927	0.886
4	24	70	500	1.006	1.182	1.157	1.115
5	32	40	200	0.852	0.868	0.842	0.853
6	32	40	500	0.894	1.086	0.883	0.954
7	32	70	200	0.711	0.701	0.672	0.690
8	32	70	500	0.792	0.762	0.815	0.790

Table 2: Results of ratio S/N of Productivity

Level of Parameters			Average		S/N
Experiment No.	WBGT Temperature, (°C)	Relative Humidity, (%)	Illuminance, (lx)	Productivity,(unit)	
1	24	40	200	0.870	-1.209
2	24	40	500	1.232	1.812
3	24	70	200	0.886	-1.051
4	24	70	500	1.115	0.945
5	32	40	200	0.853	-1.381
6	32	40	500	0.954	-0.409
7	32	70	200	0.690	-3.223
8	32	70	500	0.790	-2.047

The optimum temperature was at 24 ° C. Optimum value for the relative humidity is 40% while the most optimum brightness value to employees is 500 lux. In this case, the maximum productivity is more than the value of 1.0. This parameter is valid as well as standards set by ISO 7730 which states that the temperature at 24 ° C - 27 ° C is the best temperature for the convenience of employees. Referring to Tsutsumi et al (2007), he says that the best relative humidity range is between 40% to 50%.

Therefore, the results of the Taguchi method of analysis also shows the relative humidity range for this study is similar to the results of research done by him. For the results of brightness, the brightness of 500 lux is meeting the standards set by the European Standard (EN 12464-1:2002), which states that the brightness 500lux is best used for installation works in the automotive industry.

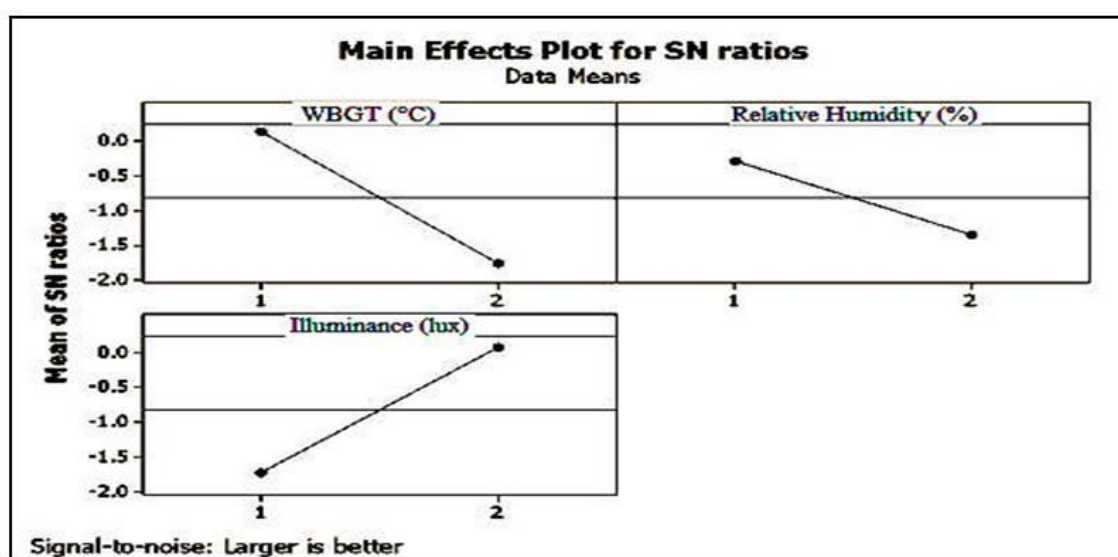


Figure 2: S/N Ratio Relationships between Environmental Factors on Productivity

IV. CONCLUSION

Overall, this study has met the objectives and scope of the target. From the data analysis was performed by Taguchi method, the relationship between environmental factors to productivity have been obtained. The optimum temperature was at 24 ° C. Optimum value for the relative humidity is 40% while the most optimum brightness value to employees is 500 lux. This study was done to prove empirically the previous perception studies, which based on the role of environmental factors to human performance. The results might vary for test carried out for different sample sizes, type of industries and countries. However, the research findings are restricted to the Malaysian workplace environment, where the awareness among workers on improving the productivity is still low.

V. ACKNOWLEDGEMENTS

The authors would like to thank the National University of Malaysia (UKM) and Ministry of Higher Education Malaysia for their support in providing a research grant for the project on: The Modeling Relationship of Thermal Comfort and Productivity in the Malaysian Energy Intensive Industries (UKM-GUP-TK-08-16-059).

REFERENCES

1. Juslén H., Wouters M. dan Tenner A. 2006. The Influence of Controllable Task- Lighting On Productivity: A Field Study In A Factory. *Applied Ergonomics*. 38: 39–44.
2. Juslén, H. T., Verbossen, Jos., Wouters, Marius C.H.M. 2007. Appreciation of localised
3. task lighting in shift work - A field study in the food industry. *International Journal of Industrial Ergonomics*. 37.(5):433-443.
4. Nicol, F., Wilson, M., Chiancarella, C. 2006. Using field measurements of desktop illuminance in European offices to investigate its dependence on outdoor conditions and its effect on occupant satisfaction, and the use of lights and blinds. *Energy and Buildings*. 38 (7): 802-813.
5. Gnanaraj, S. J. P., & Velmurugan, V. (2019). An experimental study on the efficacy of modifications in enhancing the performance of single basin double slope solar still. *Desalination*, 467, 12-28.
6. Gnanaraj, S. J. P., Ramachandran, S., & Christopher, D. S. (2017). Enhancing the design to optimize the performance of double basin solar still. *Desalination*, 411, 112-123.
7. Perumal, P., Gnanaraj, S. J. P., Pandian, G. S., Livingston, T., & Muthukumaran, N. (2023, November). Revolutionizing E-Cycle Charging with a Novel Regenerative Battery System. In *2023 International Conference on Sustainable Communication Networks and Application (ICSCNA)* (pp. 762-767). IEEE.
8. Fantin Irudaya Raj, E., Appadurai, M., Chithamabara Thanu, M., & Francy Irudaya Rani, E. (2023). IoT-Based Smart Parking System for Indian Smart Cities. *Machine Intelligence, Big Data Analytics, and IoT in Image Processing: Practical Applications*, 369-398.
9. Raj, E. F. I., Appadurai, M., Thiyaharajan, D., & Pushparaj, T. L. (2024). State-Of-The-Art Technologies for Crop Health Monitoring in the Modern Precision Agriculture. In *Precision Agriculture for Sustainability* (pp. 21-39). Apple Academic Press.
10. Gnanaraj, S. J. P., Ramasamy, S., Karthick, M., Klinton, A. G., & Appadurai, M. (2022). Enhancing the concentric tube properties by optimizing operational parameters. *Materials Today: Proceedings*, 49, 3726-3730.
11. Appadurai, M., Fantin Irudaya Raj, E., Darwin, S., & Jenish, I. (2020, December). Finite Element Analysis of Silicon Heat Sink with CNT Nanofluids for Microelectronics Applications. In *International Conference on Future technologies in Manufacturing, Automation, Design and Energy* (pp. 489-497). Singapore: Springer Nature Singapore.
12. Gnanaraj, S. J. P., & Velmurugan, V. (2022). Experimental investigation on the performance of modified single basin double slope solar stills. *International Journal of Ambient Energy*, 43(1), 206-215.
13. Ravindran, P., Mohamed, M. J. S., Gnanaraj, S. J. P., & Appadurai, M. (2022). Effect of graphite addition on dry sliding wear behavior of Self-lubricating Al-SiC-Gr hybrid composites by PM process. *Materials Today: Proceedings*, 60, 783-787.
14. Gnanaraj, S., Patrick, J., & Annaamalai, M. G. L. (2022). Enhancing solar still productivity by optimizing operational parameters. *DESALINATION AND WATER. TREATMENT*, 254, 1-14.
15. Gnanaraj, S. J. P., Ramachandran, S., & Logesh, K. (2021). Optimization of production in single basin solar still using Taguchi method-Experimental and theoretical approach. *Materials Today: Proceedings*, 47, 4468-4474.

16. Kumara, M. M., Rajesha, S., & Gnanaraj, S. J. P. (2023). Experimental investigation of double basin solar still integrated with solar flat plate collector and solar pond with modified design. *Desalination and water treatment*, 290, 26-35.
17. Maheswari, K. S., Mayandi, K., Gnanaraj, S. J. P., & Appadurai, M. (2022). Effect of transparent glass cover material on double slope solar still productivity. *Materials Today: Proceedings*, 62, 5415-5419.
18. Darwin, S., Raj, E. F. I., Appadurai, M., & Thanu, M. C. (2023). A Detailed Study on Single Electron Transistors in Nano Device Technologies. In *Energy Systems Design for Low-Power Computing* (pp. 67-99). IGI Global.
19. Kumar, M. M., Rajesh, S., Appadurai, M., & Gnanaraj, S. J. P. (2022). Performance enhancement of solar distillation system with internal modification. *Materials Today: Proceedings*, 62, 5452-5455.
20. Appadurai, M., Fantin Irudaya Raj, E., & Chithambara Thanu, M. (2023). Application of Nanofluids in Heat Exchanger and its Computational Fluid Dynamics. *Mathematics and Computer Science Volume 1*, 505-524.
21. Gnanaraj, S. J. P., Ramachandran, S., & Christopher, D. S. (2018). Enhancing the productivity of double-slope single-basin solar still with internal and external modifications. *International Journal of Ambient Energy*, 39(8), 777-782.
22. Subharaj, C., Leno, I. J., Vivek, S., Gnanaraj, S. J. P., & Appadurai, M. (2022). Sustainable manufacturing system applying on eco-design products. *Materials Today: Proceedings*, 68, 1528-1535.
23. Raja, M. A., Manikandan, V., Kumar, S. S., Amuthakkannan, P., Balasubramanian, I., Gnanaraj, S. J. P., & Jeshurun, S. B. (2022). Parametric investigation and optimization of AWJM process on stir cast al7075/basalt composite materials using Taguchi based grey relational analysis. *Materials Today: Proceedings*, 60, 815-821.
24. Gani, Z. F. A., Mohamed, J. S., Gnanaraj, J. P. S., Muthusaravanan, N., & Ariyanayagam, K. (2022). Experimental study on the stability and flame characteristics of LPG flames in O₂/N₂ and O₂/CO₂ environment. *Materials Today: Proceedings*, 49, 2019-2024.
25. Gnanaraj, S., Patrick, J., Ramachandran, S., & Logesh, K. (2016). A Review on Solar Water Distillation Using Thermal Energy Storage. *RESEARCH JOURNAL OF PHARMACEUTICAL BIOLOGICAL AND CHEMICAL SCIENCES*, 7(6), 2471-2477.
26. Nirmala, D. A. R., Kannan, V., Thanalakshmi, M., Gnanaraj, S. J. P., & Appadurai, M. (2022). Inventory management and control system using ABC and VED analysis. *Materials Today: Proceedings*, 60, 922-925.
27. Gnanaraj, S., Patrick, J., Ramachandran, S., & Logesh, K. (2017). A Review of Various Techniques used for the Improvement of Solar Still. *RESEARCH JOURNAL OF PHARMACEUTICAL BIOLOGICAL AND CHEMICAL SCIENCES*, 8(3), 1971-1979.
28. Subharaj, C., Logesh, K., Gnanaraj, S. J. P., Appadurai, M., & Vimalan, P. M. A. S. (2022). Design and development of Palmyra fruit pulp production equipment through sustainable approach. *Materials Today: Proceedings*, 68, 1762-1768.
29. Gnanaraj, S. J. P., Ramachandran, S., & Logesh, K. (2017). Enhancing the performance of solar still with solar pond. *Journal of Chemical and Pharmaceutical Science*, 10(1), 267-269.
30. Appadurai, M., Irudaya Raj, E. F., Thanu, M. C., & Pushparaj, T. L. (2023). Finite element analysis and computational fluid dynamic study of hybrid composite-based offshore wind turbines. *Materialwissenschaft und Werkstofftechnik*, 54(11), 1362-1377.
31. Augustine, M., Raj, E. F. I., Appadurai, M., & Balaji, M. (2023). Impact of silicon steel laminating materials in modified segmented rotor switched reluctance motor: electromagnetic and vibrational analysis. *Journal of Vibration Engineering & Technologies*, 1-16.
32. Balamurugan, A., Karthikeyan, K., Gnanaraj, S. J. P., & Muthukumaran, N. (2022, April). Stability Analysis of Voltage in IEEE 145 Bus System by CPF using Dragonfly Algorithm. In *2022 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS)* (pp. 778-783). IEEE.
33. Gnanaraj, S. J. P., Ramachandran, S., & Anbazhagan, R. (2017). Performance of double slope solar still with external modifications. *Desalination and water treatment*, 67, 16-27.
34. Gnanaraj, S. J. P., Kavitha, R., & Kumar, M. K. (2023, November). IoT-Powered Flood Warning and Alert System: Innovations in Flood Detection and Notification. In *2023 International Conference on Sustainable Communication Networks and Application (ICSCNA)* (pp. 487-490). IEEE.
35. Gnanaraj, S. J. P., & Velmurugan, V. (2020). An experimental investigation to optimize the production of single and stepped basin solar stills-a Taguchi approach. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 1-24.
36. Raj, F. I., Appadurai, Pushparaj, L., & Thanu, C. (2023). Mechanical characterization of randomly oriented short *Sansevieria Trifasciata* natural fibre composites. *International Polymer Processing*, 38(5), 564-581.

37. Ramaswamy, S., Shariff, Z. A., Munaf, A. A., Leno, I. J., Gnanaraj, S. J. P., & Jeshurun, S. B. (2022). Study on application of higher order lamination plate theory over various applications of natural fiber cross-ply composites. *Materials Today: Proceedings*, 60, 822-826.
38. Swikker, K., Sankaramoorthy, T., Girisha, L., Gopinath, P., Suresh, P., & Gnanaraj, S. (2022, April). Experimental investigation on the properties of glass fiber-reinforced polymer composites containing graphene. In *AIP Conference Proceedings* (Vol. 2405, No. 1). AIP Publishing.
39. Gnanaraj, S. J. P., & Ramachandran, S. (2017). Optimization on performance of single-slope solar still linked solar pond via Taguchi method. *Desalination and Water Treatment*, 80, 27-40.
40. Karthick, M., Gnanaraj, S. J. P., Appadurai, M., & Jeshurun, S. B. (2022). Productivity enhancement of a single slope solar still with energy storage medium. *Materials Today: Proceedings*, 60, 889-893.
41. Sivakumar, C. K., Robinson, Y., Prema, P., Gnanaraj, S. J. P., & Appadurai, M. (2022). Mechanical characteristics of aluminium alloy joints produced by friction stir welding. *Materials Today: Proceedings*, 62, 5620-5624.
42. Sulaiman, S. S., Jancy, P. L., Muthiah, A., Janakiraman, V., & Gnanaraj, S. J. P. (2021). An evolutionary optimal green layout design for a production facility by simulated annealing algorithm. *Materials Today: Proceedings*, 47, 4423-4430.
43. Gnanaraj, S. J. P., Arulraj, I., & Appadurai, M. (2022). Computational analysis of fine droplet in swirl injector for desalination. *Materials Today: Proceedings*, 62, 703-709.
44. Jeshurun, S. B., Thangam, J. A., Gnanaraj, S. J. P., & Klinton, A. G. (2022). An empirical study on career gratification among college bibliognosts. *Materials Today: Proceedings*, 60, 806-810.
45. Ramaswamy, S., Gnanaraj, S. J. P., Sekar, K. C., & Muthukumar, N. (2023, November). Analysis of Distribution Line in Link with Substation using GSM Technology. In *2023 International Conference on Sustainable Communication Networks and Application (ICSCNA)* (pp. 526-528). IEEE.
46. Sivakumar, C. K., Robinson, Y., & Gnanaraj, S. J. P. (2023). Enhancing the productivity of v-type and roof type single basin solar still with internal modification-a Taguchi method, 20-35.
47. Kumar, J. R., Mayandi, K., Gnanaraj, S. J. P., Chandrasekar, K., & Ramalingam, P. S. (2022). A critical review of an additive manufacturing role in Covid-19 epidemic. *Materials Today: Proceedings*, 68, 1521-1527.
48. Gnanaraj, S. J. P., Ramachandran, S., & Mageshwaran, G. (2016). Experimental analysis of single basin solar still with internal reflector and sensible heat storage medium. *International Journal of ChemTech Research*, 9(8), 328-337.
49. Manickam, I. N., Logesh, K., Gnanaraj, S. J. P., & Appadurai, M. (2022). Effect of compression on coir industry waste material. *Materials Today: Proceedings*, 62, 710-713.
50. Mangalraj, A. (2023). Smart Water Management System Powered by the Internet of Things (IoT) for Real-World Applications. In *Internet of Things* (pp. 129-142). Chapman and Hall/CRC.
51. Prabhakar, M. M., Gnanaraj, S. J. P., Allasi, H. L., Leno, I. J., Endro, S., & Kanna, S. R. (2021). Mechanical property analysis on bamboo-glass fiber reinforced montmorillonite nano composite. *Materials Today: Proceedings*, 45, 6936-6940.
52. Nirmala, D. A. R., Ramaswamy, S., Logesh, K., & Gnanaraj, S. J. P. (2022). Empirical study on risk mitigation for dairy supply chain management of Aavin Co-operative Milk Producers' Union Ltd. *Materials Today: Proceedings*, 49, 3657-3660.
53. Logesh, K., Gnanaraj, S. J. P., Jeshurun, S. B., & Klinton, G. (2022). Experimental analysis of solar still with thermal storage medium. *Materials Today: Proceedings*, 60, 791-794.
54. Thangam, J. A., Jeshurun, S. B., Thangapoo, A., Gnanaraj, S. J. P., & Appadurai, M. (2022). Industrial hazards and safety measures—An empirical study. *Materials Today: Proceedings*, 60, 834-838.
55. Nirmala, A. R., Bhalaji, R. K. A., Kumar, S. B., Gnanaraj, S. J. P., & Appadurai, M. (2022). Study on the effect of COVID- 19 pandemic on the savings and investment pattern of the manufacturing sector. *Materials Today: Proceedings*, 68, 1319-1323.
56. Thanu, C., Raj, F. I., Appadurai, & Pushparaj, L. (2023). Mechanical strength enhancement of natural fibre composites via localized hybridization with stitch reinforcement. *International Polymer Processing*, 38(5), 539-550.
57. Hansen, R. S., Mary, M. B. Q., Subramanian, S. S., Raj, J. A., Gnanaraj, S. J. P., & Appadurai, M. (2022). Utilization of PCM in inclined and single basin solar stills to improve the daily productivity. *Materials Today: Proceedings*, 62, 967-972.
58. Selvan, S. T., Mohandass, M., Ramalingam, P. S., Mayandi, K., Gnanaraj, S. J. P., & Appadurai, M. (2022). An exclusive hand protection device made of fused deposition modelling process using poly (lactic acid) polymer. *Materials Today: Proceedings*, 68, 1381-1386.

59. Infantraj, A., Augustine, M., Raj, E. F. I., & Appadurai, M. (2023). Investigation of Various Laminating Materials for Interior Permanent Magnet Brushless DC Motor for Cooling Fan Application. *CES Transactions on Electrical Machines and Systems*, 7(4), 422-429.
60. Subharaj, C., Logesh, M., Munaf, A. A., Srinivas, J., & Gnanaraj, S. J. P. (2022). Sustainable approach on cement mortar incorporating silica fume, LLDPE and sisal fiber. *Materials Today: Proceedings*, 68, 1342-1348.
61. Raj, E. F. I., Appadurai, M., Ram, V., Gnaniah, A. M., & Salkuti, S. R. (2023). Natural-Fibre-Reinforced Composite-Based Micro-Size Wind Turbines: Numerical Analysis and Feasibility Study. *Journal of Composites Science*, 7(5), 197.
62. Joe Patrick Gnanaraj, S., & Ramachandran, S. (2022). Identification of operational parameter levels that optimize the production in solar stills with plain, corrugated, and compartmental basin. *Environmental Science and Pollution Research*, 29(5), 7096-7116.
63. Chithambara Thanu, M., Appadurai, M., Fantin Irudaya Raj, E., & Lurthu Pushparaj, T. (2023). Experimental analysis of localized hybridization by means of adding woven polyester strip. *International Polymer Processing*, 38(4), 505-517.
64. Paulsyah, D. E., Gnanaraj, S. J. P., Myrtle, R. S., Grace, C. J. C., & Samuel, J. J. J. (2023, November). Green Methods of Larvae Control in Aquatic Environments: Using Solar Energy to Agitate Water. In *2023 International Conference on Sustainable Communication Networks and Application (ICSCNA)* (pp. 799-804). IEEE.
65. Karthick, M., Kumar, S. R., Athiappan, K., & Gnanaraj, S. (2022, April). Thermal analysis of counter flow concentric tube heat exchanger using Runge-Kutta method. In *AIP Conference Proceedings* (Vol. 2405, No. 1). AIP Publishing.
66. Gnanaraj, S. J. P., Balasubramanian, V., Munaf, A. A., Stalany, V. M., Chandrasekar, K., & Kumar, M. S. (2021). Investigation on drilling parameters of jute and cotton fiber strengthened epoxy composites. *Materials Today: Proceedings*, 45, 7107-7112.
67. Munaf, R. N. A., Karthikeyan, K., Gnanaraj, S. J. P., Sivakumar, T. A., & Muthukumaran, N. (2022, April). An ML Approach for Household Power Consumption. In *2022 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS)* (pp. 784-791). IEEE.
68. Devi, R. C., Girimurugan, R., Nanthakumar, S., Rajasekaran, P., Ahammad, S. H., & Gnanaraj, S. J. P. (2022). Experimental study of mechanical properties of Sisal/banana fiber hybrid sandwich composite. *Materials Today: Proceedings*, 68, 1793-1799.
69. Gnanaraj, S. J. P., & Ramachandran, S. (2016). Design and Fabrication of Modified Single Slope Solar Still with Solar Pond. *Int. J. Chem. Sci*, 14, 615-624.
70. Thangam, C., Ramaswamy, S., Karthikeyan, C., & Muthukumaran, N. (2022, April). Implementation of Barrel Shifter in Vedic Multiplier. In *2022 International Conference on Sustainable Computing and Data Communication Systems (ICSCDS)* (pp. 774-777). IEEE.
71. Samuel, J. J. J., Ramadoss, R., Gunasekaran, K. N., Logesh, K., Gnanaraj, S. J. P., & Munaf, A. A. (2021). Studies on mechanical properties and characterization of carbon fiber reinforced hybrid composite for aero space application. *Materials Today: Proceedings*, 47, 4438-4443.
72. Kolappan, S., Manickam, I. N., Swikker, K. R. J., Gnanaraj, S. J. P., & Appadurai, M. (2022). Performance analysis of aircraft composite winglet. *Materials Today: Proceedings*, 62, 889-895.
73. Raj, E. F. I., Manimala, K., & Appadurai, M. (2023). Differential Protection Scheme along with Backup Blockchain System. In *Smart and Power Grid Systems—Design Challenges and Paradigms* (pp. 135-156). River Publishers.
74. Pushparaj, T. L., Raj, E. F. I., Rani, E. F. I., & Appadurai, M. (2023). Synthesis of biogenic cerium oxide-supported osmium oxide nanoalloy from *Oldenlandia umbellata* L. plant extract for pharmacological applications. *Biomass Conversion and Biorefinery*, 1-15.



INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 9940 572 462  6381 907 438  ijirset@gmail.com



www.ijirset.com

Scan to save the contact details