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PROCESSING OF
THIN CELLULAR
SILICONE SLABS

BDX-613-353S

July, 1971

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PDO 6984549
Interim Report

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A prime contractor for the Atomic Energy Commission

Contract Number AT(29-1)-613 USAEC

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ABSTRACT

A method for obtaining thin (0.030-inch) slabs of Y-3333 cellular silicone cushion material was developed. It was determined that if a milling operation were performed between the normal cold press and hot molding operations, slabs of the desired thickness could be fabricated. Various slab thicknesses, ranging from 0.0265 to 0.0342 inch, were obtained by using different combinations of milling processes and variations in spacer thickness during the hot molding operation.

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SUMMARY

A process for fabricating thin (0.030-inch) slabs of Y-3333 cellular silicone cushions was developed. The method is applicable only for flat slabs and cannot be used for other configurations. The process includes a special milling operation which is performed between the normal cold press and hold molding operations.

During the milling operation, the slab preform is reduced from a thickness of approximately 0.060 inch, which was obtained during the cold press operation, to approximately 0.036 inch. The subsequent hot molding operation accounts for another 0.0035 inch of reduction. Finally, during the wash, dry, and postcure cycles, a shrinkage of approximately 0.002 inch is achieved, thus obtaining the required 0.030-inch slab thickness.

Twenty slabs were made during this study and thicknesses varying from 0.0265 inch to 0.0342 inch were obtained, depending on the particular combination of processing parameters employed. The final process yielded four slabs, each with an average thickness (average of five readings) within 0.001 inch of the required 0.030-inch thickness. Load-deflection tests were run on all 20 slabs fabricated during this study. Results of these tests, along with tables describing the various processing combinations which were tried, are included in this report.

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DISCUSSION

SCOPE AND PURPOSE

This process development work was initiated as a result of an LRL order for 12- by 12-inch cellular silicone slabs of 0.030- and 0.060-inch thickness for both Y-3260 and Y-3333 materials. The Y-3260 slabs and the thicker Y-3333 slabs were fabricated by the normal processing techniques that were being used at the time this order was received. However, because of the larger urea content of the Y-3333 material, sufficient material flow to produce the 0.030-inch-thick slabs was not obtainable by the normal processes used for the other slabs.

Therefore, a process development study was undertaken to develop a technique to produce the thin slabs of Y-3333 cellular silicone material. This work was funded by PDO 6984549.

PRIOR WORK

No work in this area had been undertaken prior to the attempt to mold 0.030-inch-thick slabs of Y-3333 material by the normal processing techniques in response to the aforementioned LRL order. From these efforts it was found that cold pressing with the 300-ton press available in Department 34D would not yield a preform thickness of less than 0.040 inch. When a larger cold press (1200 tons available in Department 26) was tried, the material still would not flow to a thickness less than 0.038 inch. It was also determined that the subsequent hot molding on the 300-ton press in Department 34D did not reduce the cold press thickness by an appreciable amount. Therefore, it was necessary to develop a method of obtaining a slab approaching the desired final thickness prior to the hot molding operation.

ACTIVITY

After the unsuccessful attempts to mold Y-3333 material into 0.030-inch-thick slabs (discussed above) using conventional fabrication techniques, a process combining cold pressing, milling, and hot molding was developed (Table 1).

Cold Pressing

During the cold pressing operation, the material was formed into uncured preform slabs approximately 0.060-inch thick. The cold press mold was loaded with 250 grams of raw material which had been crumbled into nearly uniform "chunks" ranging in size from small particles to larger chunks with

Table 1. Parameters of Constant Process
in Fabrication of Thin Y-3333
Cellular Silicone Cushion Material
(20 Slabs, Lot E-8-1)

Cold Press Operation:	250 grams of material 280 tons of applied pressure 2.0 minutes of applied load
Milling Operation:	0.075-inch roll gap (minimum gap) 20.0-fpm roll speed (minimum)
Hot Molding Operation:	215°F mold temperature 225 tons of applied pressure 5.0 minutes of applied load
Wash and Post Cure:	4.0-hour wash cycle 4.0-hour dry cycle at 300°F 24.0-hour post cure at 480°F

major dimensions in the neighborhood of 1/2 to 3/4 inch or more. (The raw material, as it is received at Bendix, consists of small particles intermixed with larger chunks with maximum dimensions up to 4-1/2 to 5 inches or more.)

The material was positioned off-center, approximately 1/3 on the diagonal, between two sheets of 0.005-inch Mylar (Figure 1), and the pile of material was then placed in the center of the cold press mold. This off-center orientation of the material with respect to the Mylar sheets resulted in the preform being approximately tangent to the two near edges of the Mylar sheets after cold pressing. But there was still sufficient area for flow of material toward the two far edges of the Mylar during the subsequent milling operations. This procedure was used because any contact between the uncured Y-3333 preforms and the mill rolls would result in the material sticking to rolls and tearing of the preforms. The mold consisted of two flat die plates without stops. A compressive load of 280 tons was applied for 2 minutes and the resulting preforms had a thickness of approximately 0.060 inch.

Milling

During the milling process, the slab thickness was reduced from 0.060 inch to approximately 0.036 inch while the material was passed between the mill rolls at least once in each direction. The mill rolls were adjusted to their minimum gap, which was approximately 0.075 inch, and to the minimum roll speed of 20 feet per minute (fpm). The required reduction in thickness was obtained by placing several layers of 0.015-inch-thick stencil-board on top of the slabs and passing the resulting package through the mill two or three times, alternating the leading edge at each pass. (The leading edge was always one of the two edges of the preform that were approximately tangent with the Mylar sheets, as indicated in Figure 1.)

During the development of this process, it was discovered that if the top sheet of Mylar was left in contact with the preform, it tried to flow with the material and consequently became wrinkled. Therefore, before passing the material through the mill, the top sheet of Mylar was removed and replaced by stencil-board. The preform was left on the bottom sheet of Mylar which acted as a support for the milled preform and as a surface to which the preform could adhere for easy handling. The stencil-board sheets were cut to a size sufficient to cover the total anticipated area that the preform flow would require during the milling operation. The stencil-board was sufficiently stiff to allow the preform to flow over it without becoming wrinkled. Two of the edges of the stencil-board were aligned with the two edges of the preform that were tangent to the bottom sheet of Mylar so that the material flow was not allowed to come into contact with the rolls.

Figure 1. Material Orientation Prior to the Cold Pressing and Milling Operations

Twenty slabs were fabricated in this manner, using various layup combinations of either two or three pieces of stencil-board with sometimes an additional one or two sheets of 0.005-inch Mylar on top of the stencil-board (Table 2).

Hot Molding

Prior to the hot molding operation, the preform (along with the bottom sheet of Mylar) was cut to a 13- by 13-inch size. Then the preform, while still on the Mylar, was molded under a pressure of 225 tons and at a temperature of 215°F for 5 minutes. Various spacer thicknesses were used for this operation as indicated in Table 2.

The slabs were washed for 4 hours, with the bottom sheet of Mylar being removed from the slab after the first hour of the wash cycle. The slabs were then dried for 4 hours at 300°F and postcured for 24 hours at 480°F.

Testing

Thickness measurements and load-deflection tests were made in five places (near each corner and at center) on each slab. The load-deflection tests were made using a 1.129-inch diameter (1.0 square-inch area) foot. Three compression cycles were run at each position, with the slab being compressed to a thickness of 0.018 inch on each cycle. Load (psi) readings were recorded for the third cycle at deflection values (compressed thickness of slab) of 0.025 inch and 0.020 inch. The compression tests were run with a cross-head speed of 0.050 inch per minute, and a chart scale of 0.005 inch per inch for deflection and 12.0 pounds per 1.1 inch for load. The results for both load-deflection tests and thickness measurements are found in Table 3.

ACCOMPLISHMENTS

A process for fabricating Y-3333 slabs of the desired thickness was developed. The last four slabs (numbers 17 through 20) were all made using the identical combination of milling and hot molding processes (Table 2), and the average thickness for each of these slabs was within 0.001 inch of the required 0.030-inch thickness. The thicknesses of these four slabs, at various stages of the process, are listed in Table 4.

To obtain the values after milling and after hot molding, the 0.005-inch Mylar thickness was subtracted from the measured layup thickness. These values therefore represent the actual slab thickness at that particular stage in the process. The data for the combined averages of the four slabs indicate that the average thickness reduction during hot molding is only about 0.0035 inch and that another 0.002 inch of shrinkage occurs during the wash, dry, and postcure cycles. Three to 5 percent shrinkage is normally encountered during

Text continued on page 21.

Table 2. Variable Processing Parameters in Fabrication of Thin Y-3333 Cellular Silicone Chushion Material

Slab No.	Total Mill Passes	20 Slabs, Lot E-8-1			Spacer Thickness (In.) During Hot Molding
		Layup Thickness (In Addition to Bottom Layer of Mylar)			
		Pass No.	No. of 0.015-In. Stencil-Boards	No. of 0.005-In. Mylar Sheets	
1	3	1	2	0	0.035
		2	3	1	
		3	3	1	
2	3	1	2	0	0.035
		2	3	1	
		3	3	1	
3	3	1	2	0	0.035
		2	3	1	
		3	3	1	
4	3	1	2	0	0.035
		2	3	1	
		3	3	1	
5	2	1	3	1	0.040
		2	3	1	
6	2	1	3	1	0.043
		2	3	1	
7	2	1	3	1	0.038
		2	3	1	
8	2	1	3	1	0.038
		2	3	1	
9	2	1	3	0	0.038
		2	3	0	
10	2	1	3	0	0.038
		2	3	0	

Table 2 Continued. Variable Processing Parameters in Fabrication of Thin Y-3333 Cellular Silicone Cushion Material

Slab No.	Total Mill Passes	20 Slabs, Lot E-8-1			Spacer Thickness (In.) During Hot Molding
		Layup Thickness (In Addition to Bottom Layer of Mylar)			
		Pass No.	No. of 0.015-In. Stencil-Boards	No. of 0.005-In. Mylar Sheets	
11	2	1	3	0	0.038
		2	3	0	
12	2	1	2	2	0.042
		2	2	2	
13	2	1	3	0	0.033
		2	3	0	
14	2	1	3	0	0.030
		2	3	0	
15	2	1	3	0	0.030
		2	3	0	
16	2	1	3	0	0.030
		2	3	0	
17	2	1	3	1	0.030
		2	3	1	
18	2	1	3	1	0.030
		2	3	1	
19	2	1	3	1	0.030
		2	3	1	
20	2	1	3	1	0.030
		2	3	1	

Table 3. Test Results

Slab No.	Thickness (Inch)	Load (Psi)	
		At 0.025 In.	At 0.020 In.
1	0.0282	2.1	5.6
2	0.0277	1.7	5.2
3	0.0265	1.5	4.8
4	0.0285	2.6	6.0
5	0.0318	3.1	6.9
6	0.0320	3.8	7.0
7	0.0316	3.3	6.8
8	0.0316	3.3	7.8
9	0.0342	4.3	8.6
10	0.0342	4.5	9.5
11	0.0338	4.1	8.9
12	0.0328	3.8	7.8
13	0.0322	3.7	7.5
14	0.0334	4.3	8.9
15	0.0324	4.0	8.9
16	0.0332	4.5	9.3
17	0.0298	3.0	7.0
18	0.0306	3.4	7.6
19	0.0298	3.0	7.2
20	0.0304	3.2	7.0
Note: Each value is the average of five thickness measurements and five load-deflection tests (one near each corner and one at the center) which were run on each slab.			

the wash, dry, and postcure cycles. Therefore, for this particular combination of material (Y-3333) and thickness (0.030 inch), the preform slab thickness prior to hot molding must be within 0.0055 inch of the desired final thickness.

These four slabs (17 through 20) had an average compressive load of 3.15 psi when compressed to a thickness of 0.025 inch and 7.2 psi when compressed to the 0.020-inch thickness.

Table 4. Thickness Measurements of Slabs 17 Through 20 During Process Stages

Slab Number	After Milling	After Hot Molding	After Wash, Dry, and Postcure
17	0.035	0.032	0.0298
18	0.036	0.033	0.0306
19	0.035	0.032	0.0298
20	0.037	0.032	0.0304
Average	0.0357	0.0322	0.0302

FUTURE WORK

This process, for the fabrication of thin cellular silicone cushions, is applicable only for flat slabs and cannot be used for the production of other configurations. Fabrication of irregular cushions at thicknesses of 0.030 inch or less might become feasible if a process and material using smaller urea particles were developed. The present urea particles are between 25 and 40 mesh. A study of this nature has been planned, and an effort is now being made to procure 500 pounds of 60-mesh or smaller (approximately 0.015-inch maximum) urea particles. This undertaking will also be funded by PDO 6984549.

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