Computational design and analysis of high speed train

Monil Lakdawala[1], Vishal Kuhikar[2], Rupesh Ingale[3] , Bhavesh Patel[4] , Lalit Chavhan[5]

Prof.Anil Mangukiya[6] Prof.SagarGurnani[7]

[1]Department of Mechanical Engineering

Shree Swami Atmanand Saraswati Institute of Technology, Surat, Gujarat, India

---***---

Abstract -Flow separation or boundary layer separation at the rear end of the Train is the main reason behind the aerodynamic drag. The Flow separation could be delayed by generating the vortex at the rear end of the Train with the help of vortex generators at the rear end of the train. It is tested on the modified WAP-5 Train model with and without the vortex generator. The design of the vortex generator varies with the dimensions of vehicle. The Aerodynamic CFD analysis is carried out using the Star ccm+ software and design of vortex generator is done on the solid works software. This paper presents the result and effect of the Vortex generator on Train model.

Keywords**:** Flow separation, Computational Fluid Dynamics(CFD), Vortex generator, Coefficient of Drag

1.INTRODUCTION

Locomotives are the one of the oldest mode of transport. It is also one of the highly used mode of transport. So it is required to increase the fuel efficiency of the locomotive so the transportation could be cheaper and the environmental pollution is less. In recent times the aim is to increase the velocity of the train so that the traveling time could be reduced. For that we require to reduce the aerodynamic drag so that the trains could achieve the higher speed at the same fuel.

2. Numerical Simulation

The solidworks software is used for the 3-D modeling of the Train. The Star ccm+ software is used for the CFD analysis.

2.1Geometry

Fig.1 is the modified WAP-5 Train model which is without vortex and the Fig.2 is the Train model with vortex on it. We prepared this geometry in the solidworks software where we attached the vortex on the Train Body as we can see in the Fig.2 the vortex is attached at the Rear end of the Train. For the simulation purpose the modified WAP-5 train model is used as described in the nitin gupta's thesis on computer aided design of aerodynamic shape of high speed train.
The design of the vortex generator depends on the shape and the dimensions of the aerodynamic body. It also depends on the boundary layer thickness. Normally the height of the vortex generator is equal to the height of the boundary layer thickness. The vortex generators are required to place where the flow separation is occurring so we have placed at the Rear slope of the Train. The vortex generator will direct the flow of the air towards the rear side of the Train and the staticpressure will increase and the drag will be reduced. In thisTrain model we have consider that no different aerodynamic effect is generated at the middle bogies.

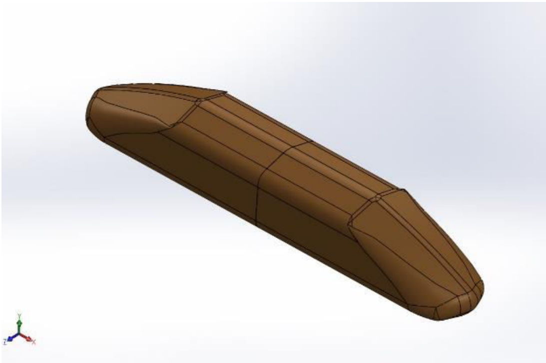


Fig -1: Train without vortex generator

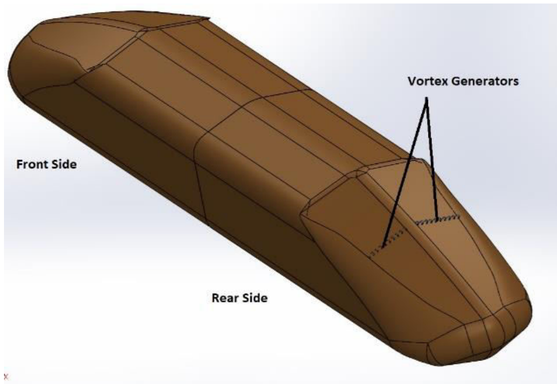


Fig -2: Train with vortex generator

2.2Boundary Condition

Boundary condition is taken same in the both condition Train without vortex and train with vortex generator. Inlet velocity and Outlet velocity of the air is taken as same. In Fig-3 L is the length of the Train.

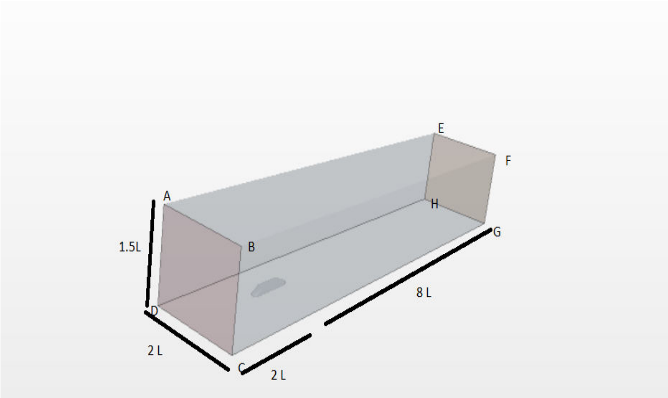


Fig -3: Boundary Condition of Simulation

ABCD - Velocity Inlet
EFGH – Pressure Outlet
AEHD, BFGH, AEFB, DCGH – Far Field
CDHG – Tangential Velocity

2.3Meshing

Three types of Meshing are used in the simulationPolyhedral, Mesh Surface Mesh, Prism layer Mesh.

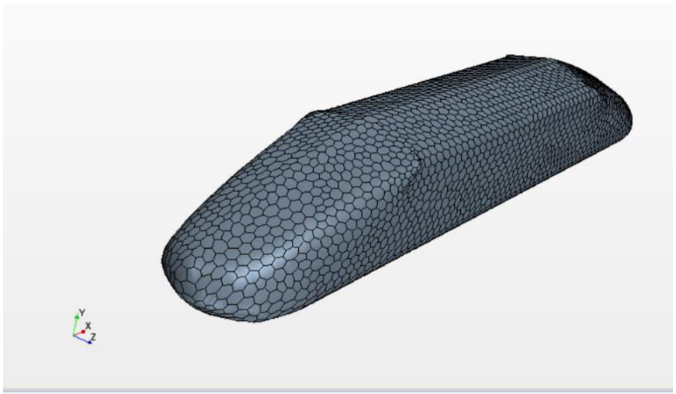


Fig -4: Meshing of Train Surface

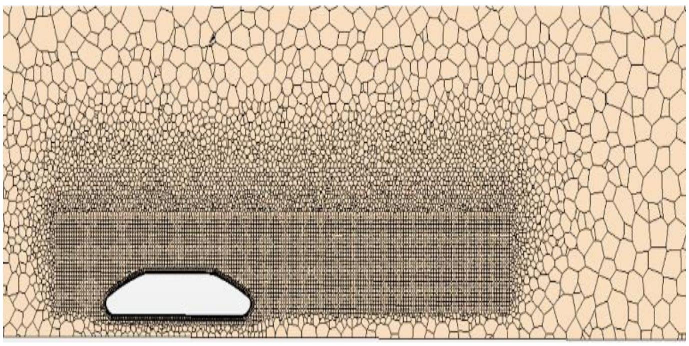


Fig -5: Meshing around the Train Body

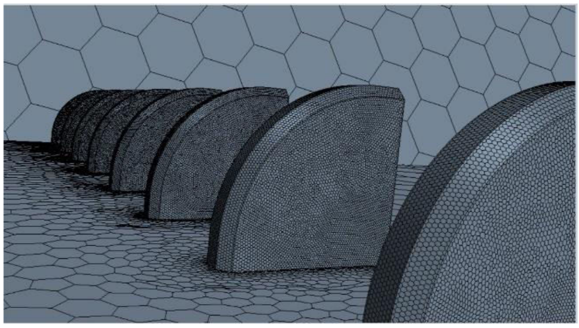


Fig -6: Meshing of Vortex

2.3Result

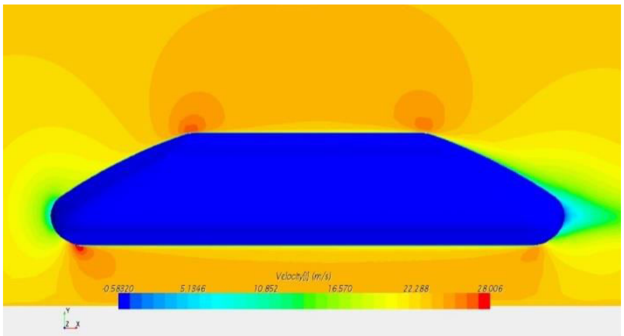


Fig -7: Velocity distribution of Train without Vortex

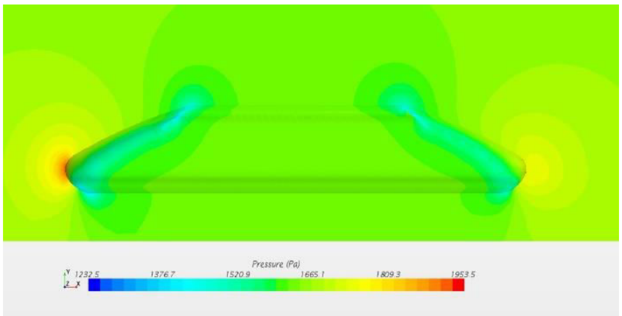


Fig -8: Pressure distribution of Train without Vortex

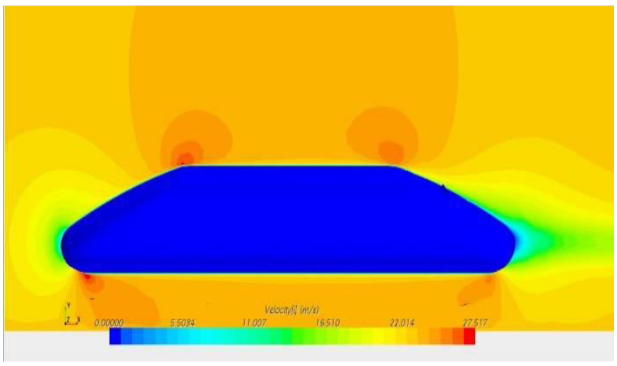


Fig -9: Velocity distribution of Train with Vortex

International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 04 Issue: 05 | May -2020 ISSN: 2582-3930

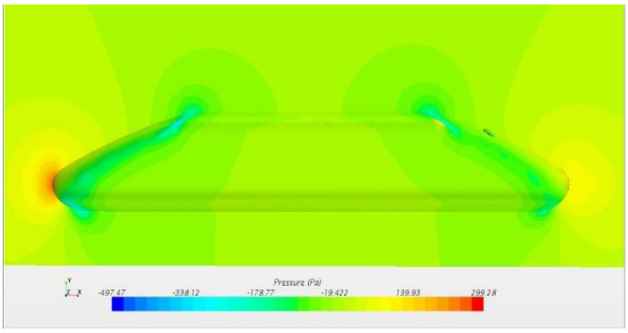


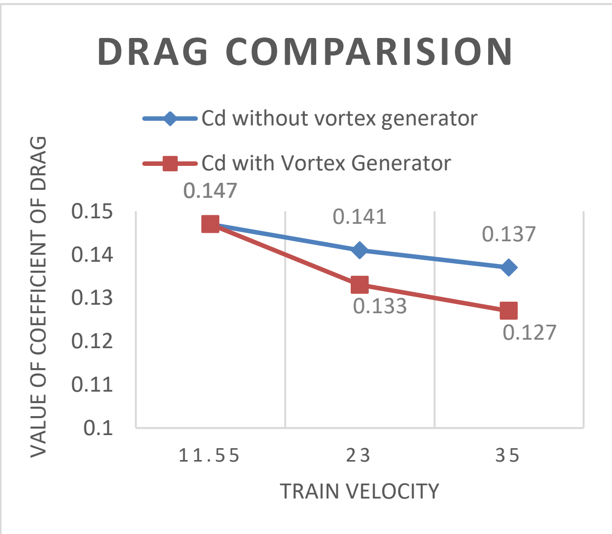
Fig -10: Pressure distribution of Train with Vortex

As We can see in Fig -7, Fig-8, Fig-9, Fig-10 The flow separation is Delayed due to Vortex Generator.

Table -1: Comparison of drag with and without vortex

Velocity (m/s)	**Coefficient of drag (Cd) without Vortex Generator.**	**Coefficient of drag (Cd) with Vortex Generator.**	**Difference (%)**
11.55	0.147	0.147	0 %
23	0.141	0.133	7 %
35	0.137	0.127	11.12 %

Chart-1: Comparison of the coefficient of drag with and without vortex.



We can see in the Table-1 and the Chart-1 shows that the coefficient of Drag changes after attaching the vortex generators on the Train body. But in the low velocity we cannot see any noticeable change in the Drag coefficient value but as the velocity increases the drag starts to reduce as compare to the without vortex generator train body.

3. Conclusion

From the results and comparison of simulations, it is clear that after installing vortex generators, drag and boundary layer separation is reduced.

Therefore, finally we can conclude that designed vortex generators have met their purpose of increasing fuel efficiency and improving aerodynamics stability of vehicle by reducing the drag.

4. Future Work

1. This Research let us know how the changes has been made to reduce the drag.
2. This Research also helps in gaining the useful knowledge of drag analysis of a train.
3. It also increases career opportunities.
4. As the research and learning project, the students can carry forward the project and gain the knowledge of CFD and aerodynamics.

REFERENCES

1. Nitin Gupta (2007) “Computer Aided Design of Aerodynamic Shape of High Speed Trains” IIT Roorkee.
1. Raghunathana. Raghu S. and Kim. H. D. (2002) "Aerodynamics of high-speed railway train", Progress in Aerospace Sciences, Vol. 38, PP. 469-514.
2. L. Anantha Raman, Rahul Hari H (2016) “Methods for Reducing Aerodynamic Drag in Vehicles and thus Acquiring Fuel Economy” Journal of Advanced Engineering Research, ISSN: 2393-8447, Volume 3, Issue 1, 2016, pp.26-32
3. Ramamurthy, E. V. V. (1997), "Wind pressure distribution over a railway bogie". M.E. (Civil) Dissertation, IIT Roorkee, India.
4. A CFD analysis of the aerodynamics of a high-speed train passing through a windbreak transition under crosswind by Tanghong Liu, Zhengwei Chen, Xisai Zhou and Jie Zhang.
5. Masaru KOIKE, Tsunehisa NAGAYOSHI, Naoki HAMAMOTO “Research on Aerodynamic Drag Reduction by Vortex Generators”