A CAD/CAE based multidisciplinary process for aircraft structure design

Background
Aerospace structures are complex systems and the components are highly interrelated with each other. The design process is multidisciplinary in nature, involving several design aspects, such as manufacturing cost, weight and structural integrity. Multidisciplinary design and optimization (MDO) will be used to find the well compromising design for a complex system in the conceptual design phase. Knowledge based engineering (KBE) is an technique for implementing MDO while the design and engineering engine (DEE) is a set of advance software tools which support and accelerate the design process of a complex product through elimination of non-repetitive activities. The paradigm of the DEE is shown in Figure 1.

Publications

Conclusions and recommendations
The fuselage and wing-like DEE have been successfully developed to support the MDO study of aerospace structure. The MMG is the core of the DEEs, generating the CAD models and preparing the inputs for FEA software and cost analysis tools. A large range of fuselage and wing-like structures can be modelled by the DEEs, as shown in Figure 2,3,6. The product knowledge and process knowledge are captured and restored, and can be reused for future projects. Compared with the several days of traditional design method takes, the DEEs is able to converge within several hours.

Integrated with more realistic analysis tools from industry, the DEEs could be able to find the optimum design.

Figure 1: The DEE and its components

Figure 2: Validation cases for conventional configuration aircraft: A300B2, A320-200, Fokker100, B737-200, ATR42 (right: FE models; left: resulted thickness distribution).

Figure 3: An application case for predicting fuselage weight of Prandtl plane, an unconventional configuration (right: the half FE model; middle: deflection under a selected load case; left: resulted thickness distribution).

Figure 4: Comparison with the predicted and actual fuselage weight of the considered aircrafts.

Figure 5: Weight tendency under different combinations of frame pitch and panel efficiency.

Figure 6: Example CAD models of the wing-like structures which the DEE is able to generate.

Figure 7: A design case for a control surface: what if a rib is added or removed.

Design Estimated Weight [kg] Estimated Cost ($) Baseline 60.53 26827 Baseline - 1 rib +1.63 -639 Baseline + 1 rib -0.66 +464
* The baseline design weight and cost values are also estimated from the wing DEE.

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