A knowledge-based master-model approach to whole jet engine design
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Novel jet engine concepts and architectures are being explored to reduce mass, fuel consumption, development costs and environmental impact while increasing performance. As component manufacturers supply jet engine parts to original equipment manufacturers (OEMs), it is desirable to design components using a systems approach in order to optimize them for system-level performance. There are several issues that hinder this approach in current practice. Continuous updates in the configuration and design at the system level do not become readily available by the OEMs. At the same, engine components must be optimized to satisfy design targets that are set at the system level. Moreover, component manufacturers are often forced to work with engine system and component simulation models that have different levels of fidelity. Therefore, they need the capability to model and predict whole engine behaviour.

This is a presentation of the NFFP5 project ‘Mechanical whole jet engine design and analysis’ who is a continuation of the NFFP4 pilot project ‘Mechanical whole engine modelling’ which both are collaboration between Luleå University of Technology and Volvo Aero Corporation. The main result from the pilot project was a knowledge-based master-modelling approach that facilitates multidisciplinary design optimization. The master-model approach promotes the existence of a single governing version of the product definition as well as operating scenarios. Rules, scripts and macros facilitate the link of the master-model to domain-specific models. Changes in the master-model are automatically propagated to the domain-specific models. A simple yet illustrative industry application, using Siemens PLM NX and The Mathworks Matlab was presented where dynamics and displacement analysis were performed using the master-model and a parameter study is conducted to find an optimal design. A presented scenario investigated the impact of changing the bearing position of the turbine rear frame of a turbo-fan engine considering the load case of a “fan-blade-off” event.

In the continuation project the master modelling approach as been extended with details to include an optimization procedure. Also the demonstrator has been developed to incorporate more details of the jet engine both regarding the structure and the rotating parts. Since an optimization procedure will be used, all design and analysis activities need to be fully automatic. The master-model has been implemented using the Knowledge Fusion module of Siemens PLM NX that allows for automation of geometry configuration, pre- and post processing as well as linking the different analysis models to the master model. The Advanced Simulation module of NX has been used as pre and post processing of 3D rotordynamical analysis and displacements analysis using the NX Nastran solver. The rotordynamical response due to a mass unbalance, caused by a fan-blade off, has been applied to the structure to evaluate displacements. A geared turbo fan engine has been modelled and thanks to the generative possibilities of the Knowledge Fusion module it is possible to either by an optimization procedure or interactively swiftly try out different jet engine configurations by changing e.g. fan diameter, number of guide vanes and motor length and optimize the structure for weight and stiffness.