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# SOME CONSIDERATIONS ON THE AERODYNAMICS OF HIGH SPEED PANTOGRAPH: CFD AND WIND TUNNEL TESTS

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## 1 INTRODUCTION

Aerodynamic aspects, related to the air flow incident on the pantograph installed on a train running at given speed, play a significant role in the definition of the quality of the current collection between the pantograph and the overhead contact line (catenary). The pantograph is made of an articulated frame and a collector head, and from the aerodynamic point of view it can be considered as an ensemble of bluff bodies variously oriented. Different aspects are relevant from the aerodynamic point of view, and in particular:

- mean contributions of the aerodynamic forces on the mean value of the contact force (aerodynamic uplift);
- mean aerodynamic forces on the collector strips, that has to be taken into account for the measurement of the contact force, and, depending on the geometry of the head and collector suspension assembly, have an effect also on the distribution of the contact force on the two collectors, both when they are mounted on the bow, and when they are on independently suspended collectors;
- dynamic effects due to the turbulence of the incident flow
- aerodynamic instabilities phenomena and vortex shedding phenomena, potentially occurring on the collector

Several investigation have been carried out, usually by pantograph manufacturer, mainly pointing at define the uplift force on the collector and for the investigation of aero acoustic aspects [1], [2], [3]. Main aim of this paper is to provide some insight about the contribution of the various members of the pantograph (parts of the articulated frame, collector head, fixed frame) to the aerodynamic forces, and to investigate the variation of such actions with respect to the yaw angle, in order to subsequently perform considerations on the cross-wind effects on the quality of the current collection [4], considering a multi body modeling of the pantograph.
The paper is organized through the following points:

- presentation of the wind tunnel test set up and obtained results

- CFD calculations, and discussion of the related problems for the reduction of the pantograph complex geometry and managing of the yawed configuration
- discussion on the comparison between the CFD results and the wind tunnel tet results, pointing out the resemblance and the source of main discrepancies

## 2 WIND TUNNEL TETS

Wind tunnel tests have been performed at Politecnico di Milano, on a Faivelecy CX25 pantograph, provided by SNCF in the framework of the EU funded Europac project. Being the section of the wind tunnel duct 4m x 4m in the test area, a open chamber configuration has been selected, taking into account the dimension of thee pantograph and the blockage that would have been provided by a closed chamber configuration. The pantograph is completely exposed over the flat surface, and connected via its insulators to the dynamometric frame, that will measure the global drag, lift and couple aerodynamic actions, both on the longitudinal and transversal plane (the last is necessary in the yawed configuration). The flat surface is closes all the inferior leaving only narrow openings around the insulators, as shown in

### 2.1 Test set-up

Aim of the test set-up is to provide have clearly defined boundary conditions and measurements of quantities necessary to perform meaningful comparison with CFD, and also:

- provide combination of longitudinal flow and lateral direction wind (possibility to investigate a side wind scenario);
- obtain coefficients for the calculations of the aerodynamic forces on the PT, according both to lumped mass model and to MB modelling, at different yaw angle.

Global longitudinal and lateral drag forces, global lift force, and moments around the three axes have been measured by means of dynamometric frame placed under the pantograph. Uplift force (an internal force between the articulated frame and the fixed frame) has been measured too using the same configuration as in the line test, i.e. connecting the collector to the fixed frame of the pantograph with steel cables, and measuring the transmitted force (see Figure 1, right).

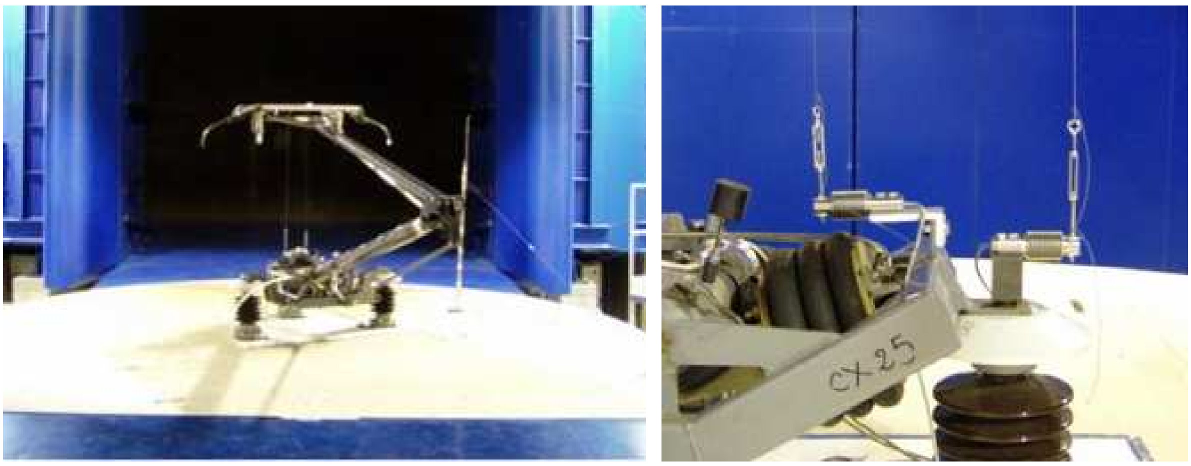


Figure 1: The pantograph in the open chamber wind tunnel (left). Connection for the measurement of the aerodynamic uplift (right)

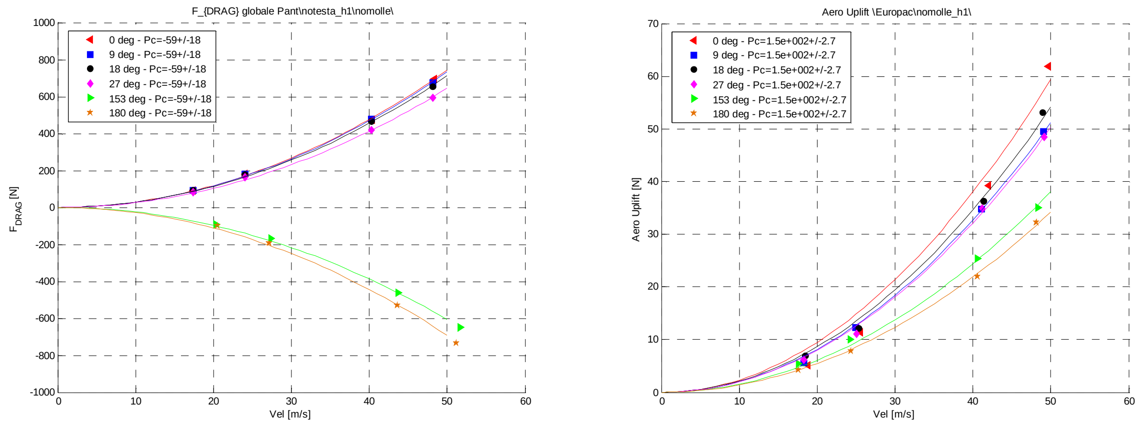


Figure 2: Global drag and uplift as a function of speed, for different yaw angles.

## 2.2 Wind tunnel test results

Examples of results concerning global measurements, such as global drag force acting on the pantograph, and uplift are reported below, as a function of flow speed and yaw angle exposure. The global forces and moments and the uplift are then considered as the sum of the contributions of the following sub-elements: fixed frame, lower and upper part of the articulated frame, arch bow. Each of the components is expressed though the related pressure coefficient. By means of a minimization procedure, that consider the global equilibrium and the action of the internal force due to the uplift, the pressure coefficients of the above mentioned sub-elements have been identified, in order to make a deeper comparison with the CFD results.

# 3 CFD ON THE PANTOGRAPH IN THE WIND TUNNEL CONFIGURATION

In order to investigate on pantograph steady aerodynamics, CFD approach has been used. Several problems related to the complexity of the shape of the pantograph, and the mesh to be used in the yawed configuration had to be managed. Pressure filed on the pantograph surface is shown as example in Figure 3 (right).

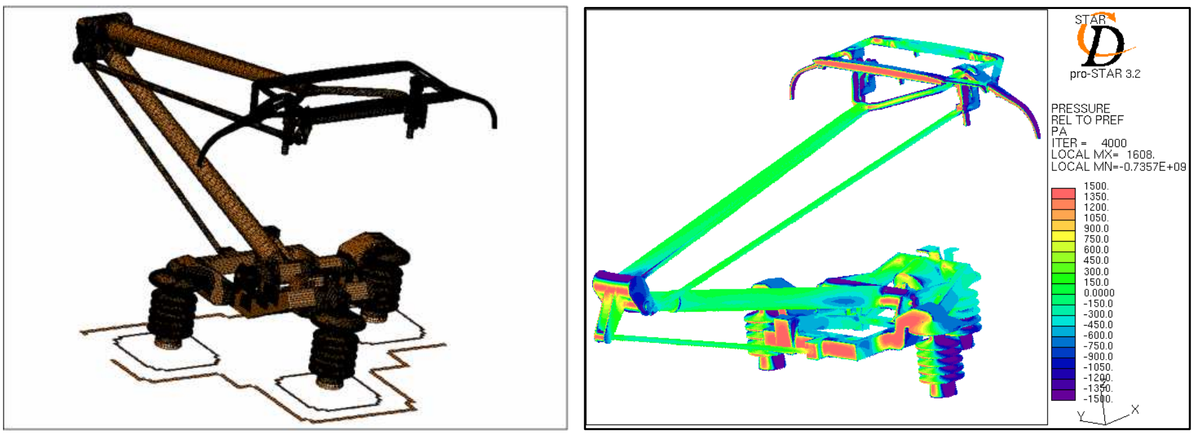


Figure 3: mesh on the pantograph surface (left). Pressure filed on the pantograph surface (right).

## 4 COMPARISON BETWEEN WIND TUNNEL TEST AND CFD RESULTS

The comparison among the global values of drag and lift forces shows great discrepancies (up to 60%). Considering the distribution of the aerodynamic actions among the sub-elements, similarities have been found: main contributions come from the fixed frame, which fortunately is obviously not active for what concern pantograph dynamics, and also the relative importance of the sub-elements is quite similar. Absolute values of aerodynamic forces are similar for what concern the collector bow and the lower arm of the articulated frame. This may be justified by the fact the former is exposed to a less disturbed flow, while the latter has e more regular shape, with respect to the upper arm of the articulated frame.

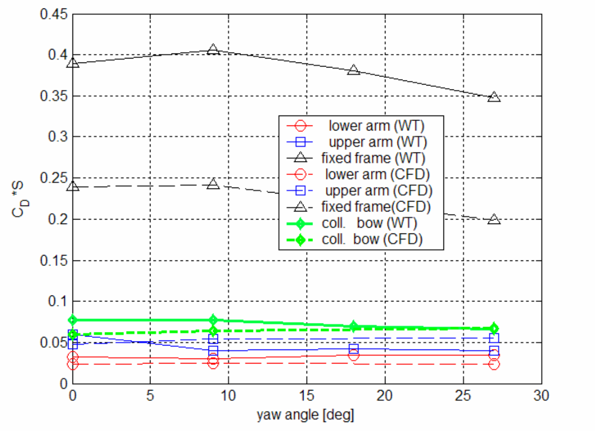


Figure 4: Pressure coefficients on the sub-elements of the pantograph: comparison between CFD and wind tunnel test.

## 5 FINAL REMARKS

The activities concerning combined CFD and wind tunnel tests on the steady aerodynamics of a pantograph in yawed configuration are presented. Similarities and discrepancies between the two approaches, to be regarded as complementary are discussed. The relative subdivision of the importance of the various sub-elements have strong similarities, while absolute values match only for the collector bow and the lower arm of the articulated frame.

## ACKNOWLEDGEMENTS

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