The Open University

Soaring by Design

Wing Design: Testing and Building

Ian Johnston:
As with any model, it's essential to compare mathematical predictions of airflow with the real thing. One easy way of doing this is with tufts – short lengths of wool – attached to the wing which give a very clear indication of airflow of the surface.

Narrator:
We're using a Dimona which is essentially a glider in shape and performance, with the added benefit of an on-board motor to get it airborne.

Ian Johnston:
We're now flying normally at a steady speed of about 100 kilometres an hour, but if we slow down and increase the angle of attack, the airflow of the wing, which is now quite smooth, changes drastically. 90 kilometres an hour…84…82… and the back of the wing has stalled. The airflow is very turbulent. Incidentally we've made the assumption that the airflow comes along a line perpendicular to the leading edge of the wing. This doesn't always have to be the case. It's also perfectly possible for the wing to slip sideways, in which case the direction of airflow changes, but this greatly increases the Drag and is normally avoided in flight.

Narrator:
Having modelled the interplay between Lift and Drag then the full profile of a wing can be designed to a chosen performance specification. Nowadays Computer Aided Design permits plans to be swiftly drawn out but you still have the task of constructing it. This is an aerofoil for a glider being constructed at the Akaflieg Karlsruhe. As in all modern gliders the main material in use is carbon fibre. Each thin sheet of this material can bear loads of up to 600 Nm-2. The carbon fibre sheets are impregnated with resin which allows them to be sandwiched together in layers in the shape of the mould. Different sections of the glider will require different thicknesses of fibre. Two layers of carbon fibre can be sufficient for the relatively low stresses placed on a tail plane like this. However, seven layers of fibre may be needed to withstand the forces on the fuselage, particularly where it meets the wings. To see how strong carbon fibre can become you only have to try trimming the edges. This is a moulded piece of the main wing. You saw something of the way in which the shape of a wing mould is put together by joining up wooden cross-sections of the wing shape. This method of mould construction is very much the industry standard, although some compromises in precision are inevitable. Remember, the ideal is to have an elliptical curve to the leading edge of the wing and that's only approximated here. However, at Karlsruhe the Akaflieg has been investigating the idea of machining the entire shape of the wing mould out of various materials to produce a precision mould of the surface, including an elliptical leading edge. It's no mean task, involving several stages. The Computer Designed surface has to be ground out of polystyrene which is, in turn, buried in sand and baked hard. The volume of the polystyrene shape is then taken up by molten aluminium once the polystyrene is evaporated away. This method of wing-mould manufacture is very much an experiment. The final stage of the mould-making involves a milling down of the surface to produce the smooth finish. It's costly business with each wing requiring eight sections like this one. It's true that at the higher levels of performance even dust on a wing can have an adverse effect so techniques like this, which produce more and more perfect aerofoils, may be needed to push gliding performance that bit further. The debate to come, after the trials, will be whether there's enough improvement in performance to justify the expense.