Experimental and CFD Investigation of Helicopter BERP Tip Aerodynamics

A Brocklehurst
Westland Helicopters Ltd., Yeovil, BA21 2YB,UK

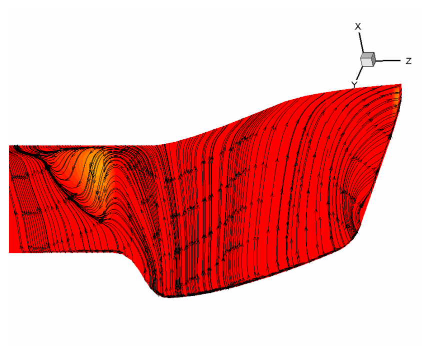
J. Beedy, G. Barakos, K. Badcock & B.E.Richards
CFD Group, University of Glasgow, Glasgow, G12 8QQ,UK

In this paper experimental results for the stall characteristics of a BERP-III blade are revisited and **C**omputational **F**luid **D**ynamics (CFD) is used to extract further understanding of the development of the flow on this planform near stall.

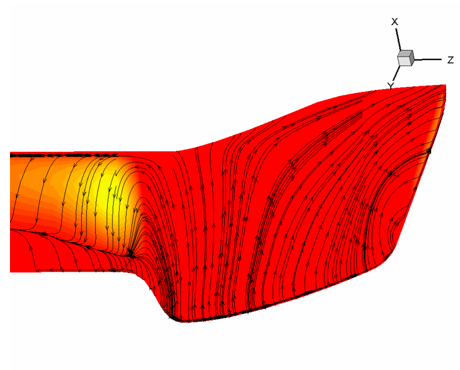
Although fixed wing aircraft have been intensively studied to determine maximum lift performance at high incidence during the landing approach, the development of stall on helicopter rotor blades limits the forward flight performance and determines the rate of divergence of control loads when the retreating blade boundary is reached.
The third phase of the **B**ritish **E**xperimental **R**otor **P**rogramme (BERP-III) resulted in a composite main rotor blade for the Lynx with a swept tip, which also incorporated forward notch offset and a highly swept outer tip edge. A key feature of the blade was that it also allowed the use of high lift aerofoils over the outer regions of the blade, while the pitching moment was compensated by employing a reflexed section inboard. This innovative design of blade enabled the Lynx to attain the world speed record of 400.87 km/hr (216.3 kts) [1], in addition to providing a significant expansion of the weight-speed envelop. Following this success, the BERP blade was also adopted for the EH101, where it enables the aircraft to operate at up to 14,500 kg AUW with a rotor diameter small enough to allow operation from small ships.
The BERP blade is now undergoing further development at Westland, and this makes it an opportune time to review some of the wind tunnel testing and analysis which was undertaken on the BERP-III blade. Although model rotor testing was carried out, this paper discussed the data obtained from a non-rotating full-scale model of the outer 25% of the BERP blade. In a collaborative programme with NASA Ames, a wind tunnel model of the BERP-III blade was prepared using the skinning tool of the Lynx blade which became available when anhedral was added to the production rotor blade. Hence the test data presented here is for the tip without anhedral. However, the use of anhedral has contributed greatly to the success of the BERP blade, in that is helps to balance sweep effects in forward flight and also enhances the performance in hover. At the time,

the main aim of the tests and NASA's CFD computations [2] was to establish CFD as a viable means of simulating the flow over such a complex planform tip. As described later in the paper, good correlation was obtained in attached flow conditions, and the major flow features of the BERP tip, both at low-speed-high incidence and at high Mach number were obtained. Later further comparisons were made with a smaller, 10" chord wing in sideslip [3].

These experiments produced a wealth of data for the BERP blade which has since been used to develop representations in rotor performance codes. However, through the EROS-UK programme, which aims to produce a complete helicopter Navier-Stokes analysis capability, and in particular using the capability developed at the University of Glasgow, has now become possible to run an unsteady viscous calculations (Figure 1) for the BERP blade. It is therefore the purpose of this paper to present these recent results, which not only confirm the earlier correlations, but also demonstrate potential for accurately simulating a rotor blade in forward flight.



25 degrees



30 degrees

Figure 1: CFD results for the flow separation near the notch region of a BERP blade. Contours indicate regions of negative stream-wise velocity (Re=0.64x10^6, M=0.2).

References

1. Perry, F.J.,Aerodynamics of the World Speed Record, 3rd Annual National Forum of the American Helicopter Society, May 1987.
2. Duque, E. P. N., A Numerical Analysis of the British Experimental Rotor Program Blade, 5th European Rotorcraft Forum, Amsterdam, September 1989.
3. Brocklehurst, A. and Duque, E. P. N., Experimental and Numerical Study of the British Experimental Rotor Programme Blade, AIAA 8th Applied Aerodynamics Conference, Portland, Oregon., August 1990, AIAA-90-3008.