The Application of Plastics Materials to

GAS TURBINE ENGINES

The following article is abstracted from a paper "The Application of Non-Metallic Materials to Gas Turbine Engines", read before a meeting of the Canadian Aeronautical Institute by J. A. Fortune of Orenda Engines Ltd.

IN THE NEVER ending search for better materials a good deal of effort has been concentrated on the development of plastics and reinforced plastics, because of their inherent properties.

Let us first consider some of their characteristics and merits for gas turbine engine usage. In addition to the possibilities of decreasing weight per unit, the use of reinforced plastics, with their inherent "vibration damping" characteristics, should lead to a significant reduction in the number of fatigue failures of components subject to alternating stresses, e.g., compressor blades. Thus reinforced plastics will eventually make their major contribution to jet engine development.

Research Applications: Due to their versatility, reinforced plastics find many uses for basic research applications. One such application, made for the purpose of studying the effect of a shroud around compressor discs, proved most effective. As the disc would be spinning at a speed of about 6800 rps, adequate hoop stresses had to be built within the shroud to combat centrifugal forces. In order to measure the maximum pre-stress possible, test specimens were wound using a split, steel disc which was then mounted in a test machine. A typical specimen had a bursting strength of 12 tons with a measured ultimate tensile strength of 185,000 psi. One interesting fact is the very low resin content and the poor primary adhesion (i.e. adhesion between the glass and the fibre). The resin content of these test shrouds ranged from 11 to 14 percent dependent upon the amount of pre-stress applied, usually 28,000 to 35,000 psi.

In spite of this low resin content and poor primary adhesion, test specimens have been wound with ultimate tensile strengths ranging from 185,000 to 265,000 psi. It would appear, therefore, that primary adhesion, which is regarded within the plastic industry as the main factor for producing strong laminates, does not completely explain the mechanics of reinforcement.

We feel that only about 10 to 15 percent of the strength within laminates comes from primary bonding of the resin and fibre and that 85 to 90 percent of the strength comes from frictional resistance between the fibre and resin. This resistance is formed when the resin shrinks against the fibre during cure and from pre-stressing or pressures applied within the laminate. Stress-strain curves plotted from tests on flat specimens indicate the above theory to be correct. This

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FIG. 1

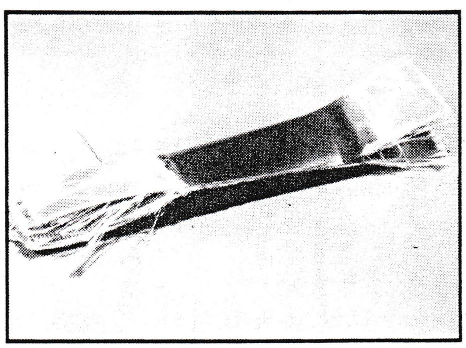


FIG. 2

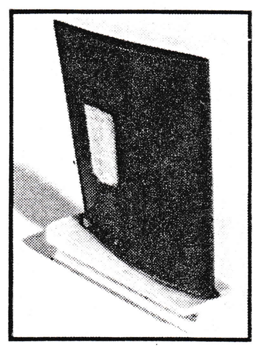


FIG. 3

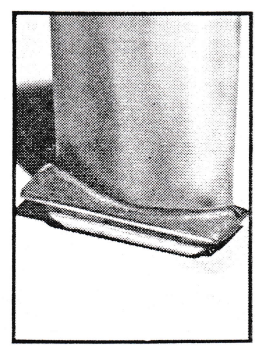


FIG. 4

Pictures show, top: Fig. 1, reinforced plastic blade, trimmed: Fig. 2, reinforced plastic blade from mould: Fig. 3, reinforced plastic blade with aluminum root mounted; Fig. 4, build-up of blade platform .055 in. with plastic. Bottom: Fig. 5, injection moulding for building up blade platform; Fig. 6, build-up of blade tip .07 in. with plastic: Fig. 7, combination of platform & tip build-up with plastic: Fig. 8, thickening of blade with plastic.

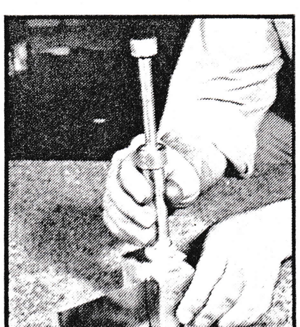


FIG. 5

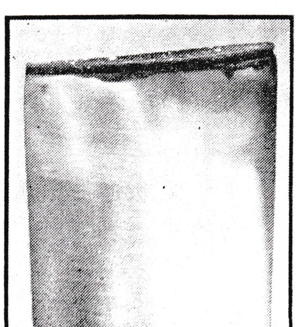


FIG. 6

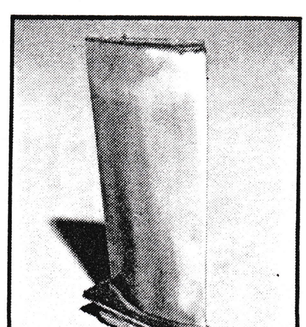


FIG. 7

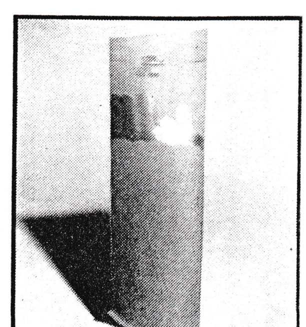


FIG. 8

vancement of science in Canada. For many years it has been acquiring scientific and technical papers from all countries, and Russia is no exception.

In addition to books, over 150 Russian language journals arrive regularly covering fields of science and technology from astronomy to zoology and atomic energy to welding.

Acquiring Russian scientific literature has never been easy, anywhere in the Western World the NRC says. Even now, when there is greater freedom, it is still very difficult. One source of books is through the Eastern Zone of Germany, where German translations of Russian books are being turned out in large numbers.

Aerophysics Activity

That the University of Toronto's Institute of Aerophysics had a busy year in 1957, is indicated by the annual progress report released recently.

The report shows that Institute researchers conducted investigations in six different fields, including the Mechanics of Rarefied Gases, Unsteady Flows—Shock Tubes, Steady Flows—Wind Tunnels, Aerodynamic Noise, Propulsion, and Airplane Dynamics & Aeroelasticity.

On behalf of the Defence Research Board, the Institute carried out some 36 investigations; for the U.S. Air Force Office of Scientific Research, nine investigations; for the USN's Office of Naval Research, two investigations; for Avro Aircraft Ltd., four investigations; for Orenda Engines Ltd., three investigations; for The de Havilland Aircraft of Canada Ltd., two investigations.

Guided Torpedo

Royal Australian Air Force Maritime Reconnaissance squadrons are equipped with an anti-submarine weapon which can seek out and destroy a submarine operating below the surface. The highly specialized weapon was developed in the U.S.

The torpedo is launched from an aircraft in an area where the submarine is known to be. After entering the water, the torpedo stalks the submarine and finally carries out a high-speed attack following every evasive maneuver by the submarine.

A RAAF training school has been training RAAF aircrew and technicians for nearly three years on the use and maintenance of the guided torpedo. The instructors at this school were originally trained at a special U.S. Navy school in the U.S.

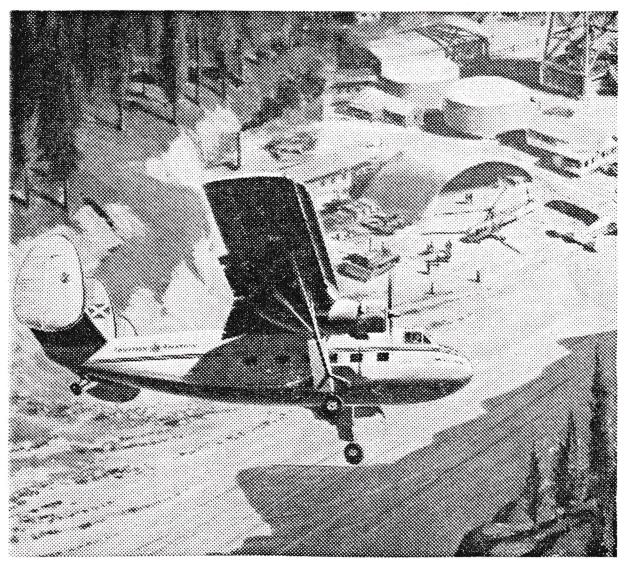
PLASTICS

(Continued from page 26)

theory and technique could lead to the production of laminates with much higher mechanical properties than have been produced up to the present time.

Plastic Blading: Figure 1 illustrates one of the most unique uses of reinforced plastics in the jet engine field — the reinforced plastic compressor blade. Figure 2 shows the blade in the as-moulded condition and Figure 3 shows the blade trimmed and with the aluminum root mounted.

Orenda Engines has gained over a thousand hours engine running experience with reinforced plastic blades. Not one failure of a plastic blade has occurred during this time. The blades have operated at temperatures greater than 400 degrees F. and were unaffected by J.P.4 jet fuel or di-ester lubricating fluids. These blades have shown extremely good wear and heat resis-



tance during operation in engines and have been tested in the third to the ninth compressor stages inclusive. Although all blades tested had aluminum roots, designs of complete plastic blades are now being evaluated.

In our plastic blading program the lack of design data in the reinforced plastics field became quite apparent. This lack of design data is probably the greatest single factor in preventing the more widespread use of reinforced plastics. The major task of the plastics laboratory at Orenda Engines Limited is the gathering of engineering data for design purposes, along with the proper applications of plastic materials for production usage.

Further demonstrating the versatility of plastics, the platforms of the roots of some blades were built up 0.055 inches with plastic. An example is shown in Figure 4 while Figure 5 shows the injection moulding technique used. Figure 6 illustrates the build up of a blade tip 0.070 inches with resin which must withstand an operating temperature of 400 degrees F. A blade with both the platform and the tip built up is shown in Figure 7.

To study the effect of thickened blades on engine performance, blades were thickened with plastic ranging from 0.055 inches thick at the base to zero at the centre, Figure 8. These blades withstood tests in vibration for 5 x 106 reversals at a stress level of 30,000 psi.

The Future: Reinforced plastics appear to have a very bright future in jet engine application. The first major step has been taken at Orenda Engines Limited by designing specifically in reinforced plastics and not merely trying to duplicate a steel or aluminum configuration. In order to do this the concept of reinforcing filaments oriented in a specific pattern to carry calculated stresses must be followed. It is possible in a laminated member to tailor the reinforcement. Careful selection of base resins, fillers, catalysts, reinforcing materials and development of new handling techniques will progress to a more widespread use of these materials.

COMING EVENTS

February 3-4—Symposium on Flight Control and Panel Integration, sponsored by Flight Control Lab., Wright Air Development Center, Biltmore Hotel, Dayton, Ohio.

February 12-13 — Annual Meeting, Air Cadet League of Canada, Seigniory Club, Montebello, P.Q.

February 27-28—CAI Mid-Season Meeting, Hotel Vancouver, Vancouver, B.C.

March 3-6—ASME International Gas Turbine Power Conference, Shoreham Hotel, Washington, D.C.

March 15—Annual Meeting, Soaring Association of Canada, Sheraton-Mt. Royal Hotel, Montreal.

March 17-21—1958 Nuclear Conference, International Amphitheatre, Chicago, Ill.

April 21-22—AITA Semi-Annual Meeting, Empress Hotel, Victoria, B.C.

May 26-27—CAI Annual General Meeting, King Edward Hotel, Toronto.

June 14—Air Force Day across Canada.

NEW GUINEA

(Continued from page 35)

administration's Development Program.

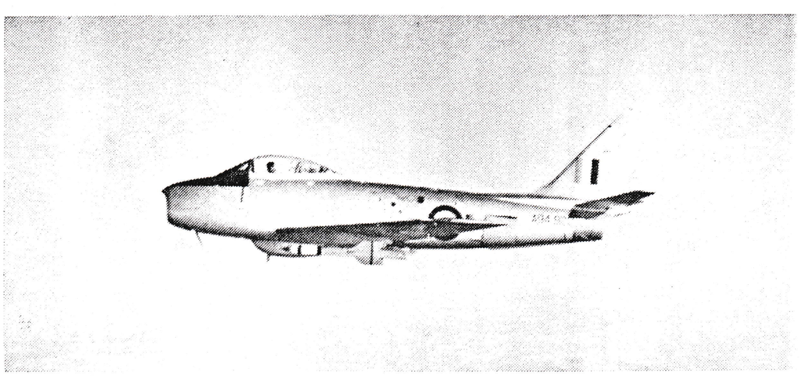
In 1956, 55,000,000 feet of logs were cut and trimmed. A modern plywood factory with an annual capacity of 48,000,000 square feet has been built at Bulolo and a considerable expansion of coffee acreage has been reported. Exports from the Papua region of rubber, copra, cocoanut oil and sawn hardwood have contributed greatly to the prosperity of that area. Gold production has also been increased in the Territory.

Extending Control: When World War II ended less than a quarter of the Australian mandated Territory was under effective Administration control. By the end of 1956, patrols using New Guinea Internal aircraft for reconnaissance and supply had established some measures of control over three quarters of the interior. It is expected that by the end of 1958 the entire Territory will be under effective Administration control.

In neighbouring Netherlands New Guinea, the rate of development has closely paralleled that of the Australian Territory. Over the past several years the areas under cultivation have been vastly extended. Existing seaports have been improved and new ones constructed. At Meruake, a principal port, a ship repair depot has been established that can drydock ships up to 2,500 tons and at Meruake and Biak airports have been constructed that can accommodate large air carriers. Other evidences of the Program's success so far include the new saw mill at Manakwai capable of an annual output of 12,000 cubic M of sawn timber and the large number of houses built to accommodate native workers.

As in the Australian Territory, utility air transport was essential to the success of the Dutch Development Program. In 1954, in addition to the four Beavers for QANTAS, two others were delivered to the Netherlands government. These aircraft formed the nucleus for Nieuw Guinea Luchtvaart Mastachappy (NGLM) an air service to link the interior communities with the coastal settlements. One of the two aircraft was fitted with floats. In 1956 the service was expanded with the purchase of two additional Beavers. While serving a similar mission to the QANTAS New Guinea Internal service, NGLM differs organizationally. Although operated by KLM personnel it is entirely a government enterprise.

Lighter Side: There is a lighter side



SABRE WITH FIRESTREAK: An Australian built Avon-Sabre is shown carrying two de Havilland Firestreak guided weapons. The photo was taken during the recent trials of the Sabre/Firestreak weapons system. The 10 ft. 6 inch Firestreak is fitted with four small wings and four control fins. Guidance of the weapons is achieved by an infra-red homing system.