METAL-to-METAL BONDING

—for Aircraft Structures : Claims of the Redux Process

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THAT synthetic glues for wood were used extensively for making Mosquito and Hornet aircraft during the 1939-45 War, and are now used for making Vampires in many European countries, is well known to aeronautical engineers, but not so well known is the fact that, since 1944, synthetic glues for metals have been used in the production of many hundreds of military and civil aircraft.

A glue for metals, which gives joints stronger than can be obtained by riveting and which is also resistant to the severe conditions to which aircraft are exposed in service, offers the possibilities of savings in structure-weight and of aerodynamically cleaner wing and fuselage surfaces. Such a glue may also be expected to be of value in the manufacture of pressurized fuselages, because it will avoid the large number of small leaks occurring at the rivet heads and may also help to solve the difficult problem of making integral fuel tanks in aircraft wings.

Any savings in structure-weight or drag which may be possible on a high-performance, jet-propelled aircraft must be of even greater importance than on a piston-engined type, because of the relatively high fuel consumption of gas turbines. It is interesting, therefore, to learn that the Redux process of metal bonding has been used extensively by de Havilland Aircraft Co., Ltd., in the construction of the wings and fuselage of the Comet.

The earliest use of Redux in aircraft construction was in the manufacture of the Hornet single-seat fighter. The de Havilland Company was faced with a difficult problem because of the large wooden booms required for the wing spars. The difficulty was overcome by making the tension booms of aluminium-alloy extrusions but still using wood for the spar webs and compression booms. The metal and wood were then glued together so as to form a spar of remarkably low weight and high strength.

A somewhat similar design is used by Vickers-Armstrongs, Ltd., for the floors of the Viking and Viscount. Aluminium alloy top-hat stringers are bonded to the undersides of sheets of plywood to form floors whose upper surfaces are quite free from any rivet or bolt heads. B.E.A. Vikings have now flown for considerable numbers of hours and no trouble has been reported with the Redux. A more recent example of metal-to-wood bonding may be found in the fin of the Canberra bomber. The fin is of wooden construction because it houses aerials and it is attached to the extruded aluminium alloy spars by means of the Redux process.

It is interesting to note that Redux has already been used by The Bristol Aeroplane Co., Ltd., in the construction of their single-rotor and twin-rotor helicopters. The process has provided a convenient way of attaching metal trim-tabs to wooden rotor blades and has been of great value in making experimental metal rotor blades. It has also been used in the construction of the fuselages of both types.

Strength Characteristics

Although uses of the process for bonding metal to wood are of interest, the application of the system to all-metal structures is likely to prove of far greater importance. The need for smooth, thin wings is more pressing than ever, and the hitherto normal riveted construction is open to criticism, both because of the need to keep structure-weights to a minimum and because of the aerodynamic effect of the rivet heads. Determined efforts have been made to diminish this effect, either by machining the heads or by finishing the wing surface with special fillers. Spot welding has been used, but even this leaves small marks where the electrode makes contact with the skin.

A gluing process offers an entirely different line of approach.

Glued joints should be designed, as far as possible, for loading in shear. As might be expected, the breaking load varies in proportion to the width of the joint, but it is only proportional to the joint length for very small overlaps. For larger ones it scarcely increases with length of overlap. The strength of the joint also increases (a) with the thickness, and (b) with the mechanical properties of the metal test-pieces.

The explanation of this behaviour is to be found in the stress concentrations in the joints. The load is not uniformly distributed over the whole of the glued area, but is mostly taken by the ends of the joints. The stress concentrations may be considerably reduced by tapering the metal test-pieces, with a corresponding increase in failing load of the joint, but it seems unlikely that tapering the metal would be an attractive proposition in practice.

Another aspect of this matter is the way in which the strength of the joint varies approximately in proportion to the yield point (0.1 per cent proof stress) of the metal strips used to make the joints. The table giving failing loads of ½in overlap joints made from 20 s.w.g. strips of metal, illustrates this point.

Material	Failing load of Redux joint (lb/sq in)	Yield point of metal strip (tons/sq in)
Aluminium, half-hard	1,100	5.8
Alclad D.T.D. 390	3,600	15.0
do. D.T.D. 546	4,000	21.0
do. D.T.D. 687	5,000	26.0

The failing loads given for glued joints between strips of Alclad are several times higher than can be obtained with spot welding or riveting. Care must be exercised, however, in applying the results of these small-scale tests to the design of aircraft structures, and I believe that the following results are likely to prove of far greater interest to designers. This is particularly true in that many of them offer a direct comparison between the strengths of riveted and glued panels when tested in the way that they are loaded in an aircraft structure. The Gloster Aircraft Co., Ltd., tested some panels of a design somewhat similar to those used on the Meteor. They consisted of a 24 s.w.g. skin to which a 24 s.w.g. top-hat stringer was bonded. In compression this panel failed at an average load of 2.5 tons, while a similar riveted panel withstood an average load of only 1.8 tons. Thus the Redux-bonded panel carried an average load 40 per cent greater than that of the riveted panel. The corresponding figures for test specimens consisting of a 24 s.w.g. skin with two 24 s.w.g. stringers were 4.25 tons for Redux and 3.16 tons for riveting.

A further point must be borne in mind when considering these results. The panels were designed for riveting and not for Redux bonding. It is possible that had the stringers been modified (but without increasing their weight), still higher results with Redux might have been obtained. Redux bonding is an entirely new technique, and the best results are obtained only if the design is made for gluing. A design which is suitable for riveting is not necessarily suitable for gluing, and vice versa.

Another interesting series of tests has been carried out by the Bristol Company. In these experiments a panel reinforced by stiffeners was bolted round its edges to a box and submitted to a fluctuating air pressure similar to that occurring, for example, on the trailing edge of an aircraft wing. The panels were all 4in × 24in and the ½in × ½in × 20 s.w.g. stiffening angles were all parallel to the shorter edge.

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