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NUMERICAL EVALUATION OF WIND ACTIONS ON PARABOLIC TROUGH COLLECTORS

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ABSTRACT

In order to enhance competitiveness of electricity production by solar source with respect to conventional energy sources the developments in trough-collector technology have to be addressed to reduce LEC (Levelized Energy Cost). As collector field represents more than half the total plant value, a key factor is to reduce the collector cost [1]. Various aspects can be taken into account in order to obtain this result: manufacturing simplicity, reduction of weight, of part number, and of field erection costs. In this tuning work performance requirements, i.e. optical and tracking accuracy, low heat losses, stiffness under loads, and corrosion resistance must be preserved. This means to solve an optimization problem having cost as objective function and performance as constraints. A relevant performance constraint is that the structure deformation induced by the applied loads should be compatible with public safety, optical accuracy, and mechanical functionality. Wind action represents the main load on the collector structure: as a consequence to predict its effects on the structure behaviour is a critical task [2]-[5].

In this work a methodology to evaluate wind loads on a parabolic-trough concentrator of an high-temperature solar plant is presented [6]. Such an evaluation, referring to the national and European codes and standards, is performed numerically using the CFD Flotran module of Ansys finite element code. The results, obtained for three reference speeds (7, 14 and 28 m/s) and for different angular positions of the collectors (see, for instance, Fig 1), have allowed to estimate the parabolic-trough concentrator shape coefficients within an approximation range suitable for design purposes. By using these coefficients, it is possible for every wind speed and concentrator angular position to obtain the corresponding actions on the structure. Then, in order to reassure on the degree of numerical reliability of the obtained results, a numerical sensitivity analysis of the model has been performed taking into account mesh-density and field-dimension parametric variations. At last, being the present CFD codes still “not certified”, some preliminary wind-tunnel experimental tests have been conducted, finalized to improve feeling with the numerical predictions. During these tests, numerical simulations have been performed to reproduce the experimental conditions in the wind tunnel. The results obtained by the tests and the numerical simulations have been compared using the aerodynamic coefficients. This comparison

has shown a good comprehensive qualitative agreement. The quantitative agreement is poor in same cases, corresponding to collector angular positions in which severe bluff-body aerodynamics conditions are involved. These discrepancies were expected due to some known limitations in the numerical modelling of the flow and in the experimental layout, and both should be improved. Nevertheless the numerical results can be assumed to have a suitable approximation level for structural design purposes according to national and European codes and standards.

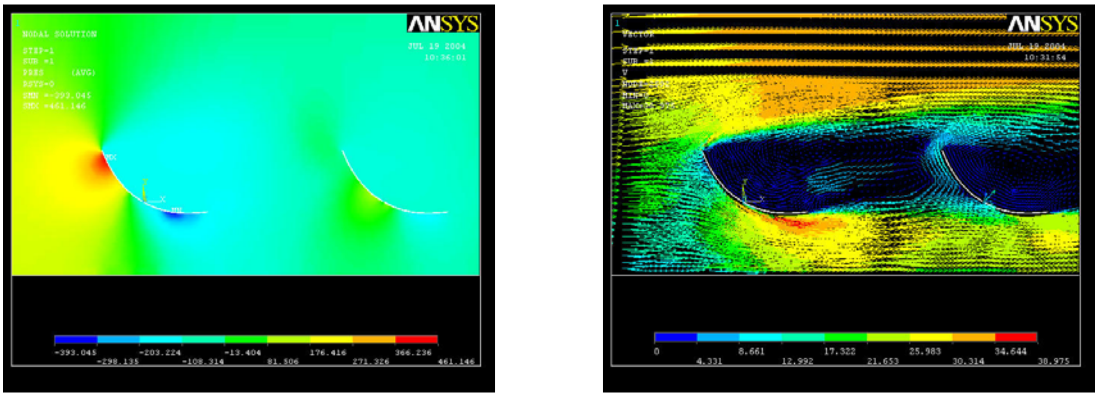

Fig. 1 – Pressure and velocity fields (wind velocity 28 m/s, angular position -30°).

The proposed methodology is able to estimate the wind actions on a parabolic-trough concentrator and it is therefore applicable to structures of this type with a level of approximation suitable for the structural design. For detailed flow characteristic predictions some improvements are required in the numerical simulation for the correct description of bluff-body aerodynamics conditions as well as some changes need in experimental layout in order to have a better matching with numerical simulation conditions.

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