Paper 8.3

Application of Laser Doppler Velocimetry to unsteady flow around rotating blades

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ABSTRACT

New computational tools associated with new numerical and experimental methods have mainly improved the understanding of rotary wing aerodynamics resulting in better performances. Nevertheless some challenging problems remain to be solved with more accuracy. So are the precise prediction of the wake structure, the formation and shedding of tip vortices from blades, and the features of the flow close and around the blade. Concerning new experimental methods, the non-intrusive nature of the Laser Doppler Velocimetry has allowed many experimental works around and in the wake of rotating blades. Recently, velocity profiles measured around and in the boundary layer of a blade began to appear in the literature. As the techniques seems to be got under control in the case of axisymmetric flow, some effort remains to be paid in the case of phase dependent rotating flow. Particularly, the knowledge of the velocity field around the blade of a helicopter rotor in forward flight is of prime interest for qualitative and quantitative purposes. The experimental method presented here has tackled this challenge.

In fact, the present paper concerns a new approach of forces (lift and drag) measurement, acting on the profile of a rotor helicopter blade in forward flight. The method is based on the use of the momentum equation in which all terms are expressed by means of the velocity field measured by a Laser Doppler Velocimeter (LDV) technique. The 3D velocity field has been determined upstream, downstream and around a blade profile by means of a long focal length LDV. The experiments, conducted in a large close section wind tunnel (see Figure 1) on a helicopter rotor model in forward flight ($\mu = 0.20$), have been realized for a radial position $r/R = 0.70$ of the blade located in the advancing and retreating zones (respectively at $\Psi_b = 90$ deg and 270 deg). On a basic point of view, the section of the blade is considered as a fixed ptofile in a fictitious 2D flow where the momentum equation is applied with success to evaluate the lift and drag forces.

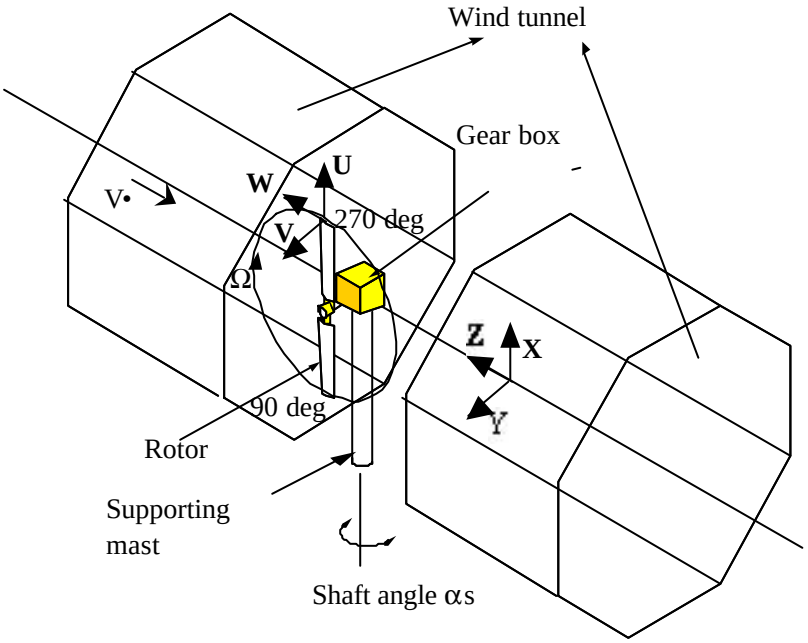

Fig. 1. Scheme of the experimental set-up in the wind-tunnel