Concepts for a large commercial aircraft rudder

Fokker Aerostructures is a world leading specialist in the application thermoplastic carbon fiber reinforced plastics (CFRP) material on control surfaces of business jets. They want to know if they can expand their business towards large commercial aircraft. First, an aircraft is chosen to function as platform for the design phase. Multiple concepts are developed and compared using a trade study.

Initially, six potentially suitable aircraft were identified as possible platforms. The aircraft are compared among their market potential, available knowledge and possible improvements. The Airbus A330 and A350 are both, according to the research, suitable aircraft. Because Airbus reveals they will focus on cost savings, the A350 is chosen to function as a platform, due to its expensive design of the rudder.

Knowing the platform to design for, an extended analysis regarding manufacturing, repair, inspection, weight, costs and post-buckling is performed. This analysis lead to a list of possible improvements and requirements (demands and wishes) that are used to guide the ideation and conceptualization phases.

The design phase is divided into three levels: topological, typological and morphological. Every level results in structural, formal and material concepts, respectively. Evaluation regarding functionality and weight potential of the topological alternatives show that a rudder with a multi-rib frame and/or stiffened skins is viable. The typological alternatives focus on weight reduction of the ribs and skins, as those components are, according to a top-down weight estimation, the main contributors to the total weight of the rudder. Weight savings on the skins, by applying the post-buckling principle, or on the ribs, by using truss structural ribs, should finally lead to a reduction in costs.

The more detailed, morphological alternatives are assessed among the requirements and reviewed by experts. Two feasible, detailed material concepts conclude the design phase. Material concept A is a thermoplastic post-buckled multi-rib design and material concept B contains an integrated spar and leading edges, truss structural ribs and separate trailing edge.

Within the trade study, a bottom-up weight estimation shows that the proposed concepts reduces the weight by 29% and 17% for concept A and B, respectively, with respect to the current A350 rudder design. The data from the bottom-up weight estimation is used to make a Product Breakdown Structure (PBS), which serves as input for the Cost Estimation Model. The costs estimation shows a reduction in costs, the focus point of Airbus, of 28% and 20% for material concept A and B, respectively, compared to the current A350 rudder.

The skins of the current rudder are, compared to the post-buckling multi-rib design, very complex, which increases the costs of the manufacturing. The main material of material concept A is thermoplastic Carbon Fiber Reinforced Plastic (CFRP), which is, in contrary to the current rudder that is made of thermoset CFRP, recyclable. Both the current as the newly developed concepts are considered as repair-friendly.

The A350 would be the most suitable platform for Fokker to design a new rudder. Two feasible concepts are developed. The trade-study reveals that the newly designed concepts reduce weight (29%) and costs (28%) compared with the current A350 rudder design. The A350 rudder provides Fokker, therefore, with new market potential to expand their business.

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Integrated Product Design

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