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Exploiting CFD in Aero-Thermo-Mechanical Modelling of Aeroengines

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As an aeroengine undergoes a flight cycle the rotating and stationary components expand and contract at different rates due to rotational and thermal effects. Gaps between components must be sufficient to accommodate these relative movements but result in performance losses due to flow leakage. To minimise performance losses and to avoid damaging contact, understanding and prediction of coupled aero-thermo-mechanical effects through the full range of operating conditions is required. In this context, advances in use of computational fluid dynamics (CFD) are presented with respect to engine internal air systems. These flows are often characterised by strong rotational effects and in some cases are still poorly understood. CFD contributes to understanding and prediction of engine behaviour though a range of techniques, varying from direct use in full system modelling over a flight cycle to generation of physical understanding in basic research. For flight cycle thermal modelling, efficient coupling of Reynolds-averaged Navier-Stokes (RANS) CFD models with finite element component models is achieved by taking advantage of the different timescales for the flow and the heat conduction in the components. Unsteady RANS models, large-eddy simulation (LES) and direct numerical simulation (DNS) are currently more likely to be used to investigate flows that are not well predicted by steady RANS models. Examples include turbine rim sealing flows which govern the degree of ingestion of hot mainstream gas into the turbine disc cavities, and buoyancy effected flows in co-rotating disc cavities occurring in multi-stage axial compressors. Such calculations are revealing the wealth of complex flow features present in the engine and confirm the susceptibility of rotating flows to wave formation.