BRITISH MANUFACTURING PRACTICE...

Section of a stainless-steel brazed honeycomb leading-edge for an Avro supersonic aircraft.

rotatable drum. A compound of chips, abrasive and foam-producing powder and water sufficient to cover the load was added, and the drum rotated for a period dependent on the hardness of the material, the nature of the chips, the load, etc.

Another method was by vapour blasting, in which process a slurry of water and a fine abrasive compound was pumped through a nozzle and accelerated by compressed air. The jet was directed on the workpiece and the abrasive, peening and compressive effect greatly increased the fatigue life of the material.

Metal Adhesives and Honeycombs. Increasing use was being made of metal adhesives in the manufacture of primary structures. Insofar as the actual bonding methods were concerned the techniques varied between companies. Some used electrically heated muffles, some steam-heated presses, and others steam-heated autoclaves. Most of the major firms used a combination of all three.

Higher Mach numbers inevitably increased the use of stainless steel in aircraft and missile construction. Stainless-steel sandwich with honeycomb core was one of the most efficient methods of fabricating these structures with the least weight penalty. Brazing of steel honeycomb was extremely difficult, but very large structures had been successfully produced by A. V. Roe. One of the problems was the high temperature necessary, which caused oxidization of the surface. The components were accordingly sealed in "coffins," which were purged thoroughly with nitrogen, then a gaseous flux was introduced. It was necessary to use a special type of honeycomb in order that each cell should be able to "breathe," and thus rid itself of all air. The brazing took place in large electrically heated furnaces and after this operation nitrogen was again introduced to clear the "coffins" of the gaseous flux.

Plastics. Considerable quantities of plastic material were being used by most British firms for tooling purposes. Plastics were used for drop-hammer tooling, rubber die tooling, ironing caps for rubber die tools, hammer form-blocks, dressing blocks, and so on. Glasscloth resin-bonded laminates were being used for the manufacture of drill gates, profile plates, routing templates, chemical-erosion templates and other purposes. Reinforced glasscloth-laminate resin-bonded tubing was in use, chiefly for the manufacture of jigs and checking fixtures.

Bristol Aircraft had been experimenting with automatic injection methods for the manufacture of Fibreglass-bonded mouldings. The same company were manufacturing asbestos phenolic resin-bonded drop tanks by the autoclave method. The pre-impregnated asbestos felt was laid up in aluminium tools and cured at a temperature of 150 deg C at a pressure of 100 lb/sq in for 20 minutes.

Vacuum forming was now almost universally favoured for the manufacture of canopies. In this method the heated Perspex did not touch any form block, the only restriction being at the edges of the canopy where it was attached to the metal frame, thus securing the peripheral shape. Much better optical properties were obtained by this method and the amount of hand polishing necessary was greatly reduced.

A number of firms were using plastic tools for the manufacture of small batches of components. They were easily and cheaply made and showed a marked economy over manufacture by machining methods.

Aircraft Production Conference—2

THE AMERICAN SCENE

COMPLEMENTING Mr. Burnard's lecture was the Lord Sempill Paper, delivered by Mr. Boyd K. Bucey, vice-president (manufacturing) of the Boeing Airplane Company. Under the title *Manufacturing in the Aeronautic Age,* it reviewed modern American methods in regard to both organization and production techniques.

Rapid and startling scientific and technological advances, said Mr. Bucey, were the most outstanding aspects of the age. In the United States some 5,000 laboratories were spending $7 billion a year on scientific and technical research. More than 200,000 professional scientists, aided by many times this number of skilled technicians, were engaged on research, while a similar number were adapting the laboratory information to everyday use. Increasing complexity and long lead times dictated that improvements be made in large increments, such as jumping from a transonic bomber to one capable of Mach 3 or 5 with corresponding improvements in altitude, range and reliability.

Cost Limitations. Stringent funding policies were complicating the design and manufacturing problems during the transition period, and there was a corresponding increase in cost of design, development and production. Greater reliability and reduced maintenance were necessary in order to lower defence costs. Costing would be a determining factor in selection of new weapons and companies to produce them.

Learning to Adjust. The steps taken by the American aircraft industry were nearly all aimed at strengthening management by better utilization of human resources. The making of day-to-day decisions had been accelerated, and the power to make and implement them had to be delegated to the lowest possible level. An additional technique, known as operations research, was used to evaluate future trends in weapons and commercial aircraft from the economic, political, psychological and technical viewpoints. This technique also highlighted areas of weakness in design or manufacturing "know-how," so that strengthening of such areas could be accomplished.

Despite criticism of the use of committees, management had found that these were very effective tools, particularly now that emphasis was on co-operative rather than individual effort.

Much more attention was being paid to personnel selection, and considerable emphasis was being placed on locating and developing the talent within each company. A planned induction period varying from a few weeks to many months was used to establish the correct relationship between the new person, his supervisor and the company. If he was ready for advancement, a training programme specially fitted to his needs was worked out with him by his supervisor.

Common Problems. All major airframe and engine builders and many major suppliers belonged to the Aircraft Industries Association of America, which was concerned with industry-wide aspects of aircraft research, development and production. It attempted to work out co-operatively among its members the solutions to problems of common interest.

Technical societies were assisting in the free interchange of ideas, developments and techniques by means of symposia, forums and technical papers. Educational and technical institutions were making valuable contributions in the fields of basic and applied research.

The basic function of inspection had been replaced by quality control. This was the responsibility of everyone, and applied not only to production of parts but also to design, planning, method study, procurement, etc., since all these could affect the end product.

The time necessary to develop a new aeroplane was being shortened by employing an organization known as manufacturing research, whose primary responsibility was to anticipate design and operational requirements and develop quickly the production know-how, tools and equipment to meet the design requirements.

Production Techniques. Cutting was one of the first operations in aircraft production, and great accuracy was necessary to prevent waste, reduce assembly time, and to provide the essential aerodynamic smoothness. Friction sawing of titanium alloys and stainless steel was becoming common. Saws were normally run at between 4,500 and 6,500 r.p.m., were cheaper and faster than tooth saws, and caused only slight burring.

"Cookie cutter" dies for sheet-metal blanking, made by a patented technique, cost only about one-tenth of the figure for conventional dies, and were capable of blanking thousands of parts from 4130 steel in thicknesses up to ¼in.

The large forging-press programme had resulted in the building of one 50,000-ton and one 35,000-ton press. It was possible with this type of machine not only to produce larger forgings, but forgings with thinner webs and closer tolerances, thus reducing machining. The newly developed draftless type of forging further reduced machining and in many cases produced forgings with mechanical properties which could not be equalled by conventional methods.

Machining. The amount of machining on high-performance aircraft continued to increase. Weapons built for Mach 3 to 4 would probably use steel for their aerodynamic surfaces and excessive tolerances on skin material could produce staggering increases in weight. It would be possible for a bomber having 2,000 sq ft of wing area to show a weight increase of about 5,000 lb if the skin material was on the high side of the tolerance. This could mean a 50,000 lb increase in a.u.w. to cover the extra powerplant, fuel and structure needed to fly the additional 5,000 lb.

Chemical Milling. This was a technique with an almost unlimited future. Besides its better known uses it was also being used for machining parts to closer tolerances than was possible by mechanical machining. Forgings and other components would be mechanically machined to a slightly greater overall size than the finished part, and then chemically milled all over to the blueprint dimension. This eliminated the warping problem, and removed the limitation of minimum web thicknesses.

Forming Techniques. Improved techniques had been developed to cope with more complex three-dimensional shapes. One such development was impact forming with a trapped rubber head. Instead of hydraulic power to apply pressures around 10,000 lb/sq in, drop hammers with rubber retaining heads were used to apply similar pressures. When these machines were used for hot forming the tool and part were in contact for so short a period that the part did not cool appreciably and the rubber remained undamaged. A variation of impact forming was explosive forming. Shotgun shells were enclosed in a die to provide power for making relatively deep or complex draws, or dimpled holes in some of the tougher steel and titanium alloys.

New Materials. Mr. Bucey concluded by reviewing new materials and various joining methods, including adhesives, brazing and fusion, spot and resistance welding. He also described a method of producing radomes in which glass-fibre rovings were mechanically wrapped round a tapered mandrel in alternate circumferential and longitudinal layers, and then cured. It was possible by this means to produce a radome with an electrical tolerance of 1 deg I.P.D.