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LOW DIMENSIONAL ANALYSIS IN MODEL IDENTIFICATION OF AEROELASTIC STRUCTURES

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Wind tunnel experiments play an important role in testing of new aircraft designs. Such experiments are very expensive both in the preparatory phase - the construction of scale model and during the measurements themselves. Therefore the numerical simulations, allowing to carry out the research without the risk of object damage, are used to predict the presence of undesirable phenomena like aerodynamic flutter (Roszak et al., 2009).

The design of the numerical model of the real object always involves some simplifying assumptions, arising both from the spatial discretization and used mathematical formulations. The examples of such simplifications are the neglected viscosity or inaccurate turbulence model of the fluid, or assumption of linear relationship between the stress and strain in the structure (Landau and Lifshitz, 1986). The aforementioned simplifications lead to discrepancies between the numerical aeroelastic model and the real object. Therefore, the recent trend in the aircraft design verification techniques is the coupling of numerical methods and experimental studies. Due to the huge number of degrees of freedom of numerical models, the coupling mentioned above is usually limited to the verification and validation of numerical model (Roszak et al., 2009).

The approach presented in this paper is based on the reduction of the aeroelastic model. Low dimensional models, with a very small number of degrees of freedom, enable the adjustment of the model's response to the measurements of real object, done in wind-tunnel experiments or in the flight tests.

The reduced order model of fluid flow is based on Galerkin method (Rempfer, 2000, Noack et al., 2003) using empirical expansion modes like POD (Sirovich, 1987, Holmes et al., 1998) or DMD (Schmid and Sesterhenn, 2010, Frederich and Luchtenburg, 2011). To include the influence of moving boundary onto flow physics, Arbitrary Lagrangian-Eulerian approach (Serrate et al., 2001, Stankiewicz et al., 2010) is used.

As the mode basis is truncated to a limited number of the most energetic modes, high frequencies are filtered and small scales are neglected in the reduced order model. The truncation, as well as possible inconsistency of data set and the reduced-order formulation (Couplet et al., 2005), result in additional discrepancies between reduced order Galerkin model and high-fidelity data (numerical or experimantal).

To correct the behaviour and improve the accuracy of Reduced Order Galerkin Model, the coefficients of the Galerkin system of ODE are adjusted (Couplet et al., 2005). Such a calibration might be done by addition of artificial, “eddy” viscosities, or modification of all linear/quadratic terms of Galerkin system, in order to recover the effects of truncated modes.

The values of corrections to the terms of Galerkin system are determined by the optimization procedure, where objective function, related to the prediction error of the model, is minimized. In this work the optimization is based on Genetic Algorithm (Stankiewicz et al., 2011).

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