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NASA TECH BRIEF

Development of Technology for Hot-Drape Forming of Large Torus Sections

The problem:

The introduction of new alloys and the increasing demand for very large, compound-contoured sheet metal structures have presented new problems to existing technology in metal forming and heat treatment. A specific problem was that of forming and heat treating aluminum alloy skin sections for a 200-inch outside-diameter torus test tank to close contour and thickness tolerances.

The solution:

A development of hot-drape forming (a procedure that was originated elsewhere), which is a method combining hot-stretch forming, die quenching, and age forming. This method of forming permits in-process control of material gage thin-out through a flexible process of heat zone control. It allows the operator to control the exact temperature requirement in different portions of the metal section during the forming operation to obtain the prescribed contour with minimum thin-out.

How it's done:

The process involves the use of an integrally heated ceramic die in conjunction with a hydraulically actuated stretch wrap press. These, together with attendant controls and electrical, hydraulic, and water supply systems, constitute the entire forming and heat treating installation.

The single (male) die is constructed on a heavy welded steel base which contains support legs and attachment means. The die surface consists of a ceramic cement which is cast over a backup of shaped, dense ceramic foam blocks cemented in place. These blocks serve both as a compression support for the die face and as thermal insulation from the steel base. Independently controlled electrical heating elements set in the die provide for the flexibility of the selective-zone temperature control. The temperature of the die is monitored by thermocouples imbedded in the die surface. The face of the die is coated with boron nitride, a high temperature lubricant. This lubricant allows the workpiece to slide more easily over the die surface while it is being stretched and also prevents scratching of the material. The need for a scuff sheet between the die and workpiece is thereby eliminated, thus providing better control of temperature uniformity over the entire area of the heated workpiece.

The workpiece, consisting of the recently developed 7039 aluminum alloy sheet material, in the annealed condition, is held at both ends in a vertical stretching machine by specially designed jaws. The die is heated to approximately 600°F, and the material is wrapped around the die. As tension is applied on the jaws, the stretching of the material is closely observed by the operator. He thus determines which heating elements are to be turned off or on to decrease or increase the yield of the material in a particular zone.

When forming is completed, the tension on the jaws is slackened only enough to stop stretching, while still keeping the material snug on the die. The heating current to the die is then then increased to produce the solution heat treatment temperature of 880°F. A pair of insulating doors, hinged to the die fixture, are now positioned close to the heated skin to reduce thermal radiation losses from the skin surface. The die and the skin are kept at a temperature of 880°F for the required length of time, after which the heat is turned off. Then, with the aid of a special spray hood, the skin is water quenched on the outside at a prescribed rate. After quenching is completed, the skin is backed

(continued overleaf)

away from the die, and water spray is directed to the surface of the die to prevent it from reheating the skin.

For aging, the skin is brought back in contact with the die, the heating current is turned on again, and the temperature of the skin is raised to the required degree. The temperature is held at this point for a prescribed number of hours, after which the heat is turned off and the skin is allowed to cool to room temperature. The 7039 alloy, then in the T63 condition, is removed from the jaws and is ready for rough trimming and inspection.

Notes:

1. In conjunction with this work, a method was developed for forming flared ports of smooth transition, which offer a minimum of resistance to fluid flow and a continuous surface for welding attaching conduits, to the hot-drape formed torus segments. In essence, the method is to withdraw a spherical punch or ball through an undersized developed cutout while the workpiece is restrained in a matched die.
2. Inquiries concerning this development may be directed to:

   Technology Utilization Officer
   Marshall Space Flight Center
   Huntsville, Alabama 35812
   Reference: B67-10341

Patent status:

No patent action is contemplated by NASA.

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