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Aeroelastic Response of Slender Full Sky Telescope

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Abstract: The paper deals with advanced approach for aeroelastic assessment of slender full sky telescope (see Fig. 1) for astronomical observation of the star-sky [1]. The telescope will be positioned outside in high geographical locations with dominant action of the wind. Functional requirements in such locations have resulted in a daring structural design of the telescope. The reliability of such device cannot be estimated unless ultimate aeroelastic response is considered. Telescope is equipped with two side sheets which can be opened in order to allow the full view function. The telescope is subjected to tuned vibration control in order to face extreme wind velocities in territories of its application for the case with open side sheets. The main question to be answered was the value of maximal wind velocity allowable for the case with slightly or full open size sheets. The measurements were made on actual telescope in the wind canal. The wind velocity varied in scope from 0 until 52 m/sec. Measured were the influences of laminar air flow, with consideration of turbulences in the boundary layer in proximity of the experimental set-up (see Fig. 2).

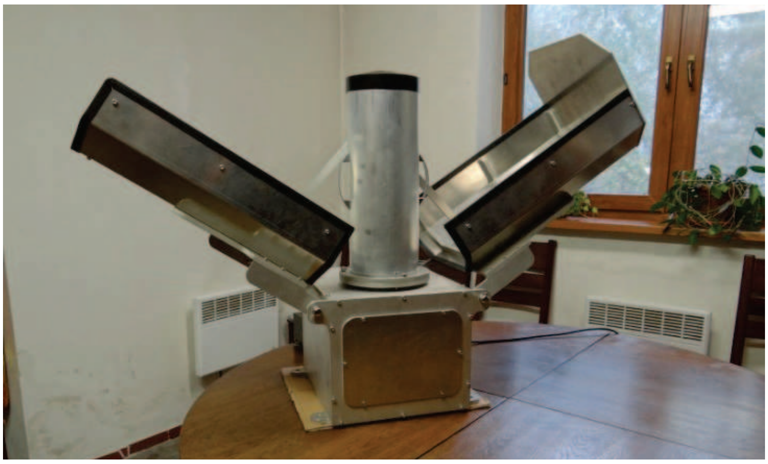

Fig. 1: Telescope in open configuration

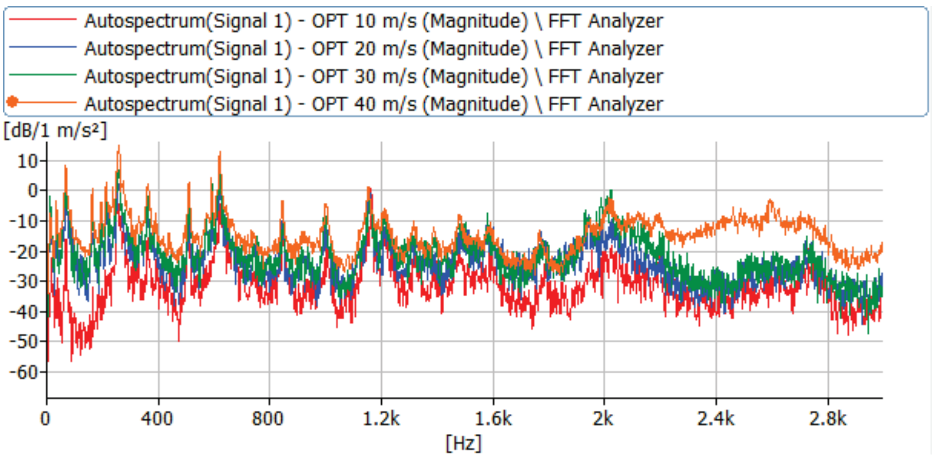

Fig. 2: Some measured RMS spectra

The measurements were made on actual telescope in the wind canal of Institute of Construction and Architecture, Slovak Academy of Sciences, Bratislava, Slovak Republic. Used was the wind canal modul with cross-section 1200 x 1200 mm and length 6000 mm. The wind velocity varied in scope from 0 until 52 m/sec. Measured were the influences of laminar air flow, with consideration of turbulences in the boundary layer in proximity of the experimental set-up. Measurements were made by the system Bruel-Kjaer, incorporated into research facilities of the wind tunnel. The experimental set-up was positioned on circular platform rotating the telescope in various directions to the wind flow.

The accelerations, velocities and deformations were registered in three points – point 1 located midspan in the face of left side sheet, point 2 located midspan in the face of right side sheet and point 3 located midspan on the top of the experimental set-up studied. The measurements were made for seven structural configurations specified below. Measured were the root mean squares (RMS spectra of vibrations) as statistical measures of accelerations studied. The accelerations were calculated and measured for series of discrete values of continuously varying functions. They were specified as square roots of the mean of squares of the values of laminar and turbulent waveforms appearing in the boundary layer.

Structural configuration:
CL – closed camera – basic position
CLR – closed camera – rotation by 45 degrees
CLQ – closed camera – rotation by 90 degrees
CLS – closed camera – rotation by 180 degrees
OP – slightly open camera – basic position
OPT – totally open camera – basic position
OPTR – totally open camera – rotation by 45 degrees

The evaluation of the results has specified the following final conclusions:

1. Closed configuration of the all sky camera studied is aerodynamically stable and reliable in whole scope of wind velocities studied (from 0 until 0 until 52 m/sec).
2. The configuration with open side fins of the camera is aerodynamically stable in scope of wind velocities from 0 until 32 m/sec.
3. The reliability of the camera at wind velocities above 32 m/sec is not available and camera must be put into closed configuration.
4. Critical wind velocity for the camera with open side fins is 32 m/sec.

The results obtained were put into the databasis adopted for tuned vibration control of the telescope.

Conclusions

Theory and numerical as well as experimental verification results sampled up in present paper submit some image on aeroelastic response of of outside located astronomy telescopes. The wave analysis adopting the FETM-approach and experiments in the wind canal were closely connected, verified and evaluated. The application was made on actual structure of the full sky telescope. The results obtained were used in the assessment of ultimate aeroelastic behaviour, aerodynamic stability as well as in tuned vibration control of the telescope studied.

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