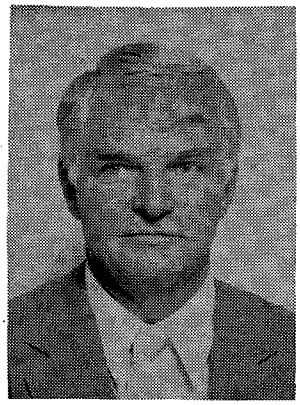
Volume 6, No. 4 Spring 1983

NEWSLETTER

THERMOFORMING division

SOCIETY OF PLASTICS ENGINEERS, INC.

MESSAGE FROM THE DIVISION CHAIRMAN



Pete Hughes

In my last message for this column I reviewed how far we thermoformers have come since we were called "Vacuum Formers" and we tested the sheet temperatures with our educated thumbs. With the experience, techniques and equipment available to us now we are on the threshold of an explosive development in our industry. Thermoforming has been called the sleeping giant of industry.

What I would like to say now concerns competition. I know that when we are competing for the specific contract or order we are competing usually with another thermoformer and that is the way it should be. But the **real** competitors are other plastic or metal or glass processes. Many of us have had the experience of making parts or products otherwise made of metal or glass. But how many of us are willing to go head-on-head against RIM or injection molding? How many of us are willing to look at improving our methods and reducing our costs so as to present an alternative manufacturing method to a part already designed for RIM or injection molding or foam molding? With our tooling costs at 10% or less of our competition and an "on line" capacity of months less, we are ideally poised to compete and get orders. With minor redesign many parts which are molded: particularly those larger, heavier walled parts, can be made using thermoforming manufacture. The attitude prevelant among almost all heavy sheet formers and some thin walled formers has been that as the quantity increases then the product should be molded. In like manner, many of us consider a contract unattainable if there were bosses or sharp detail. But it is time to take a second look and present our advantages and maybe walk away with an order we would never have received. Even if the order is unattainable we have helped those in a position to influence design and purchasing decisions to broaden their thinking regarding our industry . . . . and this might result in an order for one of us in the future.

"IS SPE FOR ME?

by JIM BAUER
Piedmont Coastal Section

At some point in time, probably every Membership Chairman - perhaps even every member of SPE - has been asked "What do I get when I join the Society?" Can YOU answer that question? Are you aware of the many benefits provided through SPE membership? Aside from the numerous technical and social benefits, here is what a new member receives for his low annual dues of $45.00:

- **Plastics Engineering** SPE's monthly publication featuring timely articles on a variety of technical topics as well as information on Society Activities.
- **Reduced registration fees** for all SPE conferences (ANTEC, RETEC, etc.) and educational seminars.
- **Lower subscription rates to:**
  Polymer Engineering & Science the technical journal of record published 18 times a year(12 monthly issues plus 6 symposium issues),
  Polymer Composites our engineering journal, published quarterly, which serves the fields of reinforced plastics and polymer composites,
  Journal of Vinyl Technology a quarterly, action-oriented scientific journal providing a central source of timely information for people serving the vinyl plastics industry.
- **Substantial reductions** on all technical books found in the SPE PUBLICATIONS LIST, including conference preprints.
- **SPE Sections and Divisions** which provide members the opportunity to meet informally with plastics-minded people, to see and discuss the plastics industry with other members and to hear interesting speakers at scheduled meetings.
- **Three free "Position Wanted" ads** in Plastics Engineering annually.
- **SPE lapel pin**
- **Life insurance** at group rates
- **Hospital Cash Insurance** at group rates
- **Automobile rental program.**
- **Annual dues rebates** to Sections, which enable them to underwrite activities beneficial to their members.
- **SPE keeps its members personally involved** and informed of advancements in the industry, thus benefitting not only each member as a professional, but also the employing companies.

SPE needs new members - and we truly believe that plastics industry personnel need the benefits we have to offer! As an involved Section/Division member, being aware of those benefits and sharing that knowledge with others in your recruitment efforts will assure the continued growth of our society.

BOARD MEETING

The next Board of Directors meeting is scheduled for Sunday, May 1 at the Hyatt Regency Hotel, Chicago, Ill.

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Thermoforming Division

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THERMOFORMER OF THE YEAR AWARD

E. Bowman Stratton, noted consultant and thermoforming historian, is scheduled to receive the second annual Thermoformer of the Year Award at the thermoforming business meeting at ANTEC on May 2, 1983.

Mr. Stratton has held various management and sales positions dealing with all phases of thermoforming in his 30 plus years of work in our industry. He has pioneered many innovations that have led to the maturity of our industry. In addition, Bo is a contributing writer to our divisional newsletter. Mr. Stratton ideally exemplifies the class of our discipline and is most worthy of this award.

BUSINESS MEETING

There will be a business meeting for thermoforming members after the technical program on Monday, May 2 at ANTEC that will include the presentation of the Thermoformer of the Year Award to Bo Stratton.

In addition, formal approval of Division Operating Procedures by the membership. A copy of the procedures will be available for review at the business meeting or an advance copy may be obtained prior to the meeting from the Division Chairman, Pete Hughes.

VACUUM & THERMOFORMING

by Wm. K. McConnell, Jr.*

In thermoforming normally the faster and better the vacuum the better the part. Rapid vacuum enables the hot sheet to be forced quickly against the mold before it has a chance to do much cooling. Provided the mold is at the proper temperature this fast vacuum gives us the least amount of internal stress thus insuring top physical properties of the finished part.

Good, high, continuous vacuum after the part has been formed guarantees faster cooling, better dimensional tolerances and detail. The vacuum guage should never drop below 20 inches of mercury during forming. At sea level 20 inches of mercury provides only 9.82 psi of atmospheric pressure on the part and as the part cools this is barely sufficient to form most material and keep it against the mold. The best parts and cycles are achieved with 25 inches of mercury (12.3 psi) or more on the formed part. See Table II.

TABLE I — CONVERSIONS

Units of absolute pressure

Standard atmospheric pressure equals	29.92 in. of mercury
	1.0 atmosphere
	760.0 mm of mercury
	14.7 psi

To convert positive atmospheric pressure (psig) to:

in. of mercury multiplied by	2.036
mm. of mercury	51.715
atmospheres	0.058

All absolute pressure units below standard atmospheric pressure are also units of vacuum. Barometric pressure is usually assumed to be standard atmospheric pressure of 29.92 in. of mercury.

VACUUM CAPACITY REQUIREMENTS

In most thermoforming systems it is essential to have a vacuum "storage" or surge tank in order to properly form a part as discussed above. With a reservoir the peaks and valleys in vacuum consumption at the mold are smoothed out. When forming cycles are long a storage tank permits use of a smaller vacuum pump. Short cycle pulsations are "leveled out" with a reservoir.

Use this formula to determine reservoir size:

$$V_o P_o + V_m P_m = V_1 P_1$$

V_o = surge tank volume including piping to vacuum control valve (cu ft)

V_m = mold area volume (consumption per cycle)

$V_1 = V_o + V_m$ (cu ft)

P_m = initial pressure in the mold, at sea level either 14.7 (atmospheric) or 17.7 psi when using prestretch forming

P_o = pressure in surge tank (psia) - use 0.5 psia (equivalent to 29 in Hg Vac) See Table II

P_1 = desired working pressure

Example No. 1 - See figure 1

Assume

V_m = Volume of mold & piping 4 cu ft

P_o = Vacuum pump can pull approximately 29 in. Hg so use 0.5 psia surge tank pressure

P_1 = Desire working pressure of 2.42 psia (25 in. H_g)

P_m = Initial mold pressure 14.7 (if at sea level)

$$V_o P_o + V_m P_m = V_1 P_1$$

$$V_o \times 0.5 + 4 \times 14.7 = (V_o + 4)\ 2.42$$

$$0.5V_o + 58.8 = 2.42\ V_o + 9.68$$

$$V_o = 25.58 \text{ cu ft}$$

or X 7.48 gal/cu ft = 191/gal

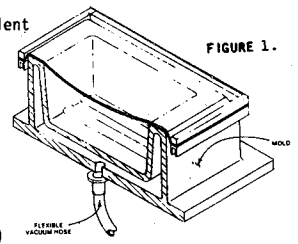

FIGURE 1.

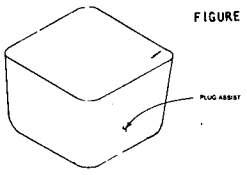

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TABLE II

Basic vacuum pressure measurements

UNITS		
Gauge Pressure PSIG	Absolute pressure PSIA	IN. Hg
0	14.7	0
-1	13.7	2.04
-2	12.7	4.07
-4	10.7	8.14
-6	8.7	12.2
-8	6.7	16.3
-9	5.7	18.32
-9.82	4.88	20
-10	4.7	20.36
-11	3.7	22.4
-12	2.7	24.43
-12.28	2.42	25
-13	2.7	26.47
-13.7	1.0	27.89
-14	0.7	28.5
-14.2	0.5	28.91
-14.24	0.46	29
-14.6	0.1	29.73
-14.7	0	29.92

PSIA - "absolute pressure" (in pounds per square inch) is measured with respect to zero-absolute vacuum. In a vacuum system it is equal to the negative gauge pressure subtracted from atmospheric pressure.

PSIG - "gauge pressure" (in pounds per square inches) is the amount by which pressure exceeds the atmospheric pressure.

HENCE:
GAUGE PRESSURE + ATMOSPHERIC PRESSURE = ABSOLUTE PRESSURE

No. 2 - Same as No. 1 except using a lower pressure of 20 in. of H_g which is 4.88 psia:

$$V_o \times 0.5 + 4 \times 14.7 = (V_o + 4)\ 4.88$$

$$0.5V_o + 58.8 = 4.88V_o + 19.52$$

$$V_o = 8.97 \text{ cu ft} \times 7.48 \text{ gal/cu ft} = 67\text{l gal}$$

No. 3 - See Figure 2

Frequently in thermoforming it is necessary to prestretch (preblow) the plastic sheet and then vacuum form the part. The prestretched bubble is usually accomplished with 3 to 5 psig of compressed air. This results in an even greater amount of air at atmospheric pressure. To compute the increased air volume and pressure add the volume of the prestretched bubble, 2.4 cu ft to V_m, for total of 6.4 cu ft and the pressure differential needed for blowing the bubble (3 to 5 psig) to the initial atmospheric pressure in the mold (example: 14.7 + 3 = 17.7 psig).

Using example No. 1 but with prestretching and plug assist:

$$V_o \times 0.5 + 6.4 \times 17.7 = (V_o + 6.4)\ 2.42$$

$$0.5V_o + 113.3 = 2.42V_o + 15.5$$

V_o = 50.9 cu ft or X 7.48 gal/cu ft = 381/gal

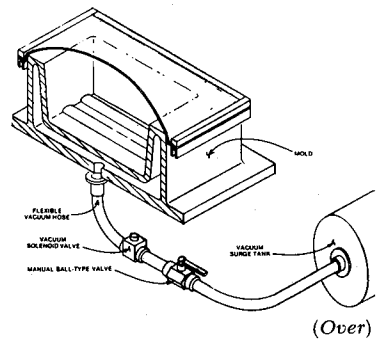

FIGURE 2.

(Over)

Locate vacuum surge tanks as close as physically possible to the thermoformer and the vacuum control valve. Flexible vacuum hose should be used from the tank to the valve and then to the mold. Straight-in connections should be made. Avoid elbows, tees and reducers in plumbing the vacuum line. Vacuum and air control valves must be **full** opening types!
See Table III.

TABLE III
VACUUM LINE SIZING

Thermoforming Machine Forming Area	Vacuum Line and Control Valve Sizes
Up to 30" X 36"	1" dia.
3 ft X 4 ft to 7 ft X 9 ft	1-1/2" dia.
8 ft X 10 ft and up	2" dia.

1984 ANTEC Papers

Have you been thinking of a topic for a paper you could write for the 1984 ANTEC in New Orleans?

1. Write up a 100-200 word abstract of your presentation. Included should be your name, address and phone number and a note that it is for Thermoforming at ANTEC 1984.
2. Send this to:
   H.R. Osmers
   Chemical Engineering Analysis
   1835 St. Paul Street, Suite 105
   Rochester, NY 14621
3. If you finish this paper after July, send it to the Conference Manager at SPE Headquarters.
4. Get busy on the full paper, 8 pages and drawings. The deadline will be probably by November 1, 1983.

Don't delay, get busy now! Remember, this is an opportunity to tell others how Thermoformers are doing.

THERMOFORMING TECHNICAL SESSION
Session #8, Toronto Room

Moderator: Herman R. Osmers
Chemical Engineering Analysis

Monday Afternoon - May 2, 1983
ANTEC 83 - Hyatt Regency in Chicago

2:00 Thermoforming - A Look Forward
J.L. Throne
Amoco Chemicals Corp.

2:30 Emission Efficiency of Reflector Materials for An Infrared Tubular Heater
R.R. Kraybill
Eastman Kodak Co., Mfg. Technology Div.

3:00 Shrinkage of Thermoformed High Density Polyethylene Parts
J.E. Keesling
Phillips Chemical Co.

3:30 Understanding and Controlling Chill Marks in Thermoforming
P. Hughes
The Hughes Plastics Co., Inc.

4:00 Thermoformed Polyester Ovenable Trays
R.J. Gartland
R.E. Fruzetti
The Goodyear Tire & Rubber Co., Fiber & Polymer Products Research Div.

4:30 Wall Thickness Distribution In Thermoforming
N. Rosenzweig
Raychem Corp. D6.11

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Advertising in Division Newsletters will be limited to insertion of individual corporate advertising no larger in size than 2"x3½". Such advertising will be grouped in one area of the newsletter with an introductory statement indicating that these individuals or companies are sponsoring the Newsletter by underwriting publication costs.

Publication in Division Newsletter of display advertising of the type normally associated with professional, trade and commercial journals continues to be prohibited.

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ABOUT THE BIRTH OF THERMOFORMING

by: E. Bowman (Bow) Stratton

For a plastic process as large as thermoforming, it is remarkable that there haven't been more articles written about it. Material manufacturers' brochures are geared for the scientists and very little useful thermoforming information can be gleaned from the data. Equipment manufacturers are equally vague on machine types, sizes and performance to be expected. I have felt for a long time that thermoforming has never been fully appreciated by the industrial world because of the lack of historical and practical information.

The birth of present day thermoforming, (nee vacuum forming), was on or about 1950. However, the use of vacuum in processing plastic sheet goes back to the 1930's (J.J. Braund) and the patents covering the vacuum process predate this by many years.

The army map service undertook the development of inexpensive relief maps in 1948 and I was appointed Chief of Materials Development Section. The project we undertook was fascinating; to develop a process and materials for producing preprinted plastic sheets formed accurately into relief maps suitable for military purposes.

We had to develop a quick, accurate way to make the original molds. This had been an eight to ten week process, laborious and not satisfactory. We laminated cast acetate sheets, each thickness representing one elevation, into blocks which fit onto large 36" x 36" German army map pantographs taken at the end of World War II.

The cutter was a special, fine drill which was controlled by a stylus (a phonograph needle) that ran in the grooves that were created by deep etching the flat map contours printed on a zinc plate. The grooves were deep enough so that the operator could affect the transfer quite easily. When one elevation was completed the acetate sheet was peeled off leaving the desired contours intact.

The finished model was then checked for accuracy and a female cast made in special non-shrinking or expanding plaster. Into this female would be cast the vacuum mold using metal needles for vacuum holes, when extracted, and creating an internal vacuum system, i.e., plastic on top and rubber blanket at the bottom, thus avoiding plaster breakage.

Our first lab machine adapted a hand lift molt table which carried the plaster mold, attached to the vacuum pump located outside the building in a shed. A stationary clamping frame was mounted on the four rods that guided the mold platform.

The operator positioned the .015" rigid vinyl printed sheet against the three edge index points on the perimiter of the mold and then raised the mold to the clamp frame. The fiber glass heater was hung on an overhead rack on rollers and was drawn over the mold for a timed heat cycle when the operator opened the vacuum valve. Later we designed and built a double ended machine with automatic travel of the heater to both mold stations. The close of the clamp frame signalled the travel of the heater to the mold; the timer clock activated the vacuum valve and the return of the heater to the middle position. The cooling cycle timer closed the vacuum and raised the clamp frame. Production cycles were approximately thirty seconds over all.

By mid 1949 we had our materials, tooiing and equipment proven out in production runs so that at the start of the Korean "incident", June 1950, production was able to swing into action. Almost immediately the shop grew from approximately forty people to over 300 and work continued seven days a week on three shifts. Large scale semi-automatic vacuum forming had arrived.

In order to get some notoriety of the process and personal credit, I managed to get an article published in the Engineering Section of Modern Plastics magazine under my own name and title.

The article, "Printed Sheets Precision Formed," appeared in the September 1950, issue and caused quite a stir in the plastics iondustry as well as in the Map Service.

My three years with the Army Map Service were fascinating and very rewarding. I was able to develop the expertise of a relatively little known industry and move on to greener fields and more challenges.