International Journal for Multidisciplinary Research (IJFMR)

E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Computational and Investigational Proportional Flow Study on Cd Nozzle

Jyothi NT[1], Ashwin Nair[2], P Ebby Darney[3]

[1]President, Lips Research
[2]Research scholar, European international University
[3]Professor & Head, EEE, Raja Rajeswari College of Engineering Bangalore
[3]Research Supervisors, LIPS Research , European International University Paris

ABSTRACT

As part of our study , we had to design, produce, and test a convergent-divergent type nozzle with a specific area ratio. The goal of this project is to replicate the operation of a converging-diverging nozzle, which is possibly the most significant and fundamental piece of engineering hardware involved with propulsion and high-speed gas flow.For this, we first examined a specific area ratio. Three distinct designs are constructed for the given area ratio (convergent, divergent, and convergent divergent).The flow through the nozzle is analysed under various back pressure situations. Then, using the values obtained from the analysis, we constructed the nozzle and evaluated its operation. We also tested the choke conditions under varied back pressures and the mass flow rate that corresponds to it. Finally, we plotted the curve of mass flow rates vs. pressure distribution with practical values. Thus, with the assistance of our department faculty, we successfully accomplished this assignment.

Keyword: Flow, Nozzle, computational studies, Shock theory

CONVERGENT-DIVERGENT NOZZLE:

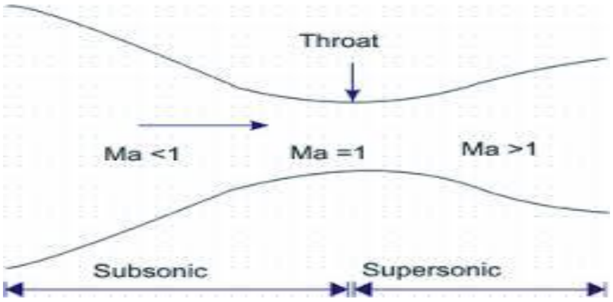

Fig 1-convergent-divergent nozzle

A Convergent- Divergent nozzle has a cross section that reduces from the input section to the throat and then increases from the throat to the outlet region.

To generate supersonic flow, a divergent-convergent nozzle is used. Because it produces supersonic flow, it is also known as a De Laval nozzle. The C-D Nozzle is linked to a compressor equipped with an inlet temperature and pressure gauge, as well as a regulating valve that regulates the amount of inlet pressure and temperature. A pipe connects the compressor, nozzle pressure, and temperature gauges.

Using a digital pressure transducer, 7 pressure tapings are put into the nozzle to determine pressure fluctuations. In this case, three tapings are placed in a convergent part, one in the throat, and the remaining three in the divergent section. The exit part additionally has a temperature and pressure gauge as well as regulating valves.

SOFTWARE AND HARDWARE REQUIREMENT

- CATIA (for design)
- NASTRAN (for structural analysis)
- CFD (fluent for flow)

CATIA V5R20

CATIA is a powerful programme for creating rich and complicated designs. It is also software for mechanical design. It is a set of feature-based, parametric solid modelling design tools that make use of the simple Windows graphical user interface. We may develop completely associative 3D solid models with or without constraints, while capturing the design purpose with automatic or user-defined relations. CATIA V5R20 is the most recent version of the software.CATIA V5 provides three platforms.

CATIA V5 P1 Users benefit from PLM Productivity at a low cost and with the assurance of future expansion. Based on CATIA V5 product design-in-context, product knowledge reuse, end-to-end associability, product validation, and collaborative change management capabilities, they may do associative product engineering.

CATIA V5 P2 Knowledge integration, process accelerators, and customised tools can help users optimise their PLM operations.

CATIA V5 P3 Users may get the most out of advanced procedures by focusing on specific solutions. They may lead expert engineering and advanced innovation by leveraging unique and highly specialised applications that combine product and process expertise.

CFD

ANSYS CFD is a more advanced version of ANSYS. CFD has been the industry standard for the computer-aided analysis of stress, vibration, structural failure/durability, heat transfer, noise/acoustics, and flutter/aero elasticity in every major industry, including aerospace, defence, automotive, shipbuilding, heavy machinery, medical, and consumer products. It is used for fluent analysis and is simple to use.

NOZZLE DISCRIPTION:

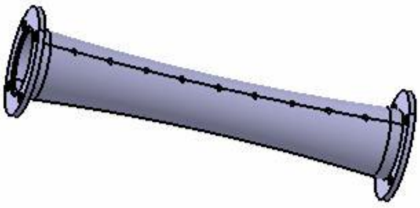

Fig 2: Nozzle description

The nozzle's overall length is 300mm (3m).From the entrance to the throat, the distance is 150mm. The throat measures 15mm in diameter. The nozzle has been separated into seven pieces and pressure tapings have been installed. The distance between each pressure tape is now 30mm, and the diameter has grown by 3mm. We separated the nozzle into seven pieces to accommodate the pressure tapings, and the holes were drilled perpendicular to the nozzle surface. The hole's diameter is 5mm.

STEPS:

1. Draw a nozzle using “CATIA”
2. Open “NASTRAN” then click advance stimulation, do right click then change Fem Stimulation, Change analyze type as structure.
3. Change SIM file to FEM file.
4. For applying material, initially select the object .Go to mesh collector click material apply. Select the material as stainless steel and click O.k.
5. For meshing the object click 3D mesh, change the element as size 20.Then select the object to be meshed, finally click O.K.
6. Change FEM file to SIM file.
7. Click the option Load type ,select pressure, at that time a dialogue box will be opened in that click select object then select the portion where pressure has to be applied then click O.K. After completing this dialogue box will be opened, type the required pressure (N/mm). We have given the pressure limit from 0-6.5 bar. Still 6.5bar there was no major fracture if exceeded the limit fracture will occur.

The following figures are obtained from the results of the above CFD process.

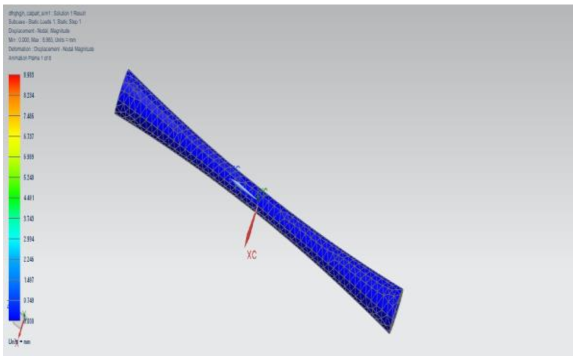

Fig 3: Initial nozzle condition

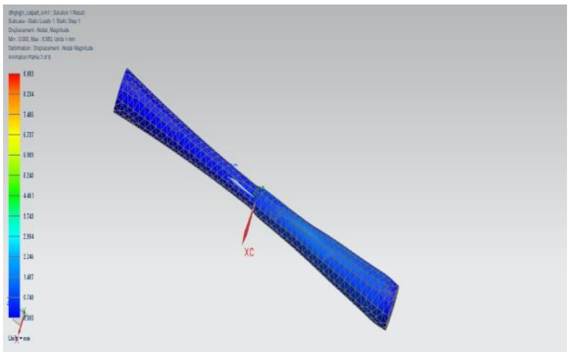

Fig 4: condition at applying stress

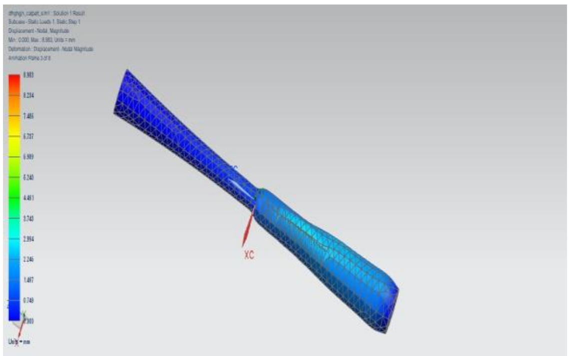

Fig 5: After applying stress

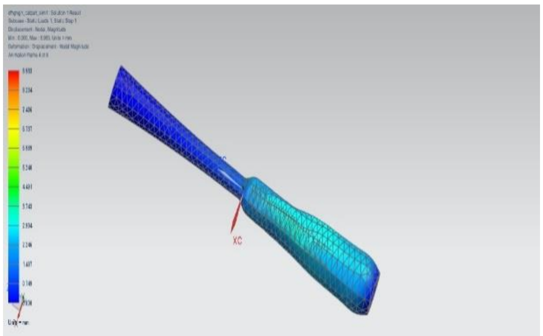

Fig 6: 2nd phase of deformation

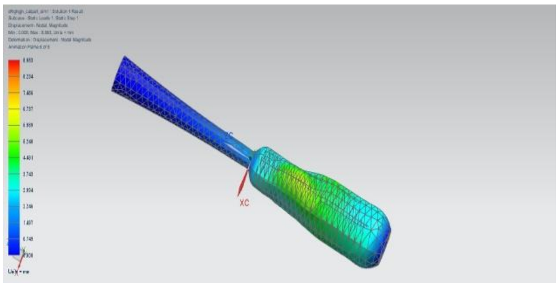

Fig 7: 3rd phase of deformation

According to the statistics above, the restriction spans from 0 to 8.983mm. The deformation is nodal-magnitude displacement. Using the pressure differential caused by colour fluctuation. The hue blue indicates that the nozzle is in good condition. The colour red represents maximum pressure and breakage.

COMPUTATIONAL RESULTS

We have designed a nozzle using “CATIA” software and then we have analyzed it using “FLUENT” software. The following results are given below.

OUTPUT RESUTS

SL. No	Length(m)	Velocity magnitude(m/s)	Static pressure (N/m^2)	X-coordinate values
1	0.0375	3.97×10^2	1.02×10^4	1.59×10^1
2	0.075	4.78×10^2	-3.5×10^4	3.8×10^1
3	0.1125	-5.60×10^2	-1.10×10^5	7.5×10^1
4	0.150	-7.43×10^2	-1.26×10^5	1.35×10^2

5	0.1875	-6.21×10^2	-1.11×10^5	1.8×10^2
6	0.225	-4.99×10^2	-5.02×10^4	2.25×10^2
7	0.2625	-3.97×10^2	-2.00×10^4	2.69×10^2

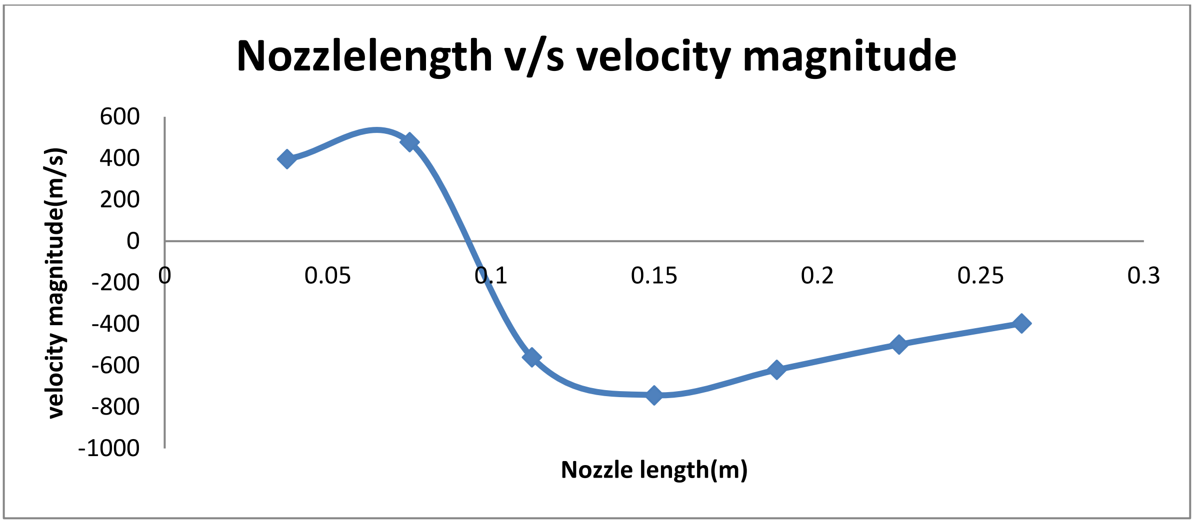

Fig8: Nozzle length v/s velocity magnitude

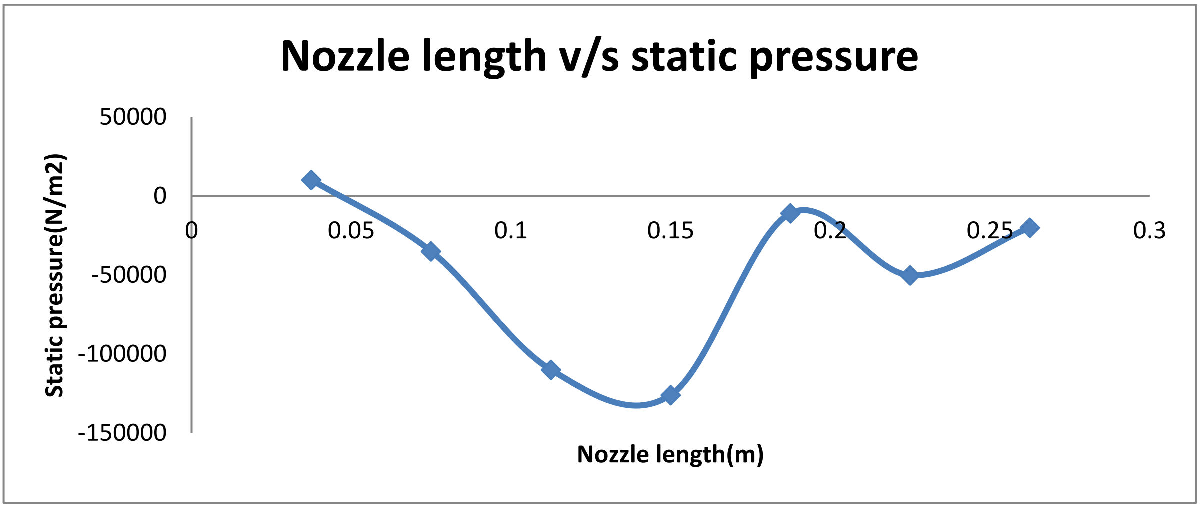

Fig 9: Nozzle length v/s static pressure

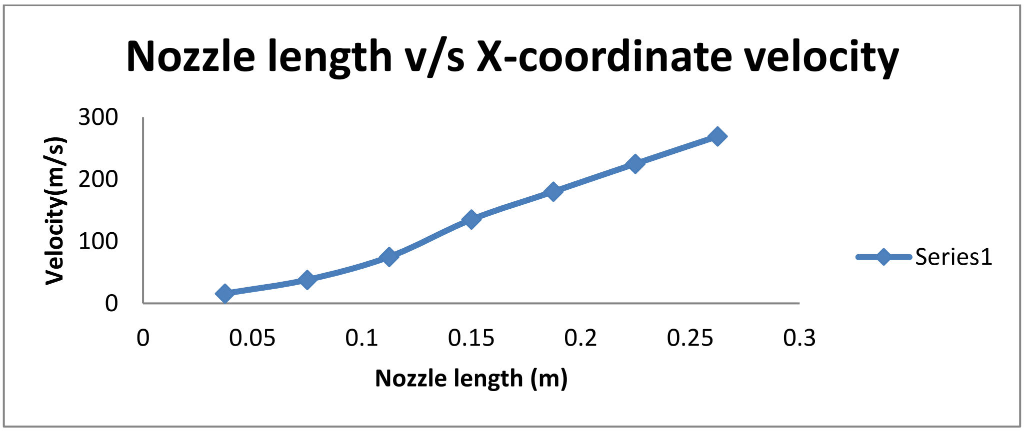

Fig10: Nozzle length v/s X-coordinate velocity

CONCLUSION:

This project assists in visualising the flow through this type of nozzle under a variety of conditions. We gave a chosen area ratio for our nozzle design, i.e. the throat diameter (15mm), and then compared the CFD and experimental findings to determine that our nozzle can tolerate a pressure of 6.5 bar. We've attained supersonic flow. The supersonic flow has a range of 2.0 Mach number. As a result, our analyses in both NASTRAN and CFD software were successful. Our model is not a failure model, and it can sustain a pressure range of 6.5 bar, allowing it to be used in a variety of applications.

REFERENCE:

1. Systematic Survey, Performance Evaluation, and Truth Flow Analysis of Two Subsonic Wind Tunnels with Two-Hole Spherical Flow Analyzer - Akhila Rupesh and J. V. Muruga Lal Jeyan In Production Pub Date: October 2022 Hardback Price: $159.95 USD | £124.00 Hard ISBN: 9781774911303 https://www.appleacademicpress.com/optimization-methods-for-engineering-problems-/9781774911303
2. K.S. Priyanka, J.V.M.L. Jeyan and S. Vihar. 2022. Investigation of Flow Separation Over NACA 24015 and 24021 Airfoils using Flow Injection Method, Int. J. Vehicle Structures & Systems, 14(3), 300-305. doi: 10.4273/ijvss.14.3.02.
3. P. S. RAMESH, J. V. MURUGA LAL JEYAN, *Comparative Analysis of Fixed-Wing, Rotary-Wing and Hybrid Mini Unmanned Aircraft Systems (UAS) from the Applications Perspective*, pp. 137-151, https://doi.org/10.13111/2066-8201.2022.14.1.12- INCAS BULLETIN, Volume 14, Issue 1/ 2022, pp. 137 – 151 Published: March 2022
4. P. S., R., & J. V. Muruga Lal, J. (2022). Hover performance analysis of coaxial Mini unmanned aerial vehicle for applications in mountain terrain. Aviation, 26(2), 112–123. https://doi.org/10.3846/aviation.2022.16901
   Published in Issue Jun 21, 2022
5. P.S., R. and J.V., M.L.J. (2022), "Evaluation of design criteria for mini unmanned aircraft systems (UAS) applications", Aircraft Engineering and Aerospace Technology, Vol. 94 No. 3, pp. 327-335. https://doi.org/10.1108/AEAT-03-2021-0089 Issue publication date: 10 February 2022
6. Aishwarya Dhara and Jeyan Muruga Lal 2021 IOP Conf. Ser.: Earth Environ. Sci. 889 012068 https://iopscience.iop.org/article/10.1088/1755-1315/889/1/012068/meta
7. R. Sabari VIHAR, J. V. Muruga Lal JEYAN, K. Sai PRIYANKA, *Effect of camber on the flutter characteristics of different selected airfoils*, pp. 215-223, Published: September 2021 https://doi.org/10.13111/2066-8201.2021.13.3.18
8. Mathew, B. C., Sahu, S. K., Dutta, P., Savale, R., & JV, M. (2021). Albatross and Falcon inspired Bionic UAV: An Aerodynamic Analysis. *International Journal of Aviation, Aeronautics, and Aerospace, 8*(3). Retrieved from https://commons.erau.edu/ijaaa/vol8/iss3/1
9. Bilji C Mathew et al 2021 IOP Conf. Ser.: Earth Environ. Sci. 775 012002 https://iopscience.iop.org/article/10.1088/1755-1315/775/1/012002 Evolutionary and Hereditary Traits of an Albatross and its Aerodynamic Optimality Bilji C Mathew, J V Muruga Lal Jeyan, Prantik Dutta and Rushikesh R. Savale Published under licence by IOP Publishing Ltd
10. R. S. Vihar, K. S. Priyanka and J. V. M. Lal Jeyan, "Design and analysis for the flutter behaviour of different selected wing plan forms computationally," 2020 International Conference on

Interdisciplinary Cyber Physical Systems (ICPS), 2020, pp. 72-78, doi: 10.1109/ICPS51508.2020.00018. https://ieeexplore.ieee.org/document/9434601

11. B. c. Mathew, K. S. Priyanka and J. V. M. Lal Jeyan, "Computational study on chamber morphing wing concept for efficient lift at various angle of attack," 2020 International Conference on Interdisciplinary Cyber Physical Systems (ICPS), 2020, pp. 68-71, doi: 10.1109/ICPS51508.2020.00020. https://ieeexplore.ieee.org/document/9434576
12. R. Balaji and M. L. Jeyan, "Performance analysis on varies bluff bodies at hypersonic speed," 2020 International Conference on Interdisciplinary Cyber Physical Systems (ICPS), 2020, pp. 62-67, doi: 10.1109/ICPS51508.2020.00017. https://ieeexplore.ieee.org/document/9434600
13. A. Rupesh, J. V. Muruga Lal Jeyan, , "Aerodynamic Design and Flow Analysis of Two Taping Spherical Flow Analyser and Mirror Edge Flow Analyser for Subsonic Wind Tunnel Calibration," 2021 International Conference on Advances in Electrical, Computing, Communication and Sustainable Technologies (ICAECT), Bhilai,India,2021,pp.1-6,doi:10.1109/ICAECT49130.2021.9392535, https://ieeexplore.ieee.org/document/9392535
14. Ramesh, P.S. and MurugaLalJeyan, J.V. (2021), "Terrain imperatives for Mini unmanned aircraft systems applications", International Journal of Intelligent Unmanned Systems, Vol. ahead-of-print No. ahead-of-print. https://doi.org/10.1108/IJIUS-09-2020-0044
15. Akhilarupesh, JV Muruga lal jeyan Experimental and Computational Evaluation of Five Hole Five Probe Flow Analyzer for Subsonic Wind Calibration - International Journal of Aviation, Aeronautics, and Aerospace , Published by Scholarly CommonsEmbry-Riddle Aeronautical University Volume 7 Issue 4 Article 3 2020
16. Ramesh PS, JV Muruga lal jeyan Mini Unmanned Aerial Systems (UAV) - A Review of theParameters for Classification of a Mini UAV - International Journal of Aviation,Aeronautics, and Aerospace , Published by Scholarly CommonsEmbry-Riddle Aeronautical University Volume 7 Issue 3 Article 5 2020
17. K.SaiPriyanka , J V MurugaLalJeyan*, R.SabariVihar. (2020). A Review on a Reassess Swot up on Airfoil Stall and Flow Separation Delay for a Range of Limitations Associated with Aerodynamics and Wing Profile. International Journal of Advanced Science and Technology, 29(06), 7659-7668.
18. R. SabariVihar, J. V. MurugaLalJeyan, K. SaiPriyanka. (2020). A Review on Aerodynamic Parameters, Methodologies and Suppression Techniques Explored in Aircraft Wing Flutter. International Journal of Advanced Science and Technology, 29(04), 3494
19. John B, A., Jeyan, J. V. M. L., NT, J., Kumar, A., Assessment of the Properties of Modified Pearl Millet Starch. *Starch.* 2022, 2200160. https://doi.org/10.1002/star.202200160
20. Suman Rana,Bhavin Soni,Dr. P. Ebby Darney,Jyothi NT, "EFFECTS OF T4 HORMONES ON HUMANBODY AND THEIR ANALYSIS", International Journal of Creative Research Thoughts (IJCRT), ISSN:2320-2882, Volume.10, Issue 10, pp.d332-d339, October 2022, Available at :http://www.ijcrt.org/papers/IJCRT2210389.pdf
21. Ashika Parveen1, JV Muruga Lal Jeyan[2], Jyothi NT[3] International Study on Application of Value Stream Mapping to Identify the Necessity of Lean System Implementation , International Journal of Scientific Research in Engineering and Management (IJSREM) Volume: 06 Issue: 09 | September - 2022 Impact Factor: 7.185 ISSN: 2582-3930
22. JV Muruga lal Jeyan, Jyothi NT Rashi Kaushik Systematic Review and Survey on Dominant Influence of Vedas and Ignorance Transpired in Space Science and Aviation", International Journal of Emerging

Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.9, Issue 7, page no.b490-b493, July-2022, Available :http://www.jetir.org/papers/JETIR2207158.pdf

23. JV Muruga lal Jeyan, Jyothi NT , Boopesh Raja, Rajarajan G "THEORY STRATEGY OF SUBSONIC WIND TUNNEL FOR LOW VELOCITY ", International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.9, Issue 6, page no.j572-j580, June-2022, Available :http://www.jetir.org/papers/JETIR2206973.pdf
24. JV Muruga lal Jeyan, Jyothi NT, Reshmitha Shree, Bhawadharanee S, Rajarajan, THEORETICAL STUDY OF HYPERSONIC WIND TUNNEL TEST FACILITY IN INDIA ", International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.9, Issue 6, page no.j512-j518, June-2022, Available :http://www.jetir.org/papers/JETIR2206967.pdf
25. JV Muruga lal Jeyan, Jyothi NT , V S Devika Thampuratty, B Nithin, Rajarajan, CONCEPT DESIGN AND DEVELOPMENT OF SUPERSONIC WIND TUNNEL ", International Journal of Emerging Technologies and Innovative Research (www.jetir.org | UGC and issn Approved), ISSN:2349-5162, Vol.9, Issue 6, page no. ppj209-j217, June-2022, Available at : http://www.jetir.org/papers/JETIR2206925.pdf
26. Muthu Venkatesh, Rajarajan G Jyothi NT JV Muruga Lal Jeyan "Systematic Survey of Wind Tunnel Test facility in India", International Journal of Emerging Technologies and Innovative Research (www.jetir.org), ISSN:2349-5162, Vol.9, Issue 6, page no.h830-h840, June-2022, Available :http://www.jetir.org/papers/JETIR2206795.pdf
27. Ashika Parveen, JV Muruga Lal Jeyan, Jyothi NT "Investigation Of Lean Developments And The Study Of Lean Techniques Through Event Studies" Internation Journal for Science and Advance Research In Technology, 8(4)
28. P Gopala Krishnan, JV Muruga Lal Jeyan, Jyothi NT "Novel Evaluation Of Aircraft Data Structure Optimization Techniques And Opportunities" International Journal for Science and Advance Research In Technology, 8(4)
29. Suryansh Upadhyay, JV Muruga lal Jeyan, Jyothi NT Preliminary Study on Brain Computer Interface © August 2021| IJIRT | Volume 8 Issue 3 | ISSN: 2349-6002 IJIRT 152537 INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN TECHNOLOGY 720
30. Sruthi.s.kumar, Jyothi Nt , Jv Muruga lal jeyan . Computational Turbine Blade Analysis with Thermal Barrier Coating International Journal of Engineering Research and Applications www.ijera.com ISSN: 2248-9622, Vol. 12, Issue 4, (Series-I) April 2022, pp. 01-08, DOI: 10.9790/9622-1204010108