International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 5, Issue 11, ISSN No. 2455-2143, Pages 229-237
Published Online March 2021 in IJEAST (http://www.ijeast.com)

DESIGN AND FABRICATION OF BLACKBOARD CLEANER

Vimal A
Asst. Prof., Department of Mechanical Engineering,
Sri Eshwar College of Engineering,
Kondampatti [post], Vadasithur(via), Coimbatore

Abinesh N, Abiram J, Abishack C, Akash Kumar V
Students, Department of Mechanical Engineering,
Sri Eshwar College of Engineering,
Kondampatti [post], Vadasithur(via), Coimbatore

ABSTRACT-One of the traditional ways of teaching learning process is carried out by using blackboards in classrooms. Blackboards and chalk are inseperable from classrooms. Thus the dusts from chalk can cause some health hazards when the human inhaled it over a long period of time. Hence an attempt has been made by introducing black board cleaner which is operated by six bar mechanism. Its working is similar to the wipers in automobiles. It reduces the potential work of the person who erase the board and reduces the time consumption in cleaning the blackboard. It also prevent the exposure of chalk dust to atmospheric air and helps to create a dust free classrooms.

KEYWORDS: Blackboard, duster, chalk dust, health hazards, six bar mechanism.

I. INTRODUCTION

Blackboards are one of essential tool for classrooms and teaching learning process. is carried out by using boards traditionally. The common way of cleaning the blackboard is by using dusters manually but that method of cleaning has some defects and causes some health hazards. Nowadays, There is an huge growth of technologies are developed to minimize the manual work in several fields. So in order to minimize the manual work in cleaning the blackboard by implementing some mechanism. The project blackboard cleaner is used to clean the blackboard and reduces the time consume in hand erasing and keeps the board clean. Here we implemented the modified application of six bar mechanism to clean the blackboard**.**

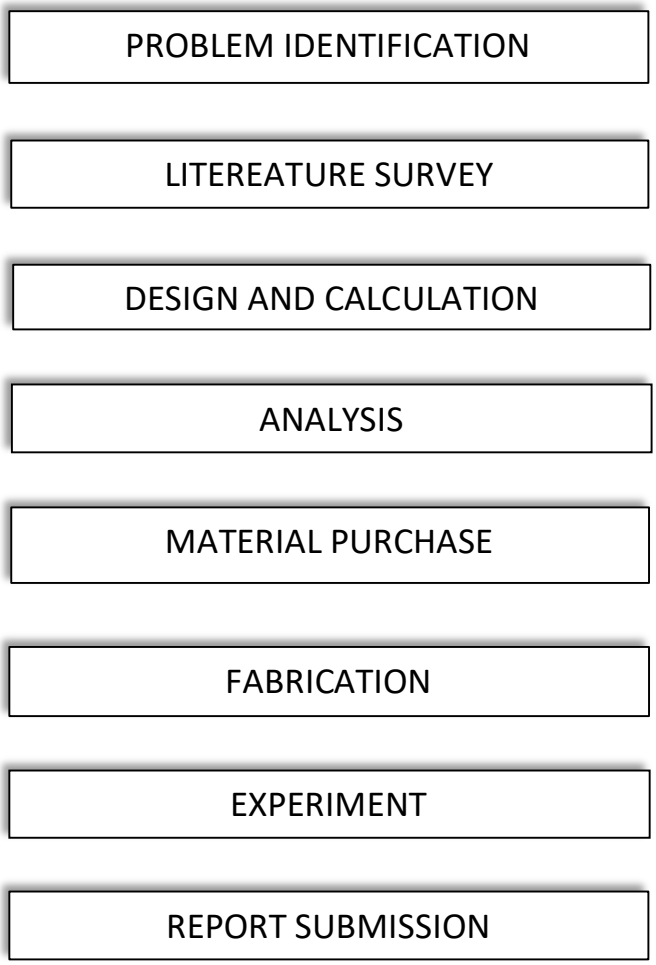
Black board cleaner is device which is used to clean the blackboard with minimum effort and free from dusts. The mechanism employed here is six bar mechanism. the rods and bars are used for linkages and felt material for cleaning the board. Upon using blackboard cleaner we can reduce the manual effort and prevent the health hazards by inhaling of chalkdusts.

II. PROBLEM IDENTIFICATION

The chalk dusts acquired from chalk pieces while erasing the blackboard causes some irritations to eyes. If human inhale it over a long period of time can causes some respiratory diseases like asthma and some airborne diseases and sometimes it causes skin allergies to the person to whom erasing the blackboard. It is not only harmful for the humans. but also causes some damage to the electronic components which are present inside the classrooms.

III. METHODOLOGY

The following methodology is adopted for the project.



IV. LITERATURE SURVEY

- **V. Kannadhasan, et al** describes the fabrication of automatic blackboard dust remover. Their main motive is to clean the blackboard using remote control and to overcome the respiratory diseases.

International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 5, Issue 11, ISSN No. 2455-2143, Pages 229-237
Published Online March 2021 in IJEAST (http://www.ijeast.com)

Automated chalk board cleaner is a device which will clean the blackboard frequently and thus reduce manual work. This device is operated using DC motor. The entire setup is controlled using remote and a sensor. The entire setup costs eight thousand rupees.

- **Dr.N.P.Mungle, et al** describes that they develop a mechanism to remove dust from the duster. Inhaling chalk dust for short period not have any effects but inhaling it for over a long period of time causes some severe health hazards and also affects the atmospheric air. Their project is to reduce manual efforts of human by made some changes in mechanical structures and employing vacuum pump along with dust collector which is removable.

- **Suzilawati binti Alias**, **et al** proposed that whiteboards are the most commonly used tool in mode of the educational institutions which will be cleaned using human effort. The aim of this smart whiteboard cleaner is to make ease the teacher's work. This whiteboard cleaner will use 12v DC motor through which the DPDT switch will be operated that will induce the cleaner to move all over the board. The result of this product is compared with manual board cleaning and found that smart whiteboard cleaner will clean the board three seconds earlier without manual effort. Finally they proved the efficient way of cleaning the whiteboard without involving human effort a is also a time saving product.

- **Dr.N.P.Mungle, et al** describes that they develop a mechanism to remove dust from the duster. Inhaling chalk dust for short period not have any effects but inhaling it for over a long period of time causes some severe health hazards and also affects the atmospheric air. Their project is to reduce manual efforts of human by made some changes in mechanical structures and employing vacuum pump along with dust collector which is removable.

- **Gaurav Gangurde**, **et al** developed a solution to avoid the difficulties faced by teachers while cleaning the blackboard. This developing word needs many innovations to be made to make our life very comfortable. So he combined his mechanical and electronic knowledge to innovate an automatic blackboard cleaner. Rack and pinion is employed to move the duster and erase the blackboard. A sensor is used to monitor the position of the duster. By using this machine we can reduce the manual work.

DESIGN OF BLACKBOARD CLEANER

Black board cleaner designed by using six bar mechanism.

SIX BAR MECHANISM

Six bar mechanism is a mechanism which consists of six links and seven joints with single degree of freedom. Here, two fixed joints and others are movable. With one crank which converts circular motion to reciprocating motion

V. COMPONENTS REQUIRED

1.Mild steel is a carbon steel which consists of 0.05-0.25% of carbon. It is ductile, easily weldable, easy handling, affordable, less weight. It is used in the form of rods, bars, disc, etc.

2. Bearing is a device which converts the relative motion to desired motion and also helps to reduce friction and provides smooth operation. Here ball bearing type is used.

3. Crank disc converts circular motion to reciprocating motion with the help of linkages.

4. Connecting rods connects the crank with other links and one link with the another adjacent link.

5. Riverts are used for the connection purposes. it acts as a joints.

6. Duster with felt material is used to clean the board.

VI. CALCULATION

Duster length = 0.5 m

Take radius (r) = 0.5 m

Assume board dimension to be

(0.7m x 0.5m).

Area of the board (A)

(A)=0.7*0.5

(A)=0.35m^2

Arc length (s)

(s)= π*r

(s)= π*0.5

(s)=1.57m

Angular displacement (ω)

(**ω**)= arc length (s) /distance(r).

(**ω**)=3.14/0.5

(**ω**)=6.28 rad.

Speed (N)

(N)=(60* ω)/2 π

International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 5, Issue 11, ISSN No. 2455-2143, Pages 229-237
Published Online March 2021 in IJEAST (http://www.ijeast.com)

(N)=60*6.28/2 π

(N)=591.87rad/sec

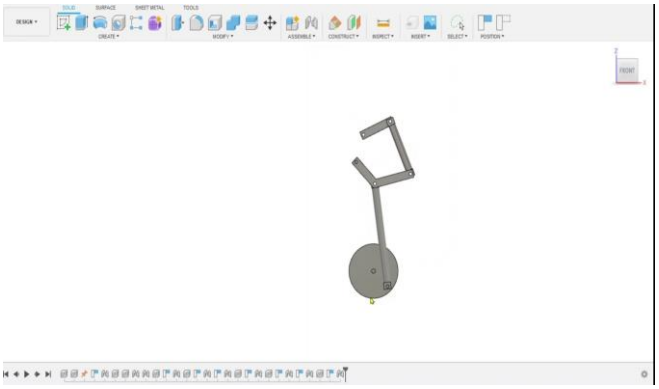
Area covered by duster(a)

(a)= (π*r^2) / 2.

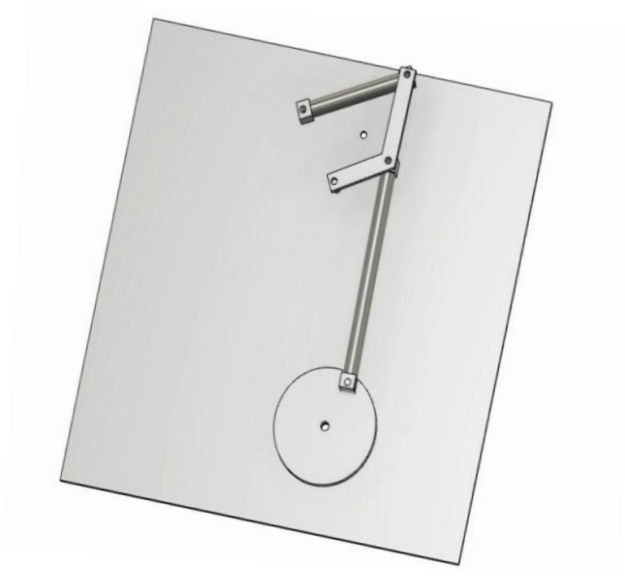
(a)=0.39m^2.

VII. DESIGN FOR MECHANISM

Designing is done at Autodesk fusion 360.



FRONT VIEW OF MECHANISM



ASSEMBLED MECHANISM

VIII. DESIGN ANALYSIS

At first it has been planned to use four bar crank rocker mechanism. but could not attain the required angle of 180 degrees for cleaning the board. The maximum angle achieved by four bar crank rocker mechanism was 135 degrees by using Fusion 360 software. Hence there was an implementation of six bar mechanism which satisfied the required angle for cleaning the black board. Then It has been decided to make the prototype for the project.

IX. EXPERIMENTATION

Initially the dimensions selected for the mechanism is minimum, so could not able to obtain the required output. Hence dimensions were scaled up to get the required output. Some unwanted unconstrained motions were obtained, later it has been overcomed.

MECHANISM WITHOUT SCALING

X. FABRICATION PROCESS

Final fabrication process is made up of (ms) mild steel by performing certain manufacturing process like welding ,cutting ,drilling, facing ,etc.

1. Drilling: at first drilling operation was performed on the plate to make holes at the desired dimensions using M8 and M6 sized drillpits.

2.Cutting: cutting operation was performed for required dimensions on a hollow circular mild steel rod to make a connecting rods and bars to make linkages using metal cutter.

3.Punching: using punching operation the bearing was fixed in the plate to make the operation smoother.

4. Welding: Manual metal arc welding (MMAW) is carried out to make fixed joints and angular linkages by the arc welding machine of (50v-240v).

5.Riverting: The connections between the linkages were made using mild steel riverts by riverting operation. To reduce friction.

International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 5, Issue 11, ISSN No. 2455-2143, Pages 229-237
Published Online March 2021 in IJEAST (http://www.ijeast.com)

XI. FABRICATION PHOTOGRAPHS

CUTTING OF PLATE

WELDING OPERATION

DRILLING OPERATION

MECHANISM

International Journal of Engineering Applied Sciences and Technology, 2021
Vol. 5, Issue 11, ISSN No. 2455-2143, Pages 229-237
Published Online March 2021 in IJEAST (http://www.ijeast.com)

BLACK BOARD CLEANER

FUTURE UPDATES

- A 12v DC motor can be used to automate the mechanism.
- Remote operated circuits can be implemented to automate the operation.
- In order to clean a large board multiple duster linkages can be used.

XII. CONCLUSION

Compared with manual dusters, blackboard cleaner has a good effect and runs smooth with good reaction speed. The blackboard cleaner has a simple structure, easy to operate, easy to obtain raw materials, manufacturing equipment simple process. It can be controlled easily and have smooth operations, simple in construction and easily manufacturable with high performance and low cost. The product is suitable for large, medium and small institutions with the promotion of certain significance.

XIII. REFERENCES

1. M.G Gauthaam, D.Sri Sai Vasanth, H.Dilli Babu , N. Sadasivan,Automation of Black Board duster for Ergonomics and Chalk dust suppression pp.482-485.

2. Dr.N.P.Mungle, Siddhant Shambharkar, Sumit Ramteke , Sonal Kamble, Bharat Tekam, Harshad Awatade ECOFRIENDLY DUSTER CLEANING MACHINE. pp.211-213.

3. P.S. Shiakolas , D. Koladiya, J. Kebrle . On the optimum synthesis of six-bar linkages using differential evolution and the geometric centroid of precision positions technique. pp.321-323.

4. V. Mohanavel , C. Kailasanathan , T. Sathish , V. Kannadhasan , S. Vinoth Joe Marshal , K. Sakthivel. Modeling and fabrication of automatic blackboard dust remover. pp.1-3.

5. Rubini B , Mrunalini T, Real-Time Automated Blackboard Eraser Using Embedded System.pp.15502-15504.

6. Prashanth Pai Manihallaa, Yathin Krishna, Nagaraja Anand Naik, Naveen Kumar , Rakshith and Rakshith Billava Ramappa. ,Design and Fabrication of an Electromechanical System to Clean the Blackboard. pp.1-5.

7. Rasit Karakus , Engin Tanık Novel compliant wiper mechanism.pp.328-333.

8.Dr.S.Nallusamy, Automatic Blackboard Erasing Mechanism.pp.41-44.

9. S. M. JAGTAP , S. B. TULJAPURE,DESIGN OF BLACKBOARD DUSTER CLEANING MACHINE.pp.862-870.

10. Gaurav Gangurde. Design and Development of Board Cleaning System.pp.38-41.

11. Omar W. Maaroof , Mehmet İsmet Can Dede Department of Mechanical Engineering, İzmir Institute of Technology, 35430 İzmir, Turkey. Mechanism and Machine Theory.pp.155-157.

12. Mr. Sunil R. Kewate , Mr Inzamam T. Mujawar, Mr. Akash D. Kewate , Mr.Hitesh R. Pant. Development of New Smart Design to Erase the Classroom Blackboard of Schools/Colleges.pp.57-60.

13. Jianguo Hu, Yousong Sun, Yongqi ChengHigh , mechanical advantage design of six-bar Stephenson mechanism for servo mechanical presses.pp.3-8.

14. E. J. F. PRIMROSE, F. FREUDENSTEIN & B. ROTH. Six-Bar Motion I. The Watt Mechanism. pp.23-30.

15. W.-B. Shieh/ L.-W. Tsai,' S. Azarm/ and A. L. Tits'. A New Class of Six-Bar Mechanisms With Symmetrical Coupler Curves. pp.150-152.

16. Weiqi Liua , Yan Chen. A double spherical 6R linkage with spatial crank-rocker characteristics inspired by kirigami.pp.3-7.

17. Deepanjan Majumdar, D.G. Gajghate, Pradeep Pipalatkar, C.V. Chalapati Rao. Assessment of Airborne Fine Particulate Matter and Particle Size Distribution in Settled Chalk Dust during Writing and Dusting Exercises in a Classroom440020, India.pp.542-549.

18. Gordon R. Pennock , Ali Israr. Kinematic analysis and synthesis of an adjustable six-bar linkage. pp.307-313.

19. Suzilawati binti Alias , Sullyfaizura binti Mohd Rawi , Marlina binti Mohamad. Politeknik Sultan Mizan Zainal Abidin, Design and development of smart whiteboard cleaner in classroom application. pp.8-11.

20. Chang-Jin Ma, Gong-Unn Kang, Mei Hamada. Behavior and Exposure of Chalk Dust during Classroom Teaching. pp. 241-246.

21. Venkatesh, S., Kumar, R.S., Sivapirakasam, S.P., Sakthivel, M., Venkatesh, D. and Arafath, S.Y., 2020. Multi-objective optimization, experimental and CFD approach for performance analysis in square cyclone separator. *Powder Technology*, *371*, pp.115-129.

22. Kumar, R.S., Alexis, J. and Thangarasu, V.S., 2017. Optimization of high speed CNC end milling process of BSL 168 Aluminium composite for aeronautical applications. *Transactions of the Canadian society for Mechanical Engineering*, *41*(4), pp.609-625.

23. Kumar, S.R., Alexis, J.S. and Thangarasu, V.S., 2017. Experimental Investigation of Influential Parameters in High Speed Machining of AMS 4205. *Asian Journal of Research in Social Sciences and Humanities*, *7*(2), pp.508-523.

24. Alexis, J. and Thangarasu, V.S., 2016. Prediction of machining parameters for A91060 in end milling. *Advances in Natural and Applied Sciences*, *10*(6 SE), pp.157-164.

25. Kumar, R.S., Thangarasu, V.S. and Alexis, S.J., 2016. Adaptive control systems in CNC machining processes--a review. *Advances in Natural and Applied Sciences*, *10*(6 SE), pp.120-130.

26. Suresh Kumar, R., John Alexis, S. and Thangarasu, V.S., 2015. Application of GA & ANN for the optimization of cutting parameters for end milling operation-A comparison. *International Journal of Applied Engineering Research*, *10*(20)

27. T Ramakrishnan, M Sathesh Babu, S Balasubramani, K Manickaraj, R Jeyakumar., 2021.Effect of Fiber Orientation and Mechanical Properties of Natural Fiber Reinforced Polymer Composites-A Review.*paideumajournal*.14 (3), pp.17-23.

28. Jeyakumar R, Balasubramanian K, Ramamoorthi R, Ramakrishnan T.,2021,Development Of Compact Electro Gear Pump For Airborne Applications. *paideumajournal*.14 (3), pp.50-57.

29. Ramakrishnan, T. and Sampath, P.S., 2017. Dry sliding wear characteristics of new short agave angustifolia marginata (AAM) fiber-reinforced polymer matrix composite material. *Journal of Biobased Materials and Bioenergy*, 11(5), pp.391-399.

30. Thirumalaisamy, R. and SUBRAMANI, S.P., 2018. Investigation of physico-mechanical and moisture absorption characteristics of raw and alkali treated new agave angustifolia marginata (AAM) fiber. *Materials Science*, *24*(1), pp.53-58.

31. Jeyakumar, R., Sampath, P.S., Ramamoorthi, R. and Ramakrishnan, T., 2017. Structural, morphological and mechanical behaviour of glass fibre reinforced epoxy nanoclay composites. *The International Journal of Advanced Manufacturing Technology*, *93*(1), pp.527-535.

32. Ramakrishnan, T. and Sampath, P.S., 2017. Experimental investigation of mechanical properties of untreated new Agave Angustifolia Marginata fiber reinforced epoxy polymer matrix composite material. *Journal of Advances in Chemistry*, *13*(4), pp.6120-6126.

33. Ramakrishnan, T., Sampath, P.S. and Ramamoorthi, R., 2016. Investigation of mechanical properties and morphological study of the alkali treated agave angustifolia marginata fiber reinforced epoxy polymer composites. *Asian Journal of Research in Social Sciences and Humanities*, *6*(9), pp.461-472.

34. Sathish, K., Ramakrishnan, T. and Sathishkumar, S., 2016. Optimization of turning parameters to improve surface finish of 16 Mn Cr 5 material. *Advances in Natural and Applied Sciences*, *10*(6 SE), pp.151-157.

35. Ramakrishnan, T., Sathish, K., Sampath, P.S. and Anandkumar, S., 2016. Experimental investigation and optimization of surface roughness of AISI 52100 alloy steel material by using Taguchi method. *Advances in Natural and Applied Sciences*, *10*(6 SE), pp.130-138.

36. Ramakrishnan, T. and Sampath, P.S., 2016. Thermogravimetric Analysis (TGA) and the Effect of Moisture Absorption on the Mechanical Properties of New Agave Angustifolia Marginata 3 Fiber (AAMF) Reinforced Epoxy Polymer Composite Material. *International Journal of Printing, Packaging & Allied Sciences*, *4*(5), pp.3245-3256.

37. Gokilakrishnan, G. and Varthanan, P.A., 2019. Development of manufacturing-distribution plan considering quality cost. *International Journal of Enterprise Network Management*, *10*(3-4), pp.280-304.

38. Varthanan, P.A. and Gokilakrishnan, G., 2018. Simulation Based Swarm Intelligence to Generate Manufacturing-distribution Plan for a Bearing Industry under Uncertain Demand and Inventory Scenario. *International*

Journal of Pure and Applied Mathematics, *119*(12), pp.2117-2134

39. Gokilakrishnan, G.E., Divya, S., Rajesh, R. and Selvakumar, V., 2014. Operating torque in ball valves: a review. *Int J Technol Res Eng*, *2*(4), pp.311-315.G

40. Vennilaa, D.B., Karuppusami, G. and Senthil, P., 2016. Analysis of different infiltration effect for selective laser sintering process through Taguchi method. *Australian Journal of Mechanical Engineering*, *14*(3), pp.217-223.

41. Venkatesh, S., Sivapirakasam, S.P., Sakthivel, M., Ganeshkumar, S., Prabhu, M.M. and Naveenkumar, M., 2021. Experimental and numerical investigation in the series arrangement square cyclone separator. *Powder Technology*, *383*, pp.93-103.

42. Venkatesh, S., Sakthivel, M., Saranav, H., Saravanan, N., Rathnakumar, M. and Santhosh, K.K., 2020. Performance investigation of the combined series and parallel arrangement cyclone separator using experimental and CFD approach. *Powder Technology*, *361*, pp.1070-1080.

43. Venkatesh, S., Sakthivel, M., Avinasilingam, M., Gopalsamy, S., Arulkumar, E. and Devarajan, H.P., 2019. Optimization and experimental investigation in bottom inlet cyclone separator for performance analysis. *Korean Journal of Chemical Engineering*, *36*(6), pp.929-941.

44. Venkatesh, S., Sakthivel, M., Sudhagar, S. and Daniel, S.A.A., 2018. Modification of the cyclone separator geometry for improving the performance using Taguchi and CFD approach. *Particulate Science and Technology*.

45. Venkatesh, S. and Sakthivel, M., 2017. Numerical investigation and optimization for performance analysis in Venturi inlet cyclone separator. *Desalination and Water treatment*, *90*, pp.168-179.

46. Venkatesh, S., Bruno Clement, I., Avinasilingam, M. and Arulkumar, E., 2017. Design of Experiment Technique for Improving the Performance of Stirling Engine. *International Research Journal of Engineering and Technology*, *4*(5), pp.62-65.

47. A Vimal, P Ravi Kumar, S Saji, D Sathish, JR Sudalai Thangamani.,2020. A Review on Wave Energy Harvester. International Journal of Research in Engineering Science and Management.(IJRESM)

48. A Vimal, S Rubesh, V Shundeep. 2019. Design and Fabrication of Multi Drive Pulley Transmission using CVT. International Journal of Research in Engineering Science and Management.(IJRESM)

49. A Vimal, RA Velayudham, P Deepak, K Elangovan, WF Prem., 2019. Semi-Automatic Paper Bag Making Machine. International Journal of Research in Engineering Science and Management. (IJRESM).

50. A. Vimal, M. Srinivasan, P. Krishnan, R. Vidyakar., 2019. A Review on Shape Optimization and Analysis of Connecting Rod using Different Materials. International Journal of Research in Engineering Science and Management. (IJRESM).

51. Yessian, S. and Varthanan, P.A., 2020. Optimization of performance and emission characteristics of catalytic coated ic engine with biodiesel using grey-taguchi method. *Scientific reports*, *10*(1), pp.1-13.

52. Sureshbabu, Y. and AshokaVarthanan, P., 2014. Study the emission characteristics of catalytic coated piston and combustion chamber of a four stroke spark ignition (SI) engine. *Journal of Chemical and Pharmaceutical Sciences, JCHPS Special*, (4).

53. Sureshbabu, Y., Ashokavarthnan, P., Balasubramani, S. and Naveenprabhu, V., 2019, October. Experimental investigation on four strokes catalytic coated spark ignition (SI) engine. In *AIP Conference Proceedings* (Vol. 2161, No. 1, p. 020041). AIP Publishing LLC.

54. SureshBabu, Y., Mutyalu, K.V. and Prasad, Y.S., 2012. A Relevant Document Information Clustering Algorithm for Web Search Engine. *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)*, *1*(8).

55. KUMAR, S.D. and KUMAR, S.S., 2021. Effect of heat treatment conditions on ballistic behaviour of various zones of friction stir welded magnesium alloy joints. *Transactions of Nonferrous Metals Society of China*, *31*(1), pp.156-166.

56. Kumar, S.D. and Kumar, S.S., 2020. Numerical and experimental ballistic performance of welded magnesium (AZ31B) plates. *Emerging Materials Research*, *9*(4), pp.1217-1228.

57. Kumar, S.D., Kumar, S.S. and Kumar, K.A., 2020. Investigation of forced frequency in a commercial vehicle suspension system. *Mechanics and Mechanical Engineering*, *22*(4), pp.967-974.

58. Sundaram, S.K., 2020. Experimental ballistic performance determination of friction stir welded magnesium (AZ31B) targets. *Mechanics Based Design of Structures and Machines*.

59. Kumar, S.S., Kumar, S.D. and Magarajan, U., 2020. Investigation of mechanical and wear behaviour of graphene reinforced aluminium alloy 6061 metal matrix composite. *KOVOVE MATERIALY-METALLIC MATERIALS*, *58*(5), pp.341-349.

60. Kumar, S.D. and Kumar, S.S., 2019. Investigation of mechanical behavior of friction stir welded joints of AA6063 with AA5083 aluminum alloys. *Mechanics and Mechanical Engineering*, *23*(1), pp.59-63.

61. Magarajan, U., Arvind, D., Kannan, N. and Hemanandan, P., 2018. A comparative study on the static mechanical properties of glass fibre vs glass-jute fibre polymer composite. *Materials Today: Proceedings*, *5*(2), pp.6711-6716.

62. Ganeshkumar S, Sureshkumar R, Sureshbabu Y, Balasubramani S 2020, A Review On Cutting Tool measurement In Turning Tools By Cloud Computing Systems In Industry 4.0 And Iot, GIS SCIENCE JOURNAL, Vol 7, No 8, pp 1-7.

63. Ganeshkumar S, Sureshkumar R, Sureshbabu Y, Balasubramani S, 2019, A Numerical Approach To Cutting Tool Stress In Cnc Turning Of En8 Steel With Silicon Carbide Tool Insert, International Journal of Scientific & Technology Research, Vol 8, No 12, pp 3227-3231.

64. Ganeshkumar, S., Thirunavukkarasu, V., Sureshkumar, R., Venkatesh, S. and Ramakrishnan, T., 2019. Investigation of wear behaviour of silicon carbide tool inserts and titanium nitride coated tool inserts in machining of en8 steel. *International Journal of Mechanical Engineering and Technology*, *10*(01), pp.1862-1873.

65. Venkatesh, S., Sivapirakasam, S.P., Sakthivel, M., Ganeshkumar, S., Prabhu, M.M. and Naveenkumar, M., 2021. Experimental and numerical investigation in the series arrangement square cyclone separator. *Powder Technology*, *383*, pp.93-103.

66. Kumar, S.G. and Thirunavukkarasu, V., 2016. Investigation of Tool Wear and Optimization of Process Parameters in Turning of EN8 and EN 36 Steels. *Asian Journal of Research in Social Sciences and Humanities*, *6*(11), pp.237-243.

67. Ganeshkumar, S., Sureshkumar, R., Sureshbabu, M.Y. and Balasubramani, M.S., A Review of Performance Investigations in Hydrogen–Oxygen Generator for Internal Combustion Engines.

68. **Subramaniam, B.,** Purusothaman, V.R., Karuppusamy, S.M., Ganesh, S.H. and Markandan, R.K., 2020. Review on properties of aluminium metal matrix composites. *Journal of Mechanical and Energy Engineering*, *4*(1), pp.57-66.

69. Balaji, N., **Balasubramani, S**., Ramakrishnan, T. and Sureshbabu, Y., 2020. Experimental Investigation of Chemical and Tensile Properties of Sansevieria Cylindrica Fiber Composites. In *Materials Science Forum* (Vol. 979, pp. 58-62). Trans Tech Publications Ltd.

70. **Balasubramani, S.** and Balaji, N., 2016. Investigations of vision inspection method for surface defects in image processing techniques-a review. *Advances in Natural and Applied Sciences*, *10*(6 SE), pp.115-120.

71. **Subramaniam, B.,** Natarajan, B., Kaliyaperumal, B. and Chelladurai, S.J.S., 2019. Wear behaviour of aluminium 7075—boron carbide-coconut shell fly ash reinforced hybrid metal matrix composites. *Materials Research Express*, *6*(10), p.1065d3.

72. **Subramaniam, B.,** Natarajan, B., Kaliyaperumal, B. and Chelladurai, S.J.S., 2018. Investigation on mechanical properties of aluminium 7075-boron carbide-coconut shell fly ash reinforced hybrid metal matrix composites. *China Foundry*, *15*(6), pp.449-456

73. N. Balaji, **S.Balasubramani,** V.Pandiaraj., 2021, Fabrication and Analysis of Al6061/Al_2O_3/TiC Hybrid Metal Matrix Composite, Paideuma Journal of Research., Vol 14, No 3, pp 24-35.

74. **Balasubramani, S.,** Dhanabalakrishnan, K.P. and Balaji, N., 2015. Optimization of machining parameters in aluminium HMMC using response surface methodology. *International journal of applied engineering research*, *10*(20), pp.19736-19739.

75. **Balasubramani S,** Manikandan.S Prasath.P, Suresh.D and Shanmuga Sundaram.P., 2018. "Vibration Analysis of Work Holding Devices in Composite Materials" International Journal for Scientific Research & Development, Vol. 6, No 2, pp 2520-2523.

76. NaveenPrabhu, V., SaravanaKumar, K., Suresh, T. and Suresh, M., 2016. Experimental investigation on tube-in-tube heat exchanger using nanofluids. *Advances in Natural and Applied Sciences*, *10*(7 SE), pp.272-279.

77. Justin Dhiraviam, F., Naveen Prabhu, V., Suresh, T. and Selva Senthil Prabhu, C., 2015. Improved efficiency in engine cooling system by repositioning of turbo inter cooler. In *Applied Mechanics and Materials* (Vol. 787, pp. 792-796). Trans Tech Publications Ltd.

78. Naveen Prabhu, V. and Suresh, M., 2015. Performance evaluation of tube-in-tube heat exchanger using nanofluids. In *Applied Mechanics and Materials* (Vol. 787, pp. 72-76). Trans Tech Publications Ltd.

79. Prabhu, V.N. and Manigandan, N., 2014. Design and Fabrication of Solar Transport Vehicle. *OSR J. Mech. Civ. Eng*, *11*, pp.14-19

80. Manigandan, N., NaveenPrabhu, V. and Suresh, M., 2015. Experimental investigation of a brazed chevron type plate heat exchanger. *International Journal of Science Technology & Engineering*, *1*(12), pp.1-7.

81. Dhiraviam, F.J., Naveenprabhu, V. and Santhosh, M., 2017. Study the Effects of Solar Assisted Vapour Compression Air Conditioning System for Winter Applications. *International Journal for Scientific Research & Development*, *4*(11), pp.505-508.

82. Manigandan, N., Naveenprabhu, V. and Devakumar, M., 2014. Design and Fabrication of Mechanical device for

Effective Degreasing in Roller Bearing. *Procedia Engineering*, *97*, pp.134-140.

83. Pravin, V.N.D.M.K. and Swamy, V.R.S.S.A., A Review of Evaporative Cooling of Finned and Non-Finned Heat Exchanger on Condenser.

84. Naveenprabhu, V. and Suresh, M., 2020. Performance enhancement studies on evaporative cooling using volumetric heat and mass transfer coefficients. *Numerical Heat Transfer, Part A: Applications*, *78*(9), pp.504-523.

85. Dhiraviam, F.J., Naveenprabhu, V., Satish, K. and Palanivelrajan, A.R., 2019, October. Emission characteristic in CI engines using zirconium porous medium in piston head. In *AIP Conference Proceedings* (Vol. 2161, No. 1, p. 020012). AIP Publishing LLC.

86. Naveenprabhu, V., Dhiraviam, F.J., Gowtham, K.M., Gowtham, S., Tharick, R.A. and Arunkumar, R., 2019. Smart Hot Chamber in Refrigeration System Based on Waste Heat Recovery. *Indian Journal of Science and Technology*, *12*, p.20.