

Analytical VALIDATION of IMPROVED DESIGNS of a Busbar for OPTIMIZED MASS and DECREASED MAXIMUM TEMPERATURE DURING OPERATION

Neel Sanghvi¹, Jui Kamble², Saurabh Rasal³, Monil Shah⁴

^{1,3,4}UG Student, Dept. of Mechanical Engineering, DJSCE, Mumbai

²UG Student, Dept. of Electrical Engineering, SPCE, Mumbai

Abstract – This paper describes an experiment that was undertaken to analytically validate two proposed improvised designs of a busbar to reduce the mass and increase the heat transfer by convection. The proposed designs are obtained a thorough scrutiny of the applications of a busbar. CAD models were constructed, and after required meshing, a commercial FEA package is used for the analysis. This paper concludes by summarizing the change in output parameters with each proposed design. This research can be used as a starting point to analyze optimization scenarios for many more specific busbar applications.

Key Words: FEA, Busbar, Electrical,

1. Introduction:

Busbars are metallic bars which are generally uninsulated and are to conduct high currents [1]. They are used in switchboards, distribution panels and other high voltage applications or in low voltage applications where insulated conductors like conventional wires and cables cannot be used. Busbar systems can be used for electrical connections for one phase or three phase power and can handle a variety of values of potential difference, which depends on the design and material of the busbar. The type of busbar considered in this paper is the basic single phase open busbar which acts as an uninsulated conductor.

1.1 Busbar materials:

The fundamental requirement for a busbar material is that it should function well for the applied potential difference, given the maximum temperature of the busbar in operation should stay well below the melting point. Other important requirements are that the material have a competitive initial cost and a sound recovery value. The material should also have a low electrical and thermal resistance [2]. Copper is generally preferred to Aluminum for this application primarily due to its high electrical conductivity.

There are some specific reasons as to why aluminum is used instead of copper in some busbar applications:

1. Presence of a highly corrosive and stressed environment.
2. Requirement of very cost-effective solutions.
3. Demand of low-weight systems.

Moreover, the oxidation issues which are inherent to Aluminum and may cause problems in the future can be readily countered with silver plating.

1.2 Experiment:

In this experiment, the goal was to optimize an aluminium busbar system for given values of input and output potentials. Two optimized designs are proposed, the first aimed at decreasing the mass, and the second aimed at decreasing the operating temperature. The first design consists of the busbar being split into two parts along the length so that width of one section is half of the width of the original busbar. The second design consists of holes drilled into the busbar at appropriate locations to minimize the amount of metal used for manufacturing the busbar. The first design is aimed at increasing heat dissipation thorough of higher surface area, while the second design is aimed at simultaneously reducing the mass as well as increasing heat dissipation.

2. Boundary conditions and variables:

As the presented analyses are thermo-electric analyses, the material properties which have to be defined externally are the emissivity and heat transfer coefficient with respect to air. Heat transfer is assumed to be absent to maintain simplicity in the analyses. Convective heat transfer coefficient is taken as 69 in SI units [3]. For the given analyses, the input and output potentials which are responsible for the current flow are taken as 770 and 230 volts. These values are selected after an extensive review of aluminum busbar applications. The ambient temperature is chosen as 22 degrees centigrade,

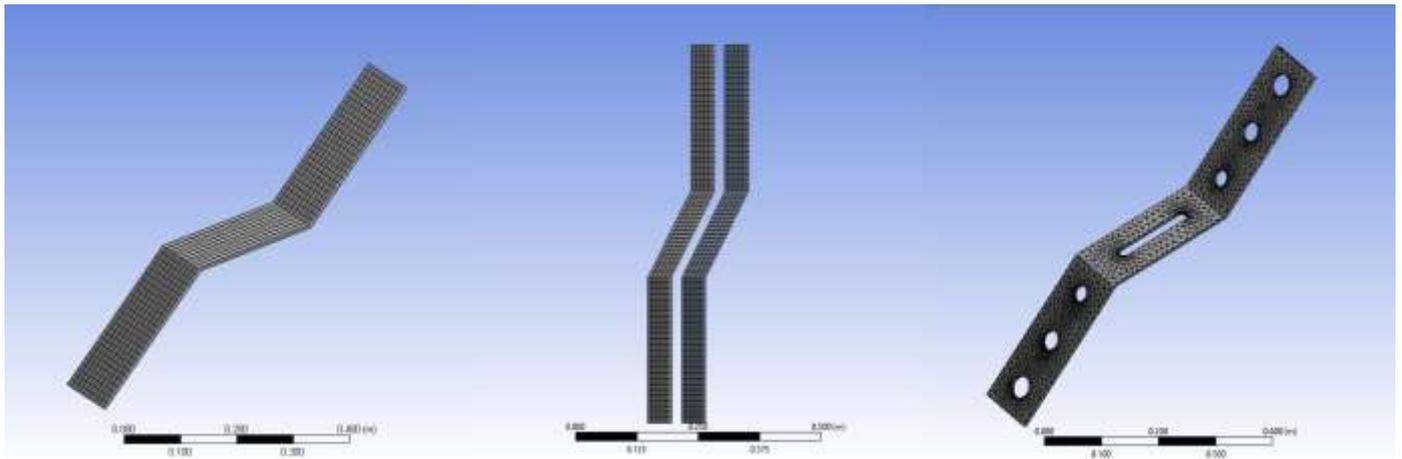
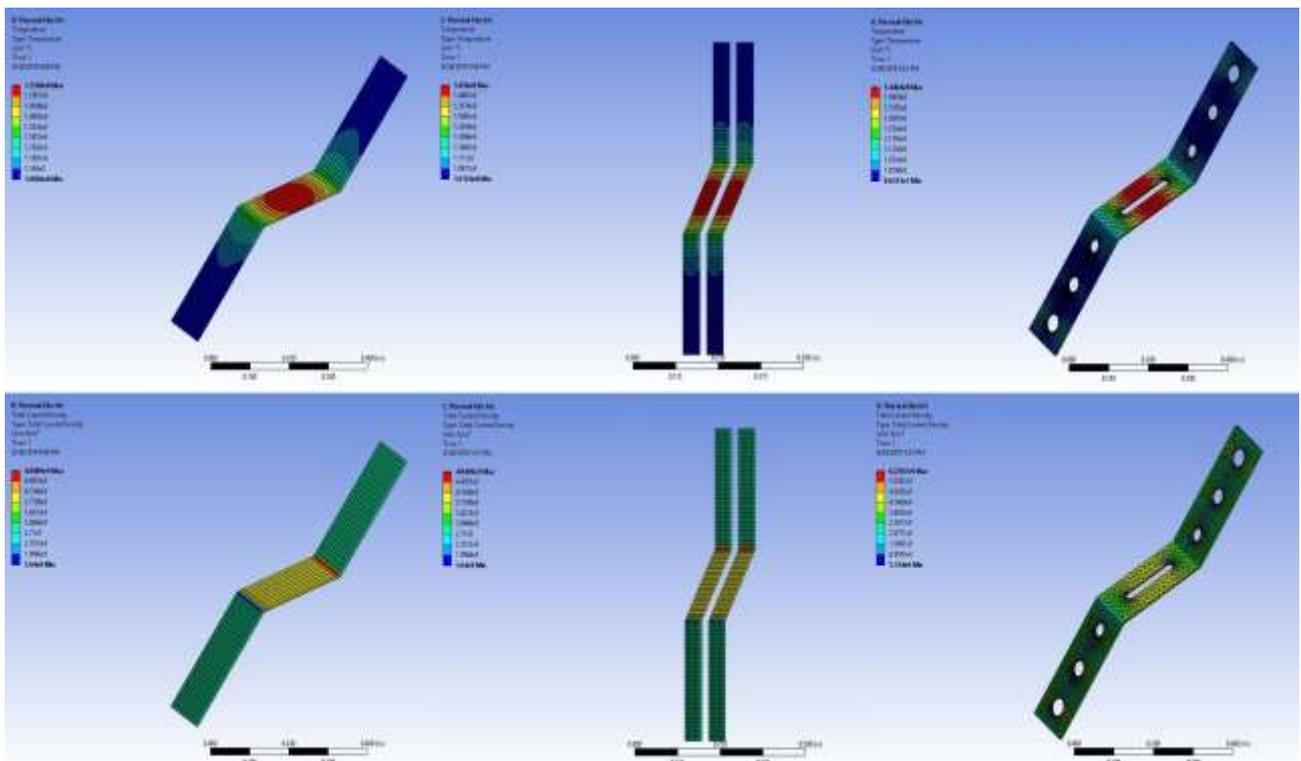


Figure 1: Meshed designs for basic busbar, and proposed designs (Basic, Split, Hole)

Table 1: Relevant results of Analyses

	Design	Mass	Max Temperature	Max Electric Flux	Max Current Density	Max Joule Heat
1	Basic	2097.3 g	1.55e+08	3.30e+10	4.84e+09	2.87e+12
2	Hole	1883.7 g	1.44e+08	5.01e+10	6.20e+09	5.79e+12
3	Split	2097.3 g	1.45e+08	3.36e+10	4.84e+09	2.87e+12



3. Problem implementation:

The cad models for the busbars was made using Solidworks 17 before which rough sketches had been made on paper for the basic design after analyzing a particular application. The optimized designs were proposed after a comprehensive analysis of the manufacturing and application aspects of the busbar. ANSYS 16 Meshing application was used to perform standard meshing to balance accuracy and computation time. ANSYS Workbench Thermo-electric was used for the simulation part

4. Results and discussion

The results obtained at the end of the experiments are along the lines of what was expected. The design intended to decrease mass yields a mass decrease of ~10%. In this design the maximum temperature decreases by ~7%. However the maximum electric flux increases by ~52%. The maximum current density and the increase by ~28% and ~100%. The low mass can increase mechanical efficiency in case of moving system but the higher joule heating can pose a significant problem, but specific ducting configurations can be used in moving systems to focus moving air in specific directions

The design intended to provide decreased operating temperature does not alter the mass. The maximum temperature decreases by ~6%. The maximum electric flux increases by 6%. The maximum joule heat and the maximum current density also do not change.

5. Conclusion

In this experiment, the goal was to optimize an aluminum busbar system for a given combination of input and output potentials and with consideration of a basic standard design. Two improvised designs were proposed, the first with an aim to have higher heat dissipation rate and the second, to have a lower mass. After constructing cad models in the form of .igs files, the necessary meshing procedures were done. The decided boundary conditions were applied to the models and the analyses were conducted. The input variables were input potential, output potential, ambient temperature, and the heat transfer coefficient. The output variables considered were the temperature, current density, electric flux and the Joule heat.

REFERENCES

1. Prasanna Shinde, Jitendra Shukla, Rajkumar.E, (2018) " Busbar Profile Optimization using Finite Element Analysis ",International Journal of Mechanical and Production Engineering (IJMPE) , pp. 28-30, Volume-6,Issue-2
2. Y. J. Bao, K. W. E. Cheng, K. Ding and D. H. Wang, "The study on the busbar system and its fault analysis," 2013 5th International Conference on Power Electronics Systems and Applications(PESA), Hong Kong, 2013, pp. 1-7. doi: 10.1109/PESA.2013.6828246
3. R. Abdul Jabbar N. Khalif, Israa Riyadh Aziz Al mousawi, "Comparision of Heat Transfer Coefficients in Free and Forced Convection Using Circular annular Finned Tubes " , International Journal of Application or Innovation in Engineering & Management (IJAIEEM), Volume 5, Issue 4, April 2016 , pp. 194-204 , ISSN 2319 - 4847