

## MANUFACTURING OF CELLULAR STRUCTURES OF THE PERFORATED STEEL TAPE

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**Abstract:** *The research regards to the development of the methods of manufacturing of the cellular structures with through channels of different form from the perforated steel tape. These methods allow recycling the metal wastes (bands), which are obtained during stamping of fine-sized details. There are given examples of steel bands with different physical-mechanical properties and geometry.*

*The methods of profiling and welding of thin perforated materials are studied. The methodology for calculating of the parameters of through channels is proposed.*

*Key words: cellular structures, perforated steel tape, profiling*

### 1. INTRODUCTION

Metallic cellular materials are effectively used in production of the cellular building construction, in aircraft building, in catalyser and filter production etc. [1-3].

The technologies of manufacturing of the cellular structures from the perforated metallic materials, for example from plate or band, are actual and developing methods. Metallic bands are already used in production of different cellular constructions [3]. For example, there are known aluminum cellular constructions, which are produced by USA Company *Ultrathin* [4]. Using of bent thin-walled elements as basis for sandwich panels allows receiving the high-strength fireproof cellular constructions.

The aim of this paper is to investigate the possibility to recycle the metal wastes (bands), which are obtained during

stamping of fine-sized details, by manufacturing from them cellular structures by profiling and welding.

### 2. METHODS AND MATERIALS

#### 2.1 Methods

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

- Stretching method (Fig.1): sheets are based layer-by-layer and then joined in the lines, for example, by gluing, then received package are stretched.

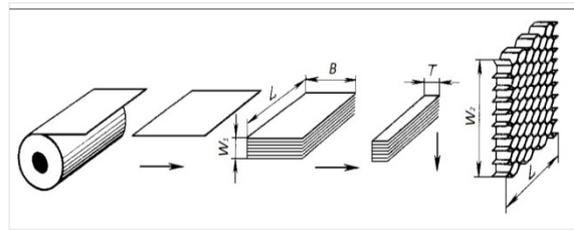


Fig. 1. Scheme of the cellular structure manufacturing by stretching method [3]

- Channeling method (Fig.2): during forge-rolling the sheets are obtained in defined form. After layer-by-layer placing and fastening the cellular construction is generated.

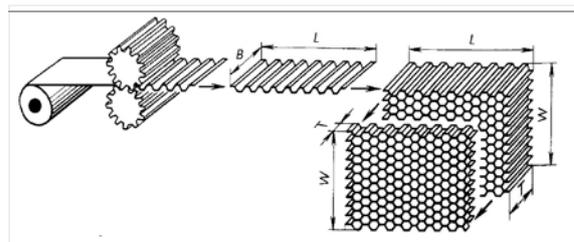


Fig. 2. Scheme of the cellular structure manufacturing by preliminary channeling of sheet material [3]

- Cutting and stretching method: on the tape on longitudinal direction the slots are done (Fig.3). Then the tape is stretched in crosswise direction. 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 (Fig.4). Simple but low-output method.

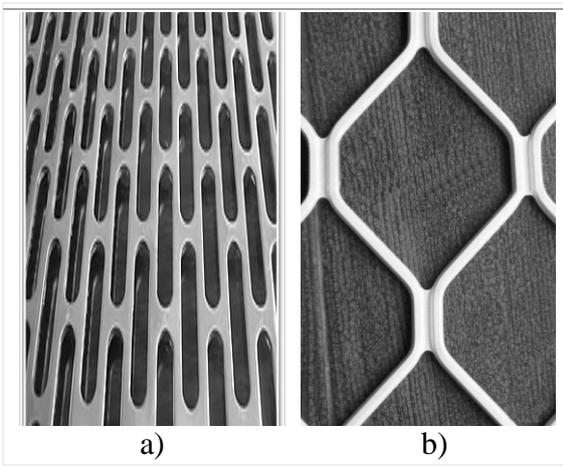


Fig. 3. Changing of form and dimensions of cells by cutting and stretching method: initial tape (a) and tape after stretching (b)



Fig. 4. Fragment of panel obtained by method of interlacement of the perforated tape

- Method of twisting of the perforated tape: relatively simple method for obtaining single-layer (Fig.5), multi-layer cylindrical or conical type cellular structures.

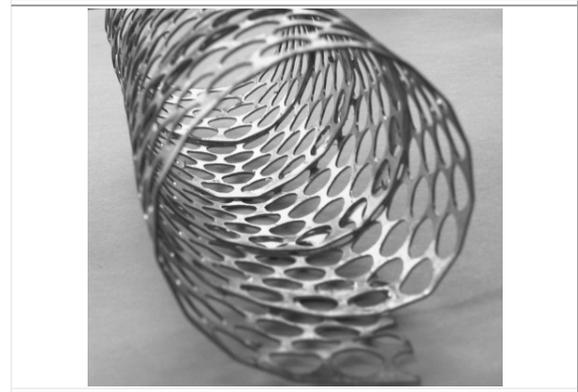


Fig. 5. Fragment of tubular cellular construction from perforated tape of cylindrical (a,b) and conical (c) type

- Welding: spot or seam resistance welding can be used for manufacturing of the profiled cellular structures (Fig.6).

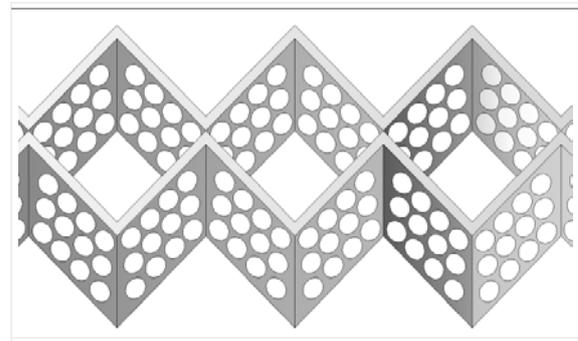


Fig. 6. Scheme of perforated tape forming before resistance welding

## 2.2 Materials

Perforated metallic materials are widely used in the ventilation and acoustic systems for sound insulation and attenuation; for manufacturing of filters and covering for safety devices in building (decorative ceiling, bars, U-troughing for electric wiring) and in technologies of material sorting. Using of perforated material open a new possibilities in manufacturing of cellular materials and constructions.

For perforated tape production following materials are often used: carbon steel, stainless steel, aluminum alloy, copper alloy and others. Most advisable from economic and technological point of view is to use qualitative carbon steels.

Perforated steel tape usual is made by notching with certain spacing and frequency on specialized forming or rolling equipment [5]. It should be mentioned, that productivity of rolling mill is much higher than forming press, but by rolling we can produce only thin tapes (0.5...2.0 mm), forming press – tapes with thickness up to 10 mm and thicker. For sheet perforating laser and another thermal cutting is used [5].

After perforating of tape the cleaning, corrosion protection and degreasing is needed. Additionally painting or galvanizing can be done.

More significant perforated tape parameters in manufacturing of cellular materials are the following: perforation type, arrangement of holes, relative area of perforation, thickness and width of tape. It is reasonable to use the perforated tape with oval and circular holes especially in the case when certain fixed placement of perforated tape is needed. Oval and rectangular holes allow easily joint several taps with displacement relative to one another.

### 3. NEW METHOD FOR MANUFACTURING OF CELLULAR STRUCTURES

In our opinion promising is the method of sheets shifting. This method has been proposed in Riga Technical University in 2011 [7]. First of all from sheets 1 the multilayer package 2 is formed, which is clamped throughout one side by mechanical clamp 3 (Fig.7).

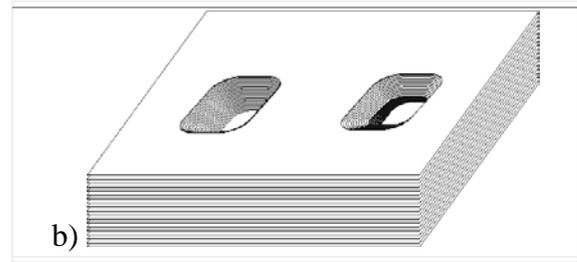
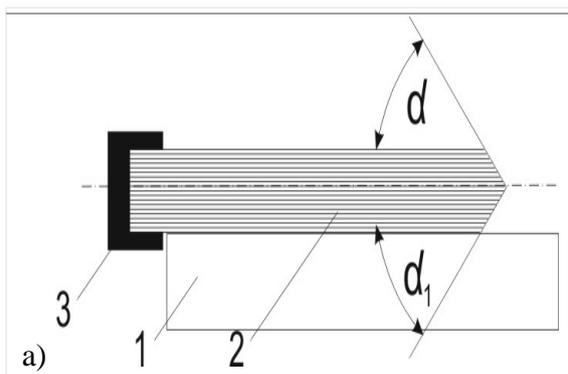


Fig. 7. Scheme of the shifting device (a) and fragment of tape with cells of variable sections (b)

### 3.1 Methodology for calculating of the parameters of through channels

Main problem in profile modelling is the definition of the form and amount of holes in tape – definition of the geometrical characteristics of cross-section.

Object of our investigation is the cellular structures with through channels (Fig.8).

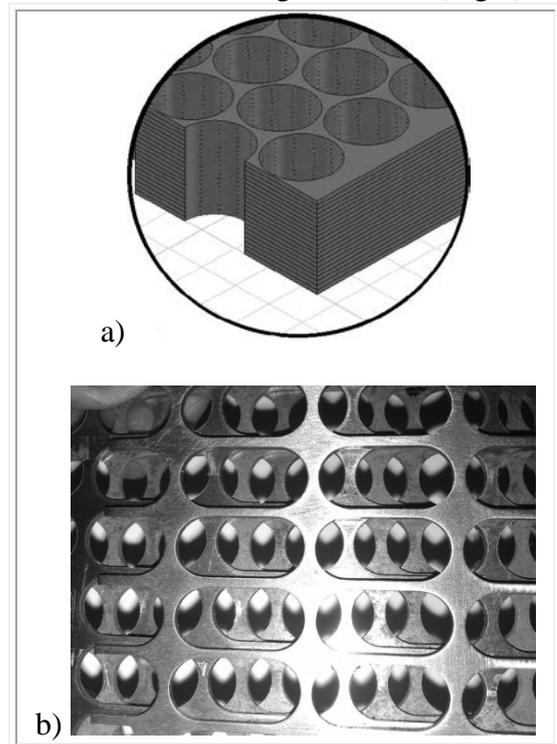


Fig. 8. Formation of through channels during coaxial placing (a) and displacement of perforated elements relative to one another (b)

Such through channels arises after layer-by-layer deposition of sheet or tape perforated material. At shifting of perforated elements in package on the

spacing value the dimensions of the through channel are changed (Fig.9).

We propose to use following formulas for calculating of the parameters of through channels:

$$\alpha = \text{ctg} \frac{t}{a} \quad (1)$$

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

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

where  $a$  – thickness of sheet;  $b$  – spacing of displacement;  $n$  – sheets number in package;  $L_0$  – thickness of package;  $L_1$  – length of the channel;  $\alpha$  – angle between axis of channel and vertical line.

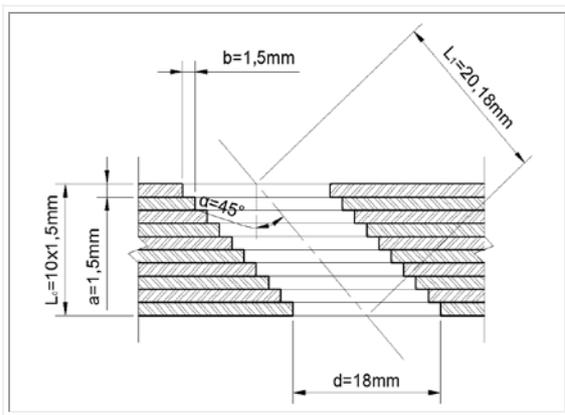


Fig. 9. Scheme illustrated calculation of the parameters of through channels

### 3.2. Experimental

In experimental investigation we use samples from metallic perforated tape, achieved as waste in forming of products [6]. Methods of producing of steel perforated tapes are examined in [5]. Samples of cellular structures were made from steel perforated tape using cutting, profiling and welding. Parameters of investigated perforated tapes are given in Table 1.

Producing of profiles shown on Figure 10 was made by bending in stamp. Profiling was made in longitudinal direction (Fig.10,a) and in crosswise direction (Fig.10,b). Previously profiled tapes were joined. As a result cavities were generated between tapes (Fig.12). Subsequently

cavities may be filled by powder, granular and fibrous filler.

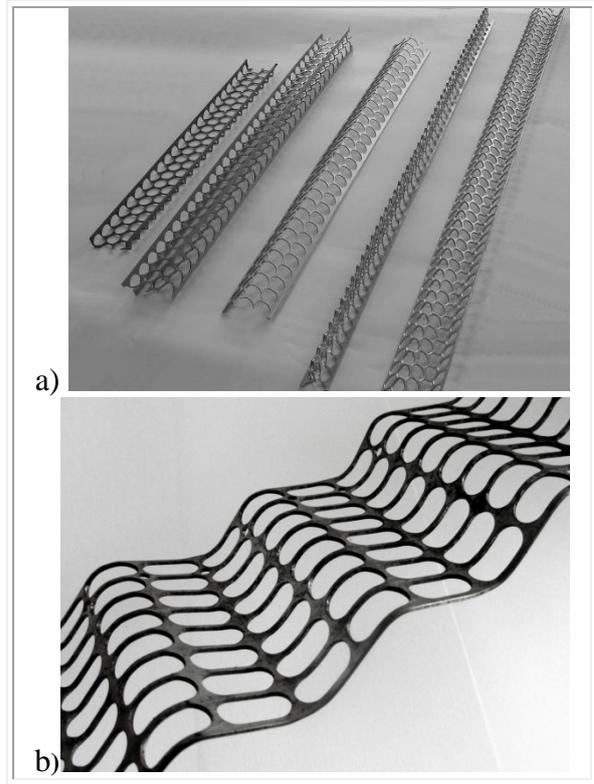


Fig. 10. Profiles from steel perforated tape (width 100 mm, thickness 1.2 mm) produced by longitudinal (a) and crosswise (b) profiling

Previously profiled tapes were joined by resistance spot welding (RSW) using experimental AC RSW equipment „Impulse KM” earlier elaborated in Riga Technical University (Fig.11).



Fig.11. RSW experimental equipment „Impulse KM”

Table 1. Properties and sizes of investigated perforated tape

Type of band				
<b>Designation</b>	LM - 1	LM - 2	LM - 3	LM - 4
<b>Mark of steel</b>	St08	St08	St50	St08
<b>Standard</b>	GOST 503-81	GOST 503-81	GOST 2284-79	GOST 503-81
<b>Permeable area, %</b>	69,10	66,97	70,50	69,97
<b>Thickness, mm</b>	1,50	1,00	1,20	1,80
<b>Cross – sect. area (brutto), mm<sup>2</sup></b>	116,25	94,00	96,00	135,00
<b>Cross – sect. area (netto), mm<sup>2</sup></b>	25,13	12,91	14,44	29,27
<b>Max. load, N</b>	5549,39	4139,75	13541,87	12500,11
<b>Tensile strength, N/mm<sup>2</sup></b>	220,83	320,66	937,80	427,06

Nowadays RSW is one of the main methods for joining of sheet metal in all industry, as well as low carbon steel is one of the most readily spot welded materials [8]. The main RSW welding parameters for steel S235JRG2 welding (material thickness is 1.2 mm) are given in Table 2.

<b>Welding parameters</b>	Welding current range, kA	Electrode force, kN	Weld time, sec (50 Hz cycles)
<b>Conditions</b>	8...9	3,5...4	0,18..0,20

Table 2. RSW welding parameters

Welding was performed by using copper electrodes with a diameter of 7 mm. The view of welded cellular structure is given in Figure 12, but view of the welding nugget is shown on the Figure 13.

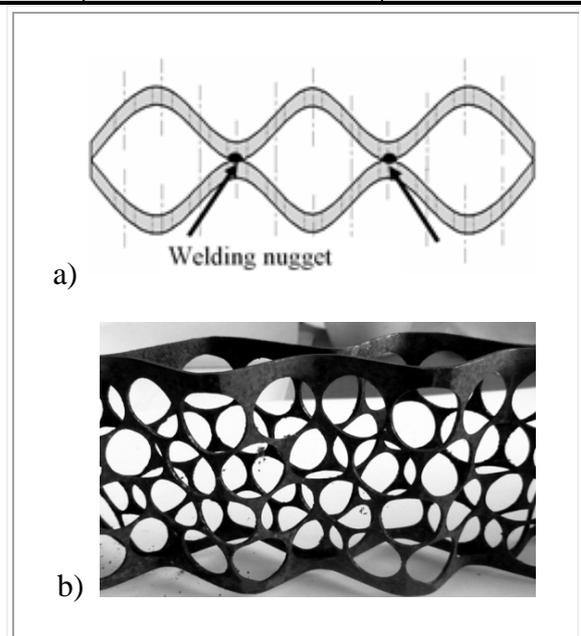


Fig. 12 Conceptual view of assembly of steel tapes (a) and cellular structures from steel S235JRG2 perforated tapes (width 100 mm, thickness 1.2 mm) produced by RSW (b)

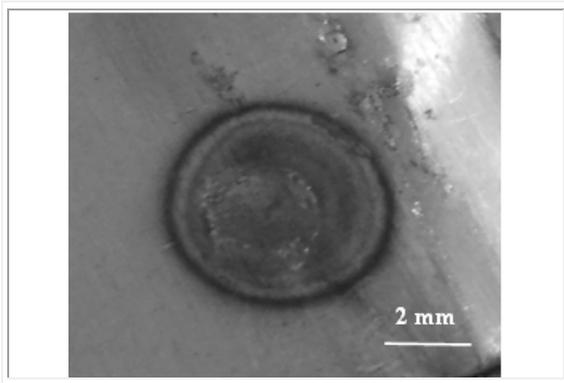


Fig. 13 View of steel S235JRG2 welding nugget

#### 4. RESULTS AND CONCLUSION

As a result of investigation we can assume that the manufacturing of the cellular structures from the perforated metallic materials (from tape or band) is a perspective technology.

Choosing of tape parameters and material is important decision that influence on mechanical properties of the products from cellular material and on its future application. Most advisable from economic and technological point of view is to use qualitative carbon steels. Parameters of through channels can be easily changed by perforated elements displacement per spacing in package.

First experiments in joining of cellular elements by resistance welding were successful. Future investigations will be connected with elaboration of spot and seam resistance welding technology for joining of cellular elements.

It is shown that welding nugget is of good performance (without spattering, cracks, welding nugget diameter on external surface was varied from 5 to 7 mm). Future investigations will be related with research on the properties of welding joints achieved under different welding conditions and applying another joining scheme.

The possibility to recycle the metal wastes (bands) by manufacturing from them cellular structures by profiling is proved. New method for manufacturing of cellular structures i.e. shifting method is proposed.

Technological abilities of new method are shown. The methodology for calculating of the parameters of through channels is proposed. Preliminary experiments were revealed that the resistance welding is an appropriate technology for generation of cellular structures.

#### 5. REFERENCES

1. Fraunhofer IWS. Annual report 2010. Dresden, Germany, 2010.
2. Kim, M.G., Kim, J.H. Porous Titanium by Using Pressure – Control Casting Process. In *Proceedings of the International Conference on Cellular Materials, Dresden, Germany, 2010*, 93 – 98.
3. *Cellular structures*. Handbook of composite materials. Edited by Lubin, Book Nr. 2. Moscow, Russia, 1988, 339 – 357 (in Russian).
4. Ultrathin Inc: <http://megastroy.co.ua/index.php?mod=news&go=view&id=3> (20.01.2012.)
5. Bogojavenskij, K., Neubauer, A., Ris, V. *Technologie der Fertigung von Lichtbauprofilen*. WEB Deutscher Verlag für Grundstoffindustrie, Leipzig, 1978
6. Mironov, V., Boyko, I., Serdjuks, D. Recycling and application of perforated steel band and profiles. In *Proceeding of the 5<sup>th</sup> Int. DAAAM Conference*, Tallinn, Estonia, 2006, 285-288.
7. Mironovs, V., Shishkins, A., Baroninsh, J. *LR patents LV 14424 B, Int. Cl. B31F1/00*, 20.01.2012.
8. Calva, C.M., Eagar, T.W. Enhancement on the Weldability in Resistance Spot Welding. In *AWS Detroit Section Sheet Metal Welding Conference IV*, Southfield, MI, USA, 1990, 1-33.

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