EXPERIMENTAL STUDY AND ANALYSIS OF STEADY FLOW ON THE ASYMMETRIC RAILWAY PANTOGRAPH

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Abstract

The high speed trains have a power system to carry the electricity which is mostly used pantograph to collect power through contact with an overhead line. This present work deals with a high-speed aerodynamic analysis of a three-dimensional asymmetric pantograph model, through the employment of 3D numerical simulations. First, the natural frequency of the asymmetric pantograph can be found by the modal analysis in ANSYS software. Then, the aerodynamics generated from the high velocity wind force in single direction to calculate fluid flows using computational fluid dynamics (CFD)

Introduction

In further years major advances of the high speed trains will make a veritable convenience for the passenger who would like to travel between metropolitan and interurban. The high speed of the train that has crossed the air incompressible flow into the air compressible flow (exceed 300 km/h) is highly influenced by the effects of aerodynamics (aerodynamic drag). Indeed, aerodynamics influence has become one of the interesting problem that contribute to the pantograph's instability.

The objective of the present study is to verify the performance of CFD numerical approach in order to increase the asymmetric type of railway pantograph-catenary stability when it was influenced by the wind-induced vibration at the high speed range between 280 km/h and 320 km/h. The activity is based on the pantograph model of the Indian high speed train cooperated by SWARAJ BISWAS. The model's scale is based on the photograph that comes similar to the actual scale.

Fig. 1. Overhead Catenary System (OCS) Harsco Rail Provides OCS Vehicles for Swiss Network

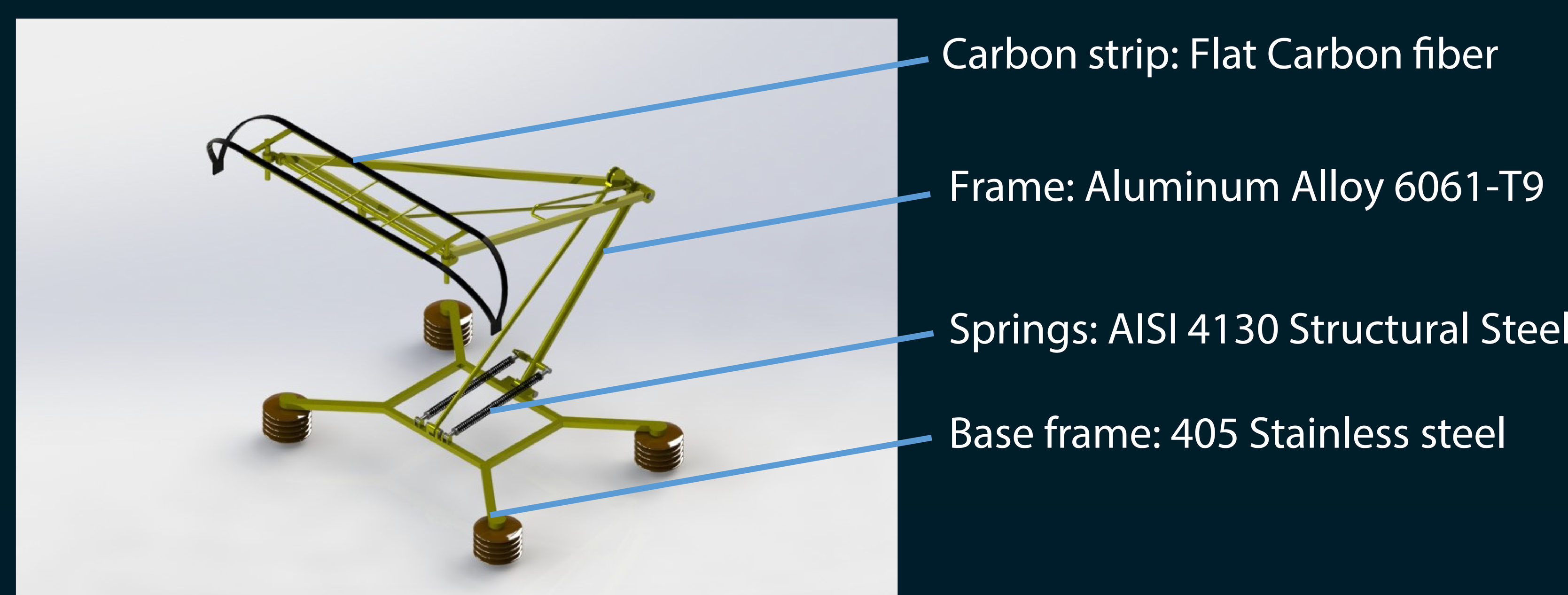

Fig. 2. Model of Pantograph configuration

Numerical Simulations

Table 1 Mode Shapes and natural frequency between free vibration with and without fixed supports

Mode Shapes	Frequency [Hz]	
	Free vibration	Fixed vibration
1	0	1.7069
2	0	2.3978
3	5.744E-04	4.5308
4	1.6910	4.5635
5	2.0248	4.7645
6	2.3006	4.7975
7	2.6072	5.7991
8	2.9795	6.3741
9	4.5371	8.5785
10	4.5678	10.9780

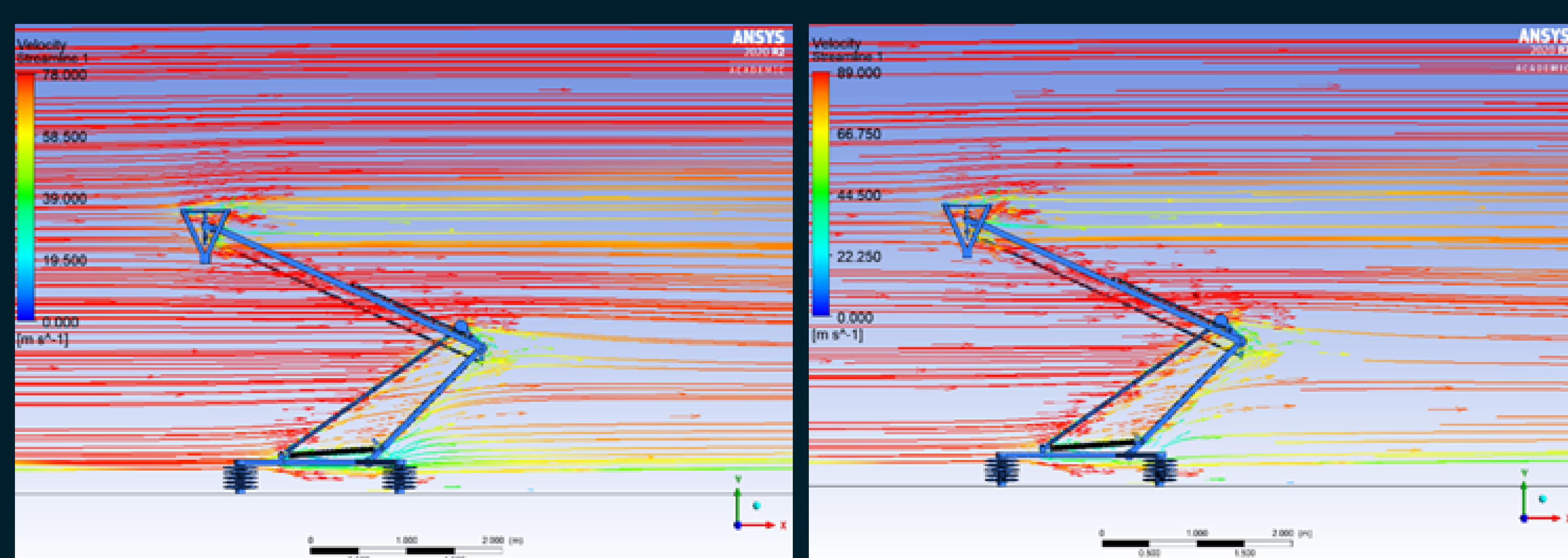

Fig. 3. The velocity results of the wind between a) 280 km/h and b) 320 km/h

Ten mode shape and corresponding natural frequencies are found and analyze in both determinations with 20 mm. element meshing size. Table 1 is indicated the comparison mode shape and natural frequencies between free vibration with and without fixed supports. Free vibration with no fixed point of the model can be generated and when fixed pins fix on a whole pedestal, it can be assumed that the model is mounted on the roof of the rail vehicles. The natural frequency of the mode shape number four of the free vibration approximates the natural frequency of the first mode shape of the fixed vibration because the first 3 modes of the free vibration imply the degree of freedom (DOF) of the workpiece.

The results of both experiments are illustrated in the figure 3 which depicted the pantograph driving through the wind at 280 km/h and 320 km/h. The characteristic of the wind flowing through the symmetry plane of the pantograph model flows naturally, while comparing to the consequence of the pantograph running through another wind speed. At 320 km/h, the space behind the pantograph's arm seems to be a vacuum, which is regarded as the separation region, and results in a large drag force.

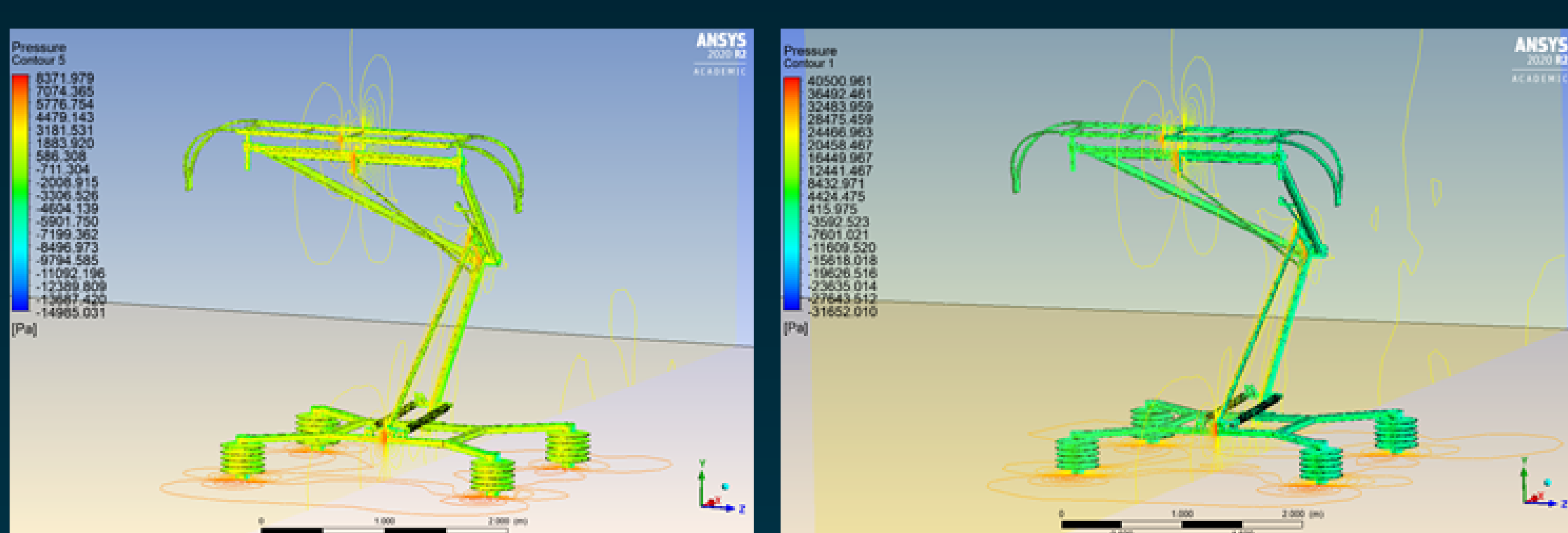

Fig. 4. The pressure contour between a wind speed at a) 280 km/h and b) 320 km/h

The influence of the high speed's wind also affects the structure of the obtained pantograph. At a constant wind speed of 280 km/h, the maximum pressure applied to the base frame is 4,305.82 Pa, while the pantograph model is obtained 3,664.24 N aerodynamic force. Compared to a pantograph model moving through a wind speed at 320 km/h, maximum pressure occurs at the same position with 5,834.82 Pa and 4,768.21 N applies on the structure model. The pressure contours of both situations are demonstrated in the figure 4.

References

[1] Siano D., Viscardi M., Donisi F., Napolitano P. (2014) Numerical modeling and experimental evaluation of a high-speed train pantograph aerodynamic noise. Cambridge, MA, USA. Conference: 5th International Conference on Automotive and Transportation Systems (ICAT '14). Volume: 22.

[2] Veerapandi R., Karthikeyan G., Jinu G.R., Kannaiah R. (2014) Experimental study and analysis of flow induced vibration in a pipeline. India: International Journal of Engineering Research & Technology (IJERT). Vol. 3. Issue 5.

[3] Hee-Min Noh. (2019) Wind tunnel test analysis to determine pantograph noise contribution on a high-speed train. Advanced in Mechanical Engineering: Hindawi Publishing Corporation. Vol. 11(10) 1–11.

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