An Integrated Approach for the Multidisciplinary Optimization of Engine Cycles for Rotorcraft

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This work elaborates on the potential to reduce mission fuel consumption and environmental impact associated with civil rotorcraft operations at mission level, through multidisciplinary optimization of the engine design point cycle parameters. An integrated methodology, consisting of models applicable to rotorcraft flight dynamics, rotor blade aeroelasticity, gas turbine performance and chemical emissions formation, has been developed. A comprehensive and computationally efficient optimization strategy, based on Latin Hypercube Design of Experiment (LHDOE), Response Surface Modeling (RSM) and Particle-Swarm Optimization (PSO), has been structured. The developed methodology has been applied on a twin-engine light and a twin-engine medium rotorcraft configuration. The potential reduction in overall fuel consumption and produced chemical emissions, has been assessed in the context of pre-defined, three-dimensional missions, representative of modern rotorcraft operations. The designated missions have been compiled in collaboration with the European Helicopter Operators Committee (EHOC).

Optimal engine design point cycle parameters, in terms of total mission fuel consumption and produced nitrogen oxides emissions (NO_x), have been obtained for each inves-

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tigated rotorcraft configuration. Pareto front models have been structured, describing the optimum inter-relationship between maximum shaft power, mission fuel consumption and produced NO_x emissions. The obtained results suggest that, mission fuel economy can be improved with the deployment of common design strategies leading to increased thermal efficiency, whilst simultaneously catering for sufficient performance to satisfy airworthiness certification requirements. The developed methodology enables the identification of optimum engine design specifications in a multidisciplinary manner using solely the following design criteria; the respective trade-off between fuel economy, produced chemical emissions and maximum contingency shaft power, that the engine designer is prepared to accept.