Westland advances rotor blade technology

Westland Helicopters has been working on composite rotor blades since 1976. Ian Parker reports on progress to date.

Aerodynamicists commonly find themselves desiring shapes that production engineers have great difficulty achieving. Material limitations—especially in metals—have restricted aerodynamic advances to the point where complete concepts have had to be filed under "pending" until such time as new materials could be developed to accommodate structures requested by designers. Now these materials are with us in the form of composites, and nowhere have they freed the designer's pen more than in the development of helicopter rotor blades.

A fixed-wing aircraft has to operate over a reasonable speed range to accommodate take-off, landing, and cruising flight. Retractable high-lift devices allow the use of a wing section better suited to higher cruise speeds. But the aerodynamic environment of a helicopter rotor blade is much more complex, in that its speed varies continuously while the helicopter is in motion. As yet, no facility to change the blade section in sympathy has appeared.

The tip of a helicopter main rotor blade has a high, constant speed when the aircraft is in hover. In cruise, the airspeed of each point along the blade cycles with a frequency equivalent to the rotor speed, and the magnitude of the oscillation is greatest at the tip. Typically, a helicopter main rotor will have a diameter of about 45ft, and a rotational speed of 320 r.p.m., giving a tip speed of 514 m.p.h. in hover.

This means that the tip speed will vary between 664 m.p.h. and 364 m.p.h. when cruising at around 150 m.p.h. These speeds are within reasonable limits, but if a helicopter's speed exceeds 200 m.p.h., the advancing blade tip exceeds 850 m.p.h. The resulting supersonic flow gives rise to sharply increased drag, noise, vibration, and just about everything else undesirable.

On the retreating side, the inboard section of the blade is stalling, and at high aircraft speed the amount of stalled blade becomes intolerable.

Designers have known for a long time that advanced aerodynamic rotor blade shapes could push helicopter cruising speeds through the 200 m.p.h. barrier, but such shapes are extremely difficult to build in metal (Sikorsky has had some success with an advanced metal blade on the UH-60 Black Hawk). Composites, on the other hand, are ideal.

In 1976 Westland Helicopters started its Technology Demonstrator Programme, with help from the UK Ministry of Defence (MoD), to develop plastic rotor blades. Both glassfibre-reinforced plastic (GFRP) and carbonfibre-reinforced plastic (CFRP) are now used in Westland's new blades. They include a Sea King tail rotor blade being offered to operators (a cropped version appears on the Westland 30), a Sea King main rotor blade which should start flying shortly, and a new Lynx Family Blade (LFB), which Westland says has the capability to raise helicopter cruising speeds to around 200kt (230 m.p.h.).

For a given blade chord and diameter, Westland says that thrust will be increased by 50 per cent, and agility much improved. A multi-million-pound contract with the MoD has been secured for continued development, and one set of LFBs will go to the Ministry for tests.

Westland is quick to point out that work on airframe drag reduction will be necessary before any helicopter approaches 230 m.p.h. with the LFB, but the blade can fly that fast by virtue of its sophisticated and subtle shape. The aerofoil section changes along the span of the blade, and although Westland will not reveal exact details, the sections are known to be aft loaded, with some reflex curvature incorporated in the inboard section to relieve blade twisting forces at the hub. The blade has a built-in nose-