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Characterization of the Structure of Cellular Plastics

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Synopsis

Equations are presented which allow calculation of the average cell volume, number of cells per unit area, cross-sectional area, and average axial lengths of cells in formed plastics. The equation for the average volume of a group of cells has been derived to include terms which adjust for the effect of cellular anisotropy. This adjustment is made by including in the equation terms defining the number of cells (in terms of air displacement volumes) which occur in three planes of the specimen. Average cell volumes calculated with the derived equation were found to agree well with average volumes determined by measuring the volume of a known number of cells.

INTRODUCTION

The characterization of the cellular structure of foams has long been of importance to foam technologists, since knowledge of the volume, eccentricity, and size distribution of cells can be extremely helpful when comparing apparently similar foams which have different properties. The relation between cell structure parameters and the thermal conductivity of foams has been discussed by Harding and James,[2] Skochdopole,[1] and Knox.[3] The relationships between cellular structure and the properties of flexible urethane foams have also been described by Jones and Fesman.[4] These studies and many others indicate the importance of relating the physical properties of foams to cell structure.

The presently available techniques for characterizing cell structure include microscopic counting of the number of cells per inch of foam, microscopic measurements of cell dimension, television scanning[5] of foam cross-sections to determine chord-size distributions, and cell volume measurements[6,7] by use of a Beckman air comparison pycnometer or the apparatus recommended by Remington and Pariser.[8]

In the procedure described by Harding[6] for determining the average volume of foam cells, no allowance is made for the effect that cell anisotropy has on the determination of cell volumes. In the Harding method the initial measurement of the volume of air displaced by a foam specimen is followed by subsequent air volume measurements with the sample cut along a plane parallel to only one axis of the sample. The volume of the sample after cutting is equal to the difference between the initial volume and the total volume of the cells opened along the cut. Since the volume decrease resulting from cut cells is equal to the number N_a of cells per unit area times the average cell gas volume $\bar{V}_g$, it becomes apparent that because of cell eccentricity the number of cells in different planes will vary, thus the calculated volume of cells opened by cutting will depend on the cut direction. An example of this effect is shown in Table I, which compares cell volumes determined by applying the Harding method to samples cut along different planes (*xy*, *yx*, and *xz* planes) with cell volumes determined by using the method described in this paper. It can be seen that cutting the specimen in only one direction yields a different average cell volume for each cut direction.

TABLE I
Comparison of Average Cell Volumes

	Average cell volumes, cm.^{3} × 10^4			
	Harding			This
Sample	*xy*	*xz*	*yz*	paper
A	19.4	3.9	3.9	0.35
C	72.7	8.1	7.1	0.82
G	213.3	105.5	53.5	5.87
K	782.9	249.6	192.5	17.33
L	933.5	278.4	215.7	23.27

In this paper a new equation is derived for determining the average cell volume in foam materials. Adjustment is made for cell eccentricity by including volume terms measured along planes cut in three perpendicular directions. Other equations are also given for determining the number of cells per unit area, the cross-sectional area, and dimensions of an average cell.

EXPERIMENTAL

All of the data presented in this paper were measured on polyurethane foams which had nominal densities of 2 lb./ft.^{3}.

The geometric volumes of the samples were measured to the closest 0.001 in. with a dial gage. Displacement volumes were measured with a Beckman air comparison pycnometer. The principle and use of the Beckman apparatus has been described in the literature.[7]

The number of cells per unit area was determined by counting the cells in the desired cross-section. After cutting the sample along the desired plane the cellular cross-section was inked by pressing the foam lightly on a black stamp pad. The inked cross-section was then photographed with a Polaroid MP-3 industrial camera. The number of cells per unit area was calculated as the product of the number of cells per unit length along the length and width of the cross-section. When determining the number of cells, all cells intersected by lines drawn parallel to the length and width of the sample were counted. It should be noted that only the number of cells per unit length or area was determined. From data presented later in this paper, it will be seen that the average cell dimensions are not equal to the reciprocal of the cells/unit length appearing in a cut cross-section.

The accuracy of the above method was checked by comparing the product of the count per unit length and count per unit width with the total visual count of cells in a unit area. Good agreement was obtained between the two methods. Keeler[10] has found that the cell counts made on polystyrene foam do not agree with the count determined as the product of cells along the length and width of the sample. He has found instead that

$$\text{number of cells/unit area} = \frac{\text{count/unit length} \times \text{count/unit width}}{1.27}$$

At present, there is no explanation for the difference between the counting results described in this paper and the method used by Keeler. A recheck of the cell counts indicated that the data listed under "Visual Count" in Table III are values which are obtained when all the cells in a unit area are counted.

The procedure for determining the experimental data necessary to calculate the parameters discussed in this paper (average cell volumes, average cell dimensions, etc.) is outlined in the following steps.

(*1*) Measure the length, width, and thickness of the sample to the nearest 0.001 in. Weigh the sample to the nearest 0.01 g. From these data, calculate the geometric volume of the sample and the sample density.

(*2*) Determine the total sample volume in an air comparison pycnometer. This is the value V_s in eq. (15).

(*3*) Cut the sample along the yz plane and determine V_{yz} as the difference in sample volume, measured with an air pycnometer, before and after cutting. In a similar manner determine V_{xy} and V_{xz}. These data are used in eq. (15) to calculate $\bar{V}_g$.

DISCUSSION

It is necessary, before developing the equations for characterizing cell parameters, to define the term "closed cell."

Because of the nature of the equations and methods discussed in this paper a cell or closed cell must be considered to be any cavity occurring in the sample which is completely surrounded by unruptured cell windows. This definition encompasses cavities which are formed by single enclosed cells and interconnecting cell chains which do not pass completely through the test specimen. Because the urethane foams used in this work had a high closed cell content (>90%), the average cell volumes are essentially those which would be obtained for individual cells. If the lengths of interconnecting cell chains are short, it is frequently difficult to distinguish between a large cell and a cellular chain. When the cellular chains are very long it is possible that the calculated average cell volumes may be greater than the average of the individual cell volumes.

It is also important to point out that the cell or cavity volumes which are calculated from the equations in this paper should represent the volumes which affect the value of the various foam properties (thermal conductivity, water vapor permeability, etc.) which have been discussed in the literature as being dependent on cell volumes.

Equation for Determining Average Cell Volume

The volume V_s of the foam specimen shown in Figure 1 measured by an air displacement technique will be equal to the volume of closed cells V_c plus the volume V_w of cell wall

$$V_s = V_c + V_w \tag{1}$$

This volume represents all of the closed cell portion of the test sample and excludes cells or cell chains connecting to the outer surface of the sample.

The volume V_c, the total gas volume of all cells in the sample, will also be given by

$$V_c = (1 - f_w)V_s = [1 - (d_f/d_p)]V_s \tag{2}$$

where f_w is the fraction of cell wall in the sample, d_f the foam density, and d_p the polymer density.

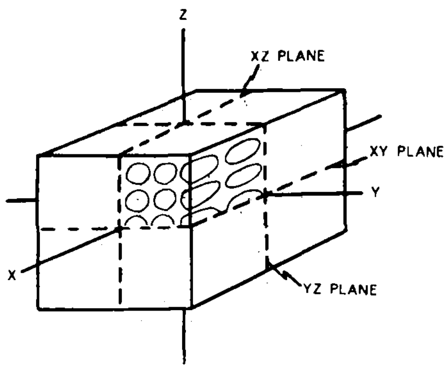

Fig. 1. Coordinates and reference planes in cellular specimen.

If the sample is cut along the three planes shown in Figure 1 the volume of gas in the closed cells cut open in each plane will be equal to the difference between the volume of all the sample pieces measured before and after cutting. Also, the total gas volume of the cells exposed in each plane will be equal to the product of the number N_{xy}, N_{yz}, or N_{xz} of closed cells cut open in each plane and the average cellular gas volume $\bar{V}_g$; therefore; the volume relations after each cut will be:

$$V_s - V_{sxy} = V_{xy} = N_{xy}\bar{V}_g \tag{3}$$

$$V_{sxy} - V_{syz} = V_{yz} = N_{yz}\bar{V}_g \tag{4}$$

$$V_{syz} - V_{sxz} = V_{xz} = N_{xz}\bar{V}_g \tag{5}$$

TABLE II
Comparison of Measured and Calculated Average Cell Volumes

Sample	$\bar{V}_g$, eq. (11), cm.^{3} × 10^4	$V = xyz$, Table V, cm.^{3} × 10^4	$\bar{V}_g$, eq. (12), cm.^{3} × 10^4
A	0.75	0.70	0.29
C	1.77	1.45	0.93
G	12.66	10.39	5.30
K	40.87	35.50	16.54

TABLE III
Comparison of Average Cell Volumes and Cells/Square Inch

	$\bar{V}_g$, cm.^{3} × 10^4		Cells/in.^{2} Calcd. by	
Sample	By eq. (15)	By eq. (12)	$\bar{V}_g$ column 2[a]	Visual count[b]
A	0.35	0.33[c]	11,300[c]	11,550[c]
		0.28	6,600	7,986
		0.28	8,500	8,131
B	0.63	0.56	8,100	9,147
		0.46	3,820	4,336
		0.46	4,500	6,127
C	0.82	0.83	7,200	7,034
		0.96	3,450	2,927
		0.96	3,300	2,731
E	3.79	5.42	2,070	1,425
		4.02	1,440	1,329
		3.34	1,250	1,332
F-1	3.92	3.24	2,090	2,499
		3.24	1,400	1,632
		2.77	1,180	1,647
G	5.87	5.06	1,440	1,653
		5.62	1,140	1,177
		5.23	905	1,010
I	10.75	9.00	910	1,150
		9.16	700	814
		9.05	630	747
K	18.95	16.26	700	780
		18.56	490	467
		14.80	440	537

[a] The cells/in.^{2} for each plane were calculated by using the equation $N_a = V_a/\bar{V}_g$ and values of $\bar{V}_g$ from column 2.

[b] Cell count made from photographs of respective cross-sections.

[c] The three cell volumes and cells/in.^{2} in each group of columns 3, 4, and 5 are, in order, the values for the xy, xz, and yz planes.

Since the total number of closed cells N_c in the volume V_s can be defined as

$$N_c^2 = N_{xy}N_{yz}N_{xz} \tag{6}$$

eqs. (3), (4), and (5) can be substituted in eq. (6) to obtain $\bar{V}_g$ in terms of the volume of cells in the xy, yz, and xz planes and the total number of cells in the sample

$$\bar{V}_g^3 = V_{xy}V_{yz}V_{xz}/N_c^2 \tag{7}$$

It has been shown[6] that the average gas volume of a cell is also equal to

$$\bar{V}_g = V[1 - (d_f/d_p)] = (1/N)[1 - (d_f/d_p)] \tag{8}$$

where V is the overall volume associated with an average cell and $1/N$ the reciprocal of the number of cells per unit volume. For the closed cell portion of the sample V_c under discussion, the number of cells per unit volume will be

$$N_c/V_c = N \tag{9}$$

By substitution of eq. (9) in eq. (7) and combining with eq. (8), eq. (10) is obtained.

$$\bar{V}_g = (V_{xy}V_{yz}V_{xz}/V_c^2)[d_p/(d_p - d_f)]^2 \tag{10}$$

Substitution for V_c from eq. (2) yields

$$\bar{V}_g = (V_{xy}V_{yz}V_{xz}/V_s^2)[d_p/(d_p - d_f)]^4 \tag{11}$$

All of the terms on the right-hand side of eq. (11) are experimentally determinable and include volumes V_{xy}, V_{yz}, and V_{xz} measured at right angles to allow for the effect of anisotropy on cell volume measurements.

Comparison of average cell volumes calculated by using eq. (11) with volumes determined by substituting V_a the volume of cut cells (corrected for open cells) in the xy, yz, or xz planes and N_a the number of cells counted in the respective planes in the equation

$$\bar{V}_g = V_a/N_a \qquad a = xy, yz, xz \tag{12}$$

showed that the cell volumes calculated with eq. (11) are the values which would be obtained if the cells were rectangular parallelepipeds. In Table II are shown data comparing volumes calculated by using eqs. (11), (12), and the equation $V = xyz$ (where x, y, and z are the average cell dimensions shown in Table V). It can be seen that good agreement is obtained between cell volumes determined by substituting cell dimensions in the equation for the volume of a rectangular parallelepiped and volumes calculated with eq. (11), while volumes determined with eq. (12) were considerably smaller. In view of this result, and because eq. (12) is probably the most basic and accurate way to determine $\bar{V}_g$, it becomes necessary to modify eq. (11) further to correct for the shape of the cells.

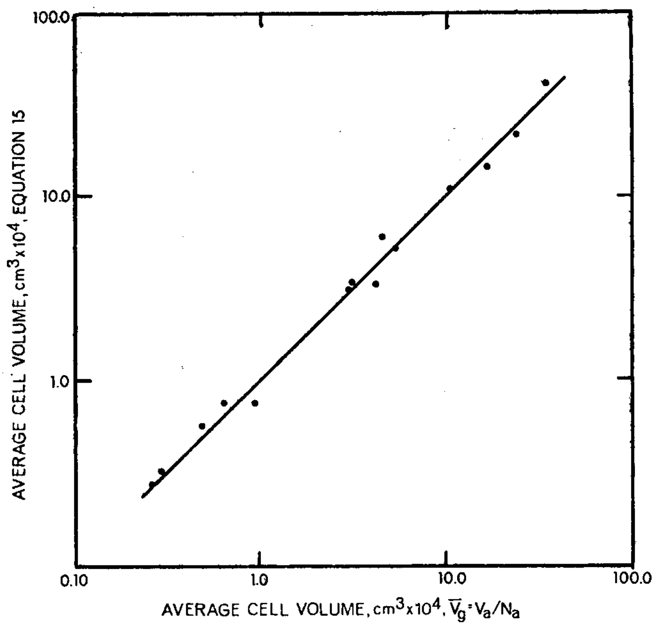

Fig. 2. Comparison of cell volumes calculated by using $\bar{V}_g = V_a/N_a$ and eq. (15).

The model used to modify eq. (11) was based on the generalized equation for a sphere or ellipsoid

$$\bar{V}_g = (\pi/6)xyz = (\pi/6)\bar{V}_{g,rp} \tag{13}$$

where x, y, and z are the axes (not semiaxes) of the cell. When $x = y = z$, the cell is spherical, and for uneven axial lengths it is an ellipsoid. V_{rp} is the average volume of a rectangular parallelepiped having the dimensions x, y, and z. Since the cells are actually deformed dodecahedra, it was also assumed that the average cell was a dodecahedron having a volume equal to the average of the volumes of a sphere or ellipsoid inscribed and circumscribed about the dodecahedron. From calculation of volumes for a dodecahedron having edges of unit length and inscribed and circumscribed spheres[9] it was found that the volume of the dodecahedron was 88.5% of the average volume of the two spheres. Equation (13), therefore, becomes

$$\bar{V}_g = (0.885\pi/6)xyz = 0.464\bar{V}_{g,rp} \tag{14}$$

Substitution of eq. (11) in eq. (14) yields the final equation for calculating average cell volumes

$$\bar{V}_g = 0.464(V_{xy}V_{yz}V_{xz}/V_s^2)[d_p/(d_p - d_f)]^4 \tag{15}$$

In Table III are compared average cell volumes calculated by using eqs. (12) and (15), and the number of cells per square inch determined from visual count and calculations by using volume data. It can be seen that there is good agreement between cell volume and cell counts determined by the two methods, indicating that the foams being examined were mainly composed of singular closed cell entities. In Figure 2 are plotted all of the cell volume data collected in this work for comparison of eqs. (12) and (15).

Average Cross-Section Area of Cells Exposed in a Cut Plane

If a plane is cut through a foam sample the average area of exposed cross sections will be given by

$$\bar{A}_a = (1 - f_w)A_{f,a}/N_a \qquad a = xy,\ yz,\ xz \tag{16}$$

where f_w is the fraction of cell wall, $A_{f,a}$ the areas of the sample cross section being studied, and N_a the number of cells in the area $A_{f,a}$. If the closed cell content of the foam is high (~90%) the term N_a can be equated to $V_a/f_{cc}\bar{V}_g$ (f_{cc} being the fraction of closed cells), and eq. (16) can be modified to allow calculation of $\bar{A}_a$ from volume measurements.

$$\bar{A}_a = (1 - f_w)f_{cc}A_{f,a}\bar{V}_g/V_a \tag{17}$$

$$\bar{A}_a = \frac{(1 - f_w)\ \bar{V}_g}{V'_a} \qquad a = xy,\ yz,\ xz \tag{18}$$

where V'_a is now the volume per square inch of cells (corrected for the open cell content) which are opened by cutting.

Axial Dimensions of an Average Cell

When an average cell, which is assumed to be an ellipsoid, is bisected along the xy, yz, and xz planes the cross-sections along each cut will have areas given by

$$\begin{aligned} \bar{A}_{xy} &= (\pi/4)xy \\ \bar{A}_{yz} &= (\pi/4)yz \\ \bar{A}_{xz} &= (\pi/4)xz \end{aligned} \tag{19}$$

where x, y, and z represent the full length axes of the ellipsoid. Solving eq. (19) for x, y, and z will give three equations

$$\begin{aligned} x &= 2(\bar{A}_{xz}\bar{A}_{xy}/\pi\bar{A}_{yz})^{1/2} \\ y &= 2(\bar{A}_{xy}\bar{A}_{yz}/\pi\bar{A}_{xz})^{1/2} \\ z &= 2(\bar{A}_{xz}\bar{A}_{yz}/\pi\bar{A}_{xy})^{1/2} \end{aligned} \tag{20}$$

defining the axial lengths in terms of the central cross-sectional areas of an average cell. If the cross-sectional areas calculated by using eq. (18) represent the central cross-section of the average cell the lengths of the x, y, and z axes could be determined by substituting area values in eq. (20).

Although it might be expected that cutting an array of randomly distributed cells would yield a cross-section through the center of the

TABLE IV
Comparison of Cell Volumes Calculated by Using Equations (15) and (21)

Sample	$\bar{V}_g$, cm.^{3} × 10^4 $\bar{v}_g$ By eq. (15)	By eq. (21)	$\bar{v}_g/\bar{V}_g$	f_v
A	0.35	0.13	0.400	0.548
B	0.63	0.27	0.465	0.601
C	0.82	0.36	0.480	0.613
D	0.85	0.37	0.474	0.608
E	3.79	1.69	0.487	0.619
F-1	3.92	1.76	0.490	0.621
F-2	3.82	1.73	0.496	0.626
F-3	3.54	1.59	0.491	0.622
G	5.87	2.69	0.501	0.631
H	6.80	3.11	0.500	0.630
I	10.75	4.94	0.502	0.632
J	12.59	5.94	0.517	0.644
K	18.95	8.50	0.490	0.622
L	23.27	11.38	0.535	0.659
N	49.85	24.91	0.547	0.668
		Avg.	0.492	0.623

TABLE V
Dimensions of Average Cells

Sample	Cell dimensions, mm. x	y	z	$\bar{V}_g$, Measured cm^3 × 10^4	$\bar{V}_g = (\pi/6)\,xyz$, cm.^{3} × 10^4
A	0.59	0.34	0.35	0.35	0.37
C	0.87	0.42	0.40	0.82	0.76
E	1.18	0.81	0.71	3.79	3.58
F-2	0.99	0.88	0.77	3.82	3.56
G	1.28	1.01	0.80	5.87	5.44
I	1.59	1.15	1.04	10.75	10.05
K	2.02	1.38	1.27	18.95	18.60
N	2.69	1.89	1.73	49.85	46.24

average cell, it was found experimentally that the average cross-section is not through the ellipsoid center. Experimental proof that the average cell is not bisected can be demonstrated in the following manner.

If the average cell discussed in the first section is cut along the three axes, the cell volume will be given by

$$\bar{v}_g = {}^4/_3(\bar{A}_{xy}\bar{A}_{yz}\bar{A}_{xz}/\pi)^{1/2} \qquad (21)$$

when the average areas $\bar{A}_{xy}$, $\bar{A}_{yz}$, and $\bar{A}_{xz}$ calculated by using eq. (18) are the cross-sectional areas through the center of the average cell, substitution of these areas in eq. (21) should give values of $\bar{v}_g$ equal to those shown in Table III. If the areas do not represent the central cross-sections, $\bar{v}_g$ will be smaller than shown in Table III. In Table IV are compared cell volumes calculated by using eqs. (15) and (21). From these data it can

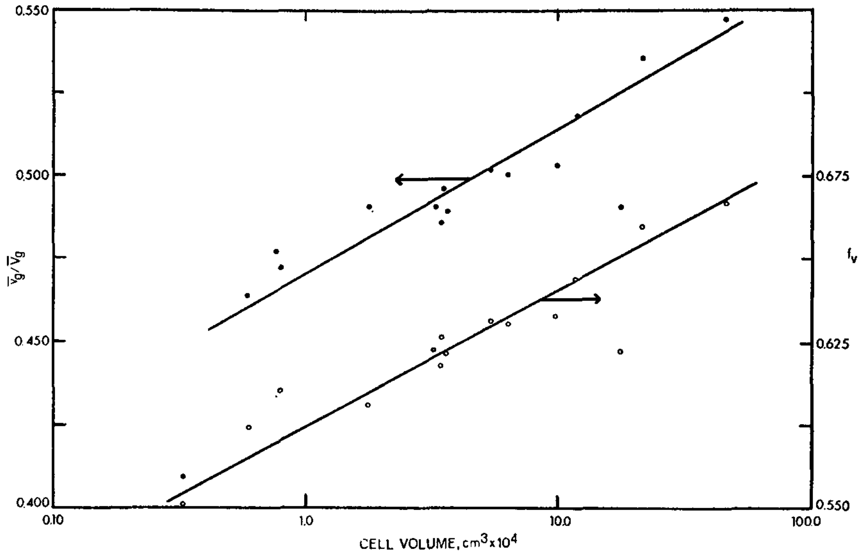

Fig. 3. Change in $\bar{v}_g/\bar{V}_g$ and f_v as a function of cell volume.

be seen that volumes calculated with eq. (21) are lower than expected, indicating that the average cell is not bisected but is cut at a point between the center and end of the ellipsoid. It is therefore necessary to modify equation 18 to obtain the cross-sectional areas which would result if the average cell were bisected.

If an ellipsoid is cut along planes normal to the three axes and equidistant from the ellipsoid center, the area of the cut sections $\bar{A}_a$ will be a fraction f_v of the areas $\bar{A}_{c,a}$ passing through the center, i.e.,

$$\bar{A} = f_v\bar{A}_c \qquad \bar{A}_{yz} = f_v\bar{A}_{c,yz} \qquad \bar{A}_{xz} = f_v\bar{A}_{c,xz} \tag{22}$$

The average cell volume $\bar{V}_g$ obtained by using areas from eq. (18) will be

$$\bar{v}_g = {}^4/_3(\bar{A}_{xy}\bar{A}_{yz}\bar{A}_{xz}/\pi)^{1/2} = {}^4/_3 f_v^{3/2}(\bar{A}_{c,xy}\bar{A}_{c,yz}\bar{A}_{c,xz}/\pi)^{1/2} = f_v^{3/2}\bar{V}_g \tag{23}$$

where $\bar{V}_g$ is the average cell volume determined using eq. (15). Rearranging and solving for f_v yields

$$f_v = (\bar{v}_g/\bar{V}_g)^{2/3} \tag{24}$$

By substituting eq. (18) in eq. (23) f_v can be obtained in terms of volumes measured in a pycnometer.

$$f_v = [4(1 - f_w)^{3/2}\bar{V}_g^{1/2}/3\pi^{1/2}](1/V'_{xy}V'_{yz}V'_{xz})^{2/3} \tag{25}$$

In Table IV are listed calculated values of $\bar{v}_g/\bar{V}_g$ and f_v. It can be seen that as the average cell volume increases $\bar{v}_g/\bar{V}_g$ and f_v also increase. The change in $\bar{v}_g/\bar{V}_g$ and f_v probably indicates that there is a shift in cell size distribution; i.e., the number of small cells decreases as the average cell volume increases. In Figure 3 are plotted values of $\bar{v}_g/\bar{V}_g$ and f_v as a function of cell volume. From the data shown in Figure 3 values of f_2 can be obtained for use in eqs. (26), (27), and (28).

If eqs. (22) and (18) are substituted in eq. (20), three relations will be obtained from which the axial lengths of an average cell can be calculated using volume data measured in a pycnometer. The necessary equations are:

$$x = 5.08[(1 - f_w)\bar{V}_g/\pi f_v]^{1/2}(\bar{V}'_{yz}/V'_{xy}V'_{xz})^{1/2} \quad (26)$$

$$y = 5.08[(1 - f_w)\bar{V}_g/\pi f_v]^{1/2}(V'_{xz}/V'_{yz}V'_{xy})^{1/2} \quad (27)$$

$$z = 5.08[(1 - f_w)\bar{V}_g/\pi f_v]^{1/2}(V'_{xy}/V'_{xz}V'_{yz})^{1/2} \quad (28)$$

In Table V are listed average cell dimensions, the measured average volume of the cells, and the average volume of the cells calculated from the cell dimensions. It can be seen that the calculated and measured values are in good agreement.

Alternate Method of Determining Cell Parameters

Although optical techniques are not as convenient to perform when compared with volumetric methods they can be utilized with the equations given in this paper to characterize the average individual cell.

If the test specimen is cut along the xy, yz, and xz planes with subsequent inking and photographing of the cut planes the average area of the section cut through the cells can be determined by using eq. (16) with the term N_a determined by counting the number of cells in a known area $A_{f,a}$. If the average cell cross-section area for the xy, yz, and xz planes are then substituted in eq. (21) the volume $\bar{v}_g$ will be obtained. This volume ($\bar{v}_g$) can then be corrected to the true average cell volume $\bar{V}_g$ using the data given in Table IV or Figure 3.

If one uses eqs. (22), and the value of f_v corresponding to the average cell volume $\bar{V}_g$ obtained above, the true cross-section areas of the average cell can also be determined. These areas can then be substituted in eqs. (20) to calculate the dimensions of the average cell.

It should be noted that determining the average cell area in a cross-section cut by counting the cells in a given area has an advantage over the microscopic measurement of the dimensions of irregularly shaped cells, since a great deal more subjectivity is incorporated in the optical method than is encountered when making a cell count.

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References

1. R. E. Skochdopole, *Chem. Eng. Progr.*, **57**, 55 (1961).
2. R. H. Harding and B. F. James, *Mg. Plastics*, **39**, 133 (1962).
3. R. E. Knox, *Am. Soc. Heating Refrig. Air Cond. Eng. J.*, **4**, 10 (1962).
4. R. E. Jones and G. Fesman, *J. Cellular Plastics*, **1**, 200 (1965).

5. J. A. Edinborgh, paper presented at 69th Annual Meeting of the ASTM, Atlantic City, N. J., 1965.
6. R. H. Harding, *Mod. Plastics*, **37**, 156 (1960).
7. D. M. Rice and L. J. Nunez, *SPE J.*, **18**, 321 (1962).
8. W. J. Remington and R. Pariser, paper presented at the 132nd American Chemical Society Meeting, New York, September 1957.
9. *The Universal Encyclopedia of Mathematics*, Simon and Schuster, New York, 1964.
10. D. E. Keeler, personal communication, Dow Chemical Co., Midland, Michigan.

Résumé

Des équations sont présentées qui permettent de calculer le volume moyen ce cellule, le nombre de cellules par unité de surface, la surface transversale moyenne et les longueurs axiales moyennes des cellules dans les mousses de plastiques. L'équation pour le volume moyen d'un groupe de cellule a été dérivée et permettait d'incluredes termes qui tiennet compte de l'anisotropie cellulaire. Cèt ajustement est fait en incluant dans l'équation des termes définissant le nombre de cellules (en termes de volumes d'air déplacé) qui se présentent dans trois plans de l'échantillon. Les volumes cellulaires moyen calculés avec l'équation dérivée ont été trouvés en accord avec les volumes moyens déterminés par mesure du volume d'un nombre connu de cellules.

Zusammenfassung

Gleichungen zur Berechnung des mittleren Zellvolumens, der Anzahl der Zellen pro Flächeneinheit, der Querschnittsfläche und der mittleren Längsachse von Zellen in geschäumten Kunststoffen werden angegeben. Die Gleichung für das mittlere Volumen einer Gruppe von Zellen wurde unter Einschluss von Termen zur Erfassung des Einflusses der Zellanisotropie abgeleitet. Das wird durch die Aufnahme von Termen erreicht, welche die Anzahl von Zellen (als Luftverdrängungsvolumen) in den drei Ebenen der Probe definieren. Die mit der abgeleiteten Gleichung berechneten mittleren Zellvolumina stimmen gut mit den mittleren, durch Messung des Volumens einer bekannten Zahl von Zellen bestimmten Volumina überein.

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