Numerical and Experimental Investigations of Dynamic Stall

Wolfgang Geissler, Markus Raffel, Guido Dietz, Holger Mai

DLR-Göttingen, Bunsenstr.10, 37073 Göttingen, Germany

Abstract

Dynamic Stall is a flow phenomenon which occurs on the retreating side of helicopter rotor blades during forward flight. It also occurs on blades of stall regulated wind turbines under yawing conditions as well as during gust loads. Time scales occurring during this process are comparable on both helicopter and wind turbine blades. Dynamic Stall limits the speed of the helicopter and its manoeuvrability and limits the amount of power production of wind turbines.

Extensive numerical as well as experimental investigations have been carried out recently to get detailed insight into the very complex flow structures of the Dynamic Stall process. Numerical codes have to be based on the full equations, i.e. the Navier-Stokes equations to cover the scope of the problems involved: Time dependent flow, unsteady flow separation, vortex development and shedding, compressibility effects, turbulence, transition and 3D-effects, etc. have to be taken into account.

In addition to the numerical treatment of the Dynamic Stall problem suitable wind tunnel experiments are inevitable. Comparisons of experimental data with calculated results show us the state of the art and validity of the CFD-codes and the necessity to further improve calculation procedures.

In the present paper the phenomenon of Dynamic Stall will be discussed first. This discussion is followed by comparisons of some recently obtained experimental and numerical results for an oscillating helicopter airfoil under Dynamic Stall conditions.

From the knowledge base of the Dynamic Stall Problems, the next step can be envisaged: to control Dynamic Stall. The present discussion will address two different Dynamic Stall control methodologies: the Nose-Droop concept and the application of Leading Edge Vortex Generators (LEVoG's) as examples of active and passive control devices. It will be shown that experimental results are available but CFD-data are only of limited comparison. A lot of future work has to be done in CFD-code development to fill this gap. Here mainly 3D-effects as well as improvements of both turbulence and transition modelling are of major concern.