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ROBUSTNESS ASSESSMENT OF A JET ENGINE SECONDARY AIR SYSTEM UNDER IMPRECISE PROBABILITIES

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ABSTRACT

In order to ensure a safe and robust design of jet engines, uncertainties must be considered during the development process. The main goal of this study is to assess the robustness of the Secondary Air System (SAS) of a low-pressure turbine (LPT). A special focus is put on the quantification of epistemic, i.e. lack-of-knowledge, uncertainties which requires efficient sampling strategies to control the computation time.
From a stochastic point of view, the input quantities of the SAS model are divided into aleatory and epistemic parameters depending on the knowledge level. For the aleatory case, a sufficient amount of data is available to assign the uncertain parameters with probability distributions. In contrast, incomplete knowledge exists about the input quantities of the epistemic category. Therefore, probability-boxes are used for the UQ, which means that the corresponding parameters are described by an ensemble of cumulative distribution functions (CDF) instead of a single CDF [1]. Hence, the epistemic component is expressed by an additional interval-valued uncertainty on the hyper-parameters.
The uncertainty sources of the SAS comprise geometrical quantities, e.g. sealing gap widths, as well as temperature and pressure boundary conditions which represent the interaction between cooling system and core gas flow. In order to model the latter in a physically consistent way, the SAS model is coupled with the aerodynamic and thermodynamic simulation which is accompanied with a higher computational effort.
Due to the variation of the distributional parameters, the stochastic moments of the response values, i.e. the cooling mass flows of the SAS, are also subject to uncertainty. Using the standard Monte Carlo (MC) Sampling approach for the robustness assessment is not reasonable because of the large computational effort. Within the scope of this contribution, the so-called Non-Intrusive Imprecise Stochastic Sampling (NISS) approach is applied which enables an efficient uncertainty propagation in the presence of epistemic uncertainties [2]. Apart from a significantly lower computation time, the study has demonstrated a high approximation quality for the response mean.
Finally, the results of the uncertainty study are used to analyze the fulfillment of the performance requirements on the cooling system. In comparison to a pure aleatory study, the influence of unknown distribution functions is taken into account.

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