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Cellular Structures Made of Perforated Metal Bands

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***Keywords* – perforated steel band, cellular structure, through channels, deformation.**

I. INTRODUCTION

Metallic cellular materials are effectively used in production of the cellular building construction, in aircraft building, in catalyser and filter production etc. Metallic bands are already used in production of different cellular constructions. Perforated metal materials such as steel bands are of the interest for cellular materials manufacturing. Application of perforated metal materials opens up new possibilities in the production of innovative materials and cellular structures.

II. METHODS OF MANUFACTURING

There are different methods that exist for manufacturing of cellular structures from sheet material:

- Stretching method: sheets are based layer-by-layer and then joined in the lines, for example, by gluing, then received package are stretched (f.v. Fig. 1).
- The method of corrugation: during forge-rolling the sheets are obtained in defined form. After layer-by-layer placing and fastening the cellular construction is generated (f.v. Fig. 2).
- The method of plate shearing: a multilayer package is formed and fastened on one side across the width by means of mechanical clamp (f.v. Fig. 3a). Package twist around cylindrical mandrel, then punching holes with an oblique cut at an angle α is performed.
- Cutting and stretching method: on the tape on longitudinal direction the slots are done (f.v. Fig. 4a). Then the tape is stretched in crosswise direction (f.v. Fig. 4b). The form and dimensions of cells as well as parameters of tape can be easily changed by variation of length and width of slots and degree of stretching of the tape.
- Method of interlacement of the perforated tape: previously perforated tapes are interlaced for rigid construction creation. Simple but low-output method (f.v. Fig. 5).
- Method of twisting of the perforated tape: relatively simple method for obtaining single-layer, multi-layer cylindrical or conical type cellular structures (f.v. Fig. 6).

III. MATERIALS AND EXPERIMENTAL

As a raw material a perforated metal band made of high-quality carbon steel was used. Band specifications, such as type of perforations, location of holes, specific area of perforations, thickness and width are of great importance.

Basically, for the manufacture of cellular material a perforated tape with round and oval holes should be used, especially in those cases where final products require a certain fixed location of perforated band. Diameter of circular holes is usually in range of 1 to 10 mm. A distance between holes is in range of 0.6 - 4.0 mm what allows flexibility in combinations of different bands.

Properties data are shown in Table 1.

The main difficulty in modeling cellular structure of the perforated tape is to determine the geometrical characteristics of cross-section, as well as parameters of channels formed.

We investigated the method of layer-stacking and subsequent shear bands. This method allows obtaining a cellular structure with adjustable through-channels (f.v.Fig. 9).

TABLE I

MECHANICAL CHARACTERISTICS OF PERFORATED STEEL BAND PRODUCED BY PUNCHING

Designation	LPM - 1	LPM - 2	LPM - 3
Mark of steel	St08	St50	St08
Standard	GOST 503-81	GOST 2284-79	GOST 503-81
Permeable area, %	66,97	70,50	69,97
Thickness, mm	1,50	1,20	1,80
Tensile strength, N/mm^2	320,66	937,80	427,06

When a displacement of perforated elements at a step size (t) occurs, the length of through channel in the package is changed (Fig. 10).

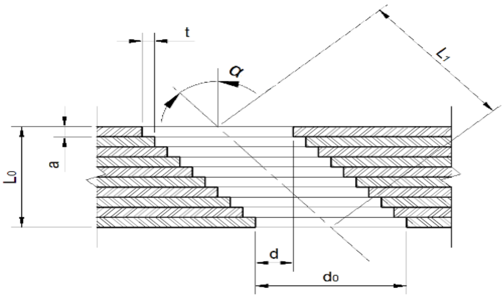

Fig. 10.The scheme for calculating the length of the through channel

Channel parameters can be determined using the following formula:

$$\alpha = ctg\,\frac{t}{a} \qquad (1)$$

$$L_0 = a \cdot n \qquad (2)$$

$$L_1 = \frac{a \cdot n}{\cos\alpha}. \qquad (3)$$

Opening ratio, depending on the angle of inclination of permeable channels (Fig. 11):

$$k = d / d_0 \qquad (4)$$

Evaluation of mechanical properties was carried out on samples (f.v. Fig. 12) of the structure shown above (f.v. Fig. 7a).

The strength of compression elements ranged from 2644 N to 2815 N. The maximum deformation of the y-axis was 1.0 - 1.4 mm.

Modeling the experimentally obtained load in the environment COSMOSWorks (linear analysis under static loading), the maximum deformation was - 1.15 mm, which is on a 1.17% lower than experimental results.