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FABRICATION TECHNIQUES FOR
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ABSTRACT

Techniques are presented for fabricating a cylindrical liquid H₂ accelerator target from 0.005-in. Kapton film. Two unique modifications of existing target construction technology were developed: (1) hydroforming of target end domes, and (2) the use of a water-soluble mandrel to facilitate adhesive bonding of the second end dome to each target cylinder. The targets are for use in the Los Alamos Meson Physics Facility. They are pressure-tested at 30 psig with liquid N₂ before use.

I. INTRODUCTION

Mylar* films are in common use as materials for fabricating liquid H₂ accelerator targets because: (1) they can be fabricated in thin sections of varying configurations which cause minimal interference to accelerator beams, and (2) they exhibit excellent strength/mass properties at cryogenic temperatures. Kapton* polyimide film possesses the desirable properties of Mylar, and in addition it has superior radiation resistance. It has, therefore, been selected for use in the fabrication of experimental liquid H₂ targets for future use in the Los Alamos Meson Physics Facility (LAMPF).

Targets were initially constructed by methods developed at Argonne National Laboratory. Many of these techniques have been retained, but it has been found advantageous in terms of speed and reproducibility to cold-form target end domes by hydroforming instead of by the standard manual cold-pressing operation. Hydroforming is an established technique at Los Alamos Scientific

Laboratory (LASL) for cold-forming a variety of shapes from metals, but this is the first important use of it in cold-forming plastics.

The lower tensile modulus of Kapton compared with Mylar (430,000 psi vs 800,000 psi) makes it difficult to fit a target end dome snugly over the end of a cylinder body without internal support in the cylinder. When the first end dome is being applied, support may be provided by a metal mandrel. A meltable or soluble mandrel is needed during application of the second end dome. The use of water-soluble Rigidax-WS* cast mandrels has greatly facilitated this stage of target construction and has substantially improved overall target quality.

To date, only one target configuration has been used (Fig. 1). The techniques used in fabricating targets of this geometry will be applied to other target sizes and configurations as the need arises.

II. FABRICATION TECHNIQUES

Kapton polyimide film of 0.005-in. thickness is used in the fabrication of all target components

*DuPont trademark

*M. Argueso & Co. trademark

Fig. 1. Target configuration.

except connecting hardware. The procedure is divided into five steps: (1) preparation of blanks, (2) fabrication of the target cylinder body, (3) cold-forming of the end domes, (4) adhesive-bonding of the end domes to the cylinder body, and (5) attachment of the connecting hardware. Each step will be described in detail.

A. Preparation of Blanks

1. Target Cylinder Body

A blank cylinder body measuring 3-1/2 in. by 13-1/2 in. is cut from Kapton film.

2. Target End Domes

Two 8-1/7-in.-diameter disks are cut from Kapton film as blanks for the target end domes.

B. Fabrication of the Target Cylinder

The blank target cylinder body is wrapped snugly around an aluminum forming mandrel, and inlet/outlet holes are located approximately 90° from each side of the overlap. Locating holes are taken from those on the mandrel (Fig. 2). Masking tape is then applied to the film surfaces as shown in Fig. 3. Surfaces not covered by masking tape are lightly sandblasted to prepare them for adhesive bonding.

The masking tape is removed after sandblasting, and the blank cylinder body is again wrapped snugly around the mandrel. The 1-in. overlap is adhesive-bonded to the sandblasted area with an

Fig. 2. Forming mandrel.

epoxy adhesive made of 100 parts by weight of Epon 828* with an equal amount of Versamid 125.** The

Fig. 3. Cylinder body blank (masked for sandblasting).

* Shell Chemical Co. trademark

** General Mills trademark

bond areas are held firmly in contact by wrapping rubber bands around the assembly, and the adhesive is cured overnight at room temperature. Figure 4 shows the cylinder at this stage of fabrication.

C. Cold-Forming of Target End Domes

The target end domes are cold-formed in a Hydroform machine (Fig. 5) by LASL's Group CMB-6 Fabrication Section. Figure 6 illustrates the principle on which the machine operates. A shaped forming die is impacted onto a sheet of the material that is to be formed. The base on which the material rests is a liquid-filled rubber diaphragm which flows around the die under impact, forcing the material to take the same shape as the die. Forming takes place instantaneously.

Fig. 4. Cylinder body on mandrel.

Fig. 5. Hydroform machine.

When Kapton film is to be hydroformed, it must first be enclosed in a metal jacket. The metal jacket keeps the film from returning to its original shape until the film can be heat set. To hydroform target end domes, an 8-1/2-in.-diam film

Fig. 6. Diagram of the hydroforming process.

blank is sandwiched between layers of metal in the following sequence: (1) a base sheet of 1/16-in. annealed copper, (2) one sheet of 0.023-in. ferrochrome plate, chrome side up, (3) one Kapton film blank, (4) one sheet of 0.023-in. ferrochrome plate, chrome side down, and (5) a top sheet of 1/16-in. annealed copper. Each component is an 8-1/2-in.-diam disk. The highly polished ferrochrome plates are included on each side of the Kapton to prevent galling or marking of the film. The entire assembly is held together by four rivets, equally spaced on a bolt circle of approximately 8 in. A hole of 1/32 in. diam is drilled in the centers of the top sheets of ferrochrome and copper, respectively, to release air and facilitate the removal of these sheets after processing.

After the sandwich assembly has been hydroformed, it is heated in an oven at 300°C for 1 h to heat set the Kapton film. After cooling, the outer layers of copper and ferrochrome are parted by machining, as is the Kapton film dome. The completed dome is shown in Fig. 7 with the outer metal shells removed.

D. Bonding of End Domes to Cylinder Body

A 1/2-in.-wide band is lightly sandblasted on the inside diameter of each target end dome in preparation for adhesive bonding. Matching sandblasted strips were previously applied to the outside edges of the cylinder body. The film overlap on the seam of the cylinder body is "feathered" in

the sandblasted area by sanding it lightly. The cylinder is then placed on the aluminum mandrel. Epoxy adhesive is applied sparingly to the sandblasted strips on one end of the cylinder body and one end dome, and the end dome is slid into place over the cylinder body. The adhesive is cured overnight at room temperature.

During bonding of the second end dome to the cylinder, internal support is provided by inserting a water-soluble mandrel into the open end of the cylinder body. The water-soluble mandrel is prepared by casting molten Rigidax-WS into a mold of the dimensions shown in Fig. 8. The material solidifies upon cooling. The outside diameter of the casting is then machined to a snug fit for the inside diameter of the target cylinder body. With internal support provided by the water-soluble mandrel inside the target cylinder body, the second end dome is adhesive-bonded in place with epoxy.

After overnight cure of the epoxy adhesive, the Rigidax casting is removed from the target through the inlet/outlet holes on the cylinder wall. The bulk of it is removed by melting at 80°C; the remaining material is flushed out with

Fig. 7. Hydroformed end dome.

Fig. 8. Rigidax casting mold.

warm water. A final rinse is given with dilute acetic acid.

E. Attachment of Hardware

Each target requires stainless steel "saddles" on the inlet/outlet parts and on the connecting tubing. The saddle design is shown in Fig. 9. These components must be attached to the target body before the second end dome is bonded in place. It is done by applying epoxy adhesive to the circular sandblasted areas surrounding the inlet/outlet holes on the target body and clamping the internal and external saddle components in place while the adhesive cures.

Four pieces of connecting hardware are attached to complete the target assembly: (1) a 2-1/2-in. straight tube attached to one saddle inlet/outlet, (2) a 90° elbow attached to the opposite saddle, (3) a curved tube which joins to the elbow and curves around the outside of the target circumferentially, and (4) an acrylic spacer to stabilize the connecting tubes. All of the tubing is stainless steel of 1/4-in. o.d. and 3/16-in. i.d. The joints between sections are all silver-soldered, including those to the target saddles. Swagelock fittings are to be attached to the tube ends by the user group. The completed target is shown in Figs. 10, 11, and 12.

Fig. 9. Saddle design.

Fig. 10. Completed target.

III. CONCLUSION

Liquid H_2 accelerator targets fabricated by the above techniques have been pressure-tested with liquid N_2 up to 40 psig. An acceptance pressure level of 30 psig was arbitrarily established, and most targets will pass this test. As would be expected, the strength and leak resistance of each target is to some extent dependent upon the skill and care with which it is fabricated.

Fig. 11. Completed target.

Fig. 12. Completed target (far right) and target components.

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