300.
BDX-613-927 (Rev.)

DEVELOPMENT OF A SELF-CONTAINED
LAMINATING FIXTURE

PDO 6984794, Topical Report

J. D. Sheeley, Project Leader

Project Team:
J. A. Bebermeyer

Published May 1974

MASTER

Prepared for the
United States Atomic Energy Commission
Under Contract Number AT(29-1)-613 USAEC

**Kansas City
Division**

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DEVELOPMENT OF A SELF-CONTAINED
LAMINATING FIXTURE

BDX-613-927 (Rev.)

Published May 1974

Project Leader:
J. D. Sheeley
Department 812

Project Team:
J. A. Bebermeyer

PDO 8984794
Topical Report

NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Technical Communications

**Kansas City
Division**

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

BB

DEVELOPMENT OF A SELF-CONTAINED LAMINATING FIXTURE

BDX-613-927 (Rev.), UNCLASSIFIED Topical Report, Published
May 1974

Prepared by J. D. Sheeley, D/812, under PDO 6984794

A bonding/laminating fixture with self-contained heating, cooling, pressure, and vacuum features has been developed. The fixture has been used successfully to laminate adhesive-coated Mylar or Kapton insulators to etched circuits with a significant reduction in process cycle time.

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Atomic Energy Commission, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

THE BENDIX CORPORATION

KANSAS CITY DIVISION

KANSAS CITY, MISSOURI

A prime contractor for the
Atomic Energy Commission

Contract Number AT(29-1)-613 USAEC

CONTENTS

Section	Page
SUMMARY	5
DISCUSSION.	6
SCOPE AND PURPOSE.	6
PRIOR WORK	6
ACTIVITY	6
<u>Autoclave Lamination</u>	6
<u>Laminating Fixture</u>	7
<u>Performance</u>	8
ACCOMPLISHMENTS.	13
FUTURE WORK.	13

ILLUSTRATIONS

Figure	Page
1 Autoclave Bond Form.	7
2 Layup in Laminating Fixture (P-79859).	9
3 Complete Laminating Fixture (P-79855).	9
4 Typical Heating and Cooling Cycles for Self- Contained Platen.	10
5 Comparative Cycle Time for Bonding Mylar to Mylar and Mylar to Aluminum/Mylar Laminates	12
6 Shrinkage Evaluation of 0.00045-Inch-Thick (0.01143 mm) Aluminum Laminated to 0.002-Inch-Thick (0.0508 mm) Mylar.	14

TABLE

Number	Page
1 Cycle Time for Bonding Mylar and Mylar to Aluminum/Mylar Laminates.	11

SUMMARY

A laminating fixture with self-contained heating, cooling, pressure, and vacuum features has been developed for use in laminating adhesive-coated Mylar or Kapton to flat cables and other etched circuitry. Recent production with Mylar covercoat includes three separate conductor cables, large quantities of experimental test strips, and two advanced development systems.

The fixture was designed to take advantage of the desirable features of autoclave bonding while eliminating the major drawback of cycle length. Autoclave bonding gives uniform pressure and the ability to evacuate air from the layup, a desirable feature for moisture sensitive materials such as Kapton. Total elapsed time for a typical laminating cycle requiring a 5-minute cure at 300°F (148.9°C) is 30 minutes in the laminating fixture as compared to approximately 4 hours for a comparable autoclave cycle and 45 minutes for a comparable press cycle.

DISCUSSION

SCOPE AND PURPOSE

Techniques using autoclave bonding have been in use at Bendix Kansas City for several years. Special flat cables and special circuit boards were required for various advanced system studies. These cables and circuit boards required the lamination of Mylar over the surface of the etched parts. Because autoclave cycles are very long and because pressures and temperatures are too low for efficient press operation in some cases, the need for a specialized laminating fixture became apparent. This effort was undertaken to fill that need.

PRIOR WORK

Development work on autoclave lamination techniques on copper-Kapton flat cables was reported in February, 1972. No work on specialized laminating fixtures has been reported by Bendix.

ACTIVITY

Autoclave Lamination

The usual procedure for autoclave lamination is to assemble the layers to be bonded on a vacuum bond form. Alignment can be maintained by punching tooling holes in the layers and assembling the layers over pins on a bonding plate or taping the layers together, depending on the accuracy required. A silicone rubber blanket is laid over the materials to be laminated and sealed under the edge of the bond form with silicone rubber rope. After sealing, the fixture is evacuated and loaded in the autoclave, where vacuum is maintained while heat and positive pressure are

added. A thermocouple attached to the bond form monitors temperature of the bond form in the autoclave. Figure 1 shows a cross section of a typical bond form.

Excellent bonds are obtained during autoclave laminations. Although maximum pressures and temperatures in an autoclave are lower than those possible in a press, they are nevertheless more than adequate for most applications. Kapton covercoat with an epoxy adhesive gives an excellent bond when cured in an autoclave at 350°F (176.7°C) and 100 psi (689.4 kPa). Most Mylar covercoats with thermoplastic adhesive are readily cured at 260 to 300°F (126.7 to 148.9°C) and 30 psi (207 kPa). Pressure in an autoclave is extremely uniform and therefore good bonds are obtained.

It is desirable to cool the material while maintaining the laminating pressure in most cases. Some materials can be removed from the autoclave and allowed to cool to room temperature while holding vacuum on the bond form. To allow the bond form to cool under pressure in the autoclave is a lengthy process, usually taking 4 to 6 hours.

Figure 1. Autoclave Bond Form

Laminating Fixture

A special, self-heating laminating fixture has been designed and fabricated to take advantage of the desirable features of autoclave laminating while shortening the cooling cycle. Design goals were minimum size, vacuum cycle, short heat and cool cycles,

100 psi (689.4 kPa) capability, uniform temperature distribution, and ease of operation. The fixture has a maximum temperature capability of 375°F (190.5°C) and a maximum pressure of 100 psi. Cooling is with tap water, and shop vacuum (nominally 29 inches (736.6 mm) Hg) is used. The usable platen area is 14 by 22 inches (35.56 by 55.88 cm). The electrical parameters are 230 Vac and 7000 W.

An aluminum electrically-heated platen with cooling coils was equipped with a vacuum system and a lip around the outside to seal the silicone rubber blanket. In effect, this becomes a self-heating and cooling bond form, and it is possible to laminate certain adhesives where vacuum alone exerts enough pressure to achieve a bond. To extend the usefulness of the heated bond form, a steel pressure container was constructed to contain the bond form. The bonding platen rests on Transite in the pressure container and is separated from the walls of the container by more Transite. The Transite thermally isolates the container from the platen. No power is wasted heating the container in addition to the platen.

Vacuum, water, and electrical connections are passed through the wall of the container to the platen. As in the autoclave, laminating pressure is extremely uniform and is supplied by connecting shop air to the box. A pressure regulator at the air connection can set any desired pressure from 0 to 100 psi. Good quality laminations of medium temperature adhesive Kapton covercoat can be produced at 100 psi. Thirty psi (207 kPa) is sufficient to produce a good bond with thermoplastic adhesive Mylar covercoat.

Figure 2 shows a layup with Mylar covercoat being laminated to aluminum-Mylar flat test cables. Figure 3 shows the laminating fixture with all connections in place and ready to begin the laminating cycle.

Performance

As discussed earlier, an autoclave may take from 4 to 6 hours to cool to room temperature under pressure. The laminating fixture will cool from 350° to 100°F (176.7° to 37.8°C) in approximately 5 minutes while maintaining the laminating pressure. Cooling under pressure helps reduce shrinkage, improves the bond, and prevents shifting of the layers, as sometimes occurs when material is removed from an autoclave before the adhesive is cool. Five cycles of heating and cooling times were recorded with temperatures provided by a thermocouple taped to the surface of the platen. The silicone rubber blanket was in place; the fixture was closed but no material was in the fixture. Heating and cooling times would be slightly different with material in the fixture, depending on total mass of the material being laminated. Figure 4 is a plot of typical heating and cooling times.

Figure 2. Layup in Laminating Fixture

Figure 3. Complete Laminating Fixture

Figure 4. Typical Heating and Cooling Cycles for Self-Contained Platen

To compare the performance of the laminating fixture with conventional laminating techniques, similar peel test samples were laminated in the fixture, autoclave, and press. In all cases, 1/2-inch-wide by 8-inch-long (1.27 by 20.32 cm) strips of adhesive-coated Mylar were laminated to Mylar and to aluminum/Mylar laminate. Cure was 5 minutes at 300°F (148.9°C) for all three methods. Cycle times for the fixture and the autoclave are given in Table 1, and plotted in Figure 5.

When attempting to measure the bond strength of the laminated strips, the material failed in all cases before the bond failed; therefore, it was not possible to measure peel strength. It is concluded that, for this application, the laminating fixture can produce as good a bond as either an autoclave or a press.

Temperature distribution on the surface of the platen was plotted by dividing the platen into 2-inch (5.08 cm) squares and measuring the temperature inside each square with a pyrometer. This procedure was repeated for temperatures of 200°, 250°, 300°, and 350°F (93.3, 121.1, 148.9, and 176.7°C). Temperature range was less than 10 percent of the set temperature in all cases but not as uniform as desired.

Table 1. Cycle Time for Bonding Mylar and Mylar to Aluminum/Mylar Laminates

Laminating Fixture		Autoclave	
Description	Time	Description	Time
Parts in Fixture, 50 psi (345 kPa) Vacuum	0:00	Bond Form to Autoclave	0:00
Heat On	0:01	In Autoclave (Preheat) 50 psi (345 kPa) Vacuum	1:10
Temperature at 300°F (148.9°C)	0:13	Out of Autoclave	2:10
Cure	0:18	Cool to 100°F (37.8°C) Under Vacuum	4:00
Cool to 100°F (37.8°C)	0:24		
Parts Out	0:28

Figure 5. Comparative Cycle Time for Bonding Mylar to Mylar and Mylar to Aluminum/Mylar Laminates

Shrinkage Evaluation

Laminate material of 0.00045-inch (0.0114 mm) aluminum laminated on each side of 0.002-inch (0.0508 mm) Mylar was used in a study to determine if material cooled under pressure could be expected to shrink less than if it were allowed to cool slowly to room temperature under vacuum only. Four temperatures were used during this study: 260, 280, 300, and 320°F (126.7, 137.8, 148.9, and 160°C). The material was cut into 1-inch by 8-inch (2.54 by 20.32 cm) strips, divided into four groups of 20 each, and identified. A paper punch was used to punch two holes approximately 6 inches (15.24 cm) apart in each strip. The exact distance was measured and recorded. Each group of 20 was cured at one of the above temperatures. Half were rapidly cooled under pressure; the other half was allowed to cool slowly under vacuum only. Distance between holes was again measured and recorded after the cure cycle. Shrinkages were obtained by subtracting the measurement after curing from the measurement before curing. Comparative shrinkages for each temperature were obtained by averaging the 10 differences for the fast pressure cool and the 10 differences for the slow vacuum cool. Average shrinkages are plotted in bar graph form in Figure 6. Results indicate that there is somewhat less shrinkage during the fast pressure cool in the 280 to 300°F (137.8 to 148.9°C) range, which is common for curing many Mylar thermoplastic adhesive covercoats. Range of shrinkage was approximately the same for fast or slow cooling, with a typical spread of 0.002 to 0.003 inch (0.0508 to 0.0762 mm).

ACCOMPLISHMENTS

Design goals have been met, and a laminating fixture that retains the advantages of autoclave bonding but reduces average cycle time by approximately 3.5 hours has been constructed. The fixture is used continuously to laminate Mylar on various flat test circuits and non-planar device hardware parts.

FUTURE WORK

A larger fixture which will have the capability to handle large non-planar parts will be designed with a rectangular platen size of 24 by 36 inches (61 by 91.5 cm) to support fabrication of special copper-Kapton test hardware. The new fixture will feature a platen design which will give more uniform heat distribution and simplify layup and evacuation. Additional controls will be added to the fixture which will allow the laminating cycle to be preset and controlled automatically.

Figure 6. Shrinkage Evaluation of 0.00045-Inch-Thick (0.01143 mm) Aluminum Laminated to 0.002-Inch-Thick (0.0508 mm) Mylar