Agronomy Research **16**(5), 2110–2116, 2018
https://doi.org/10.15159/AR.18.185

Tools for building production and woodworking made from the perforated steel wastes

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Abstract. The rising of efficiency of the building and construction production is an actual task. One of the possible ways to ensure higher efficiency is using innovative tools and facilities of small-scale mechanization, which increase productivity and enhance working condition. Most observable influence of such strategy is on concrete works, plastering and earthworks. Another important tendency in production engineering, building and construction production is recycling of the technological wastes, which sufficiently reduce cost of the products and improve ecology. The goal of the present paper is to offer new possibility for recycling of the technological wastes, i.e. perforated steel tapes achieved after stamping of fine parts, by producing from mentioned perforated tapes the building tools and facilities of small-scale mechanization. In particular, the technological wastes of the JSC 'Ditton' (Daugavpils, Latvia) – perforated steel tapes – received after stamping of the elements of driving chains for different apparatus were used in this research. The prototypes of the scrapers for the finishing building work, as well as cutting edges and circular coronas for the woodworking were elaborated and offered in this work. The results of approbation of elaborated prototypes of the tools are offered. It was proven, that proposed innovative tools could be used effectively in building production and woodworking.

Key words: perforated metallic waste, building tools, scrapers.

INTRODUCTION

Nowadays the perforated metallic materials (PMM) have wide and various applications in the building, mechanical engineering, chemical industry, agricultural machinery industry and others branches (O' Donnell & Associates, 1993). Most of all the steel PMM are used. A lot of companies commercially produce perforated steel bands and plates, grids, tubes, filters, sieves and others goods (Accurate Perforating Company, 2018; Euro Sitex Company, 2018). Shapes variety, small weight and high strength are the most important advantages of PMM. Fast achievement and distribution of the PMM is based on the modern technologies of sheet-metal stamping and high speed cutting. Thus, recently the CNC technology to perforate metal with 3D textures from one single sheet was developed (Ceilings Plus Company, 2018).

At the same time as the development of new materials production technologies, the recycling of wastes is becoming more and more urgent issue. Thereby the waste-to-resource vision (Durr, 2017; Stahel, 2017) also became more relevant.

In a number of published works the possibility of using the technological waste in the shape of steel PMM for producing new building goods and constructions is shown (Lisicins et al., 2011; Mironovs et al., 2013; Mironovs & Lisicins, 2015).

In author's opinion additionally to the known applications of the PMM such materials from alloyed steels, which are characterized by high mechanical properties, could be used for producing edged tools like comber-type tools and sawing tools. Thus, the comber-type tool in the shape of number of plates with teeth (Poletaev et al., 1997) is used for machining wood materials as well as for removing the paint and coatings. As a rule, such tool produce from the all-metal serrate leaf on which the teeth are notched.

Another possible application of PMM could be circular cutting coronas. Coronas with the larger diameter (more than 30 mm) are equipped with the centring drill (Fig. 1). The centring drill increase the work accuracy of the corona as well as increase the stiffness of the construction of tool, i.e. exclude possible skews and other deviations and damages. The technology of producing such tool is quit complicate and labor-consuming. As a result, the cost of tool is relatively high.

During exploitation of cutting coronas the careful control and maintenance are needed. Most significant is to ensure the sharpness and wholeness of teeth, as well as the cleanness of tool cavity. If the control and maintenance are not sufficient the wearing of cutting edges of corona will occur faster than expected, even damage is possible.

Figure 1. Cutting corona with the ribbon sawing disc and centring drill.

Using the technological wastes, i.e. perforated steel tapes achieved after stamping of fine parts, for producing edged tools like described above could decrease the cost of such tools as well as open up the new possibilities in development of edged tools. Some technical ideas are presented in the Author's patent (Mironovs & Lisicins, 2015).

Thus, the comber-type tool was produced from the perforated steel tape (PST) (base material: steel C50). This tool comprises the body (1) and perforated plate (2) with preliminary shaped teeth (Fig. 2, a). The teeth were produced by cutting of the perforated tape through the perforated holes, that's why the teeth step coincided with the perforation step of holes. The perforated plate (2) is mounted on the body (1) by the rivets (3). To change the cutting angle during cutting process the perforated tape plates with different angle α were produced (Fig. 2, b).

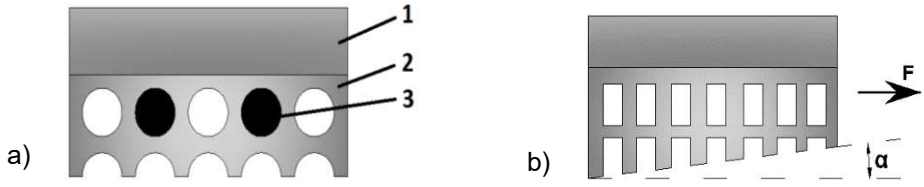


Figure 2. Design of the comber-type tool produced from the PST: with the equal length teeth (a) and with different length teeth (b); F – loading force.

For increasing the stiffness and reliability of tools, it was proposed to mount in the tool body (1) the number of parallel plates (2) as shown on Fig. 3.

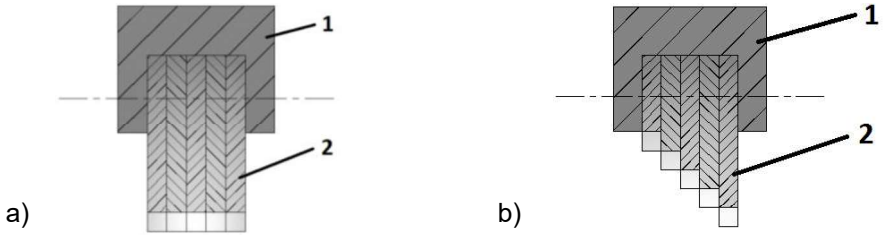


Figure 3. Anchorage scheme of PST as a block: with the equal length plates (a) and with different length plates (b).

On the other hand undoubtedly there is another important tendency in production engineering, building and construction production – the recycling of the technological wastes, which not only sufficiently reduce cost of the products, but improve ecology and raise the effectiveness of material usage as well.

The goal of the present paper is to offer new possibility for recycling of the technological wastes, i.e. perforated steel tapes achieved after stamping of fine parts, by producing from mentioned perforated tapes the building tools like scrapers for the finishing building work, as well as cutting edges and circular coronas for the woodworking.

MATERIALS AND METHODS

In general, the perforated steel tapes are received after stamping of the elements of driving chains for different apparatus. The base material as a rule is a steel with the carbon content from 0.1 to 0.5%. Chemical compositions of the appropriate carbon steel as well as mechanical properties are listed in the Table 1.

Table 1. Carbon content and mechanical properties of carbon steel used for producing driving chains

Steel grade	Carbon content, wt %	Tensile strength, N mm^{-2}	Strain, %
St08	0.05–0.12	275–390	8–33
St15	0.12–0.19	325–470	8–27
St20	0.17–0.24	340–490	7–28
St30	0.27–0.35	400–650	7–21
St50	0.47–0.55	540–720	6–14

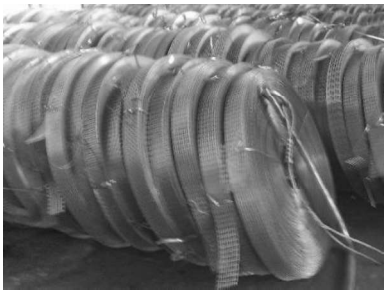
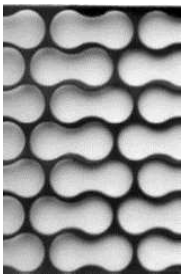
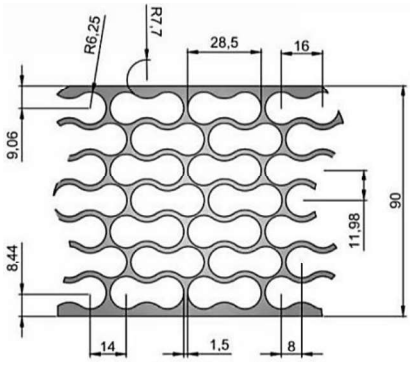
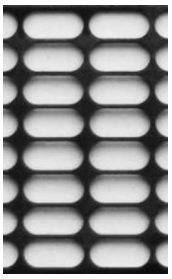
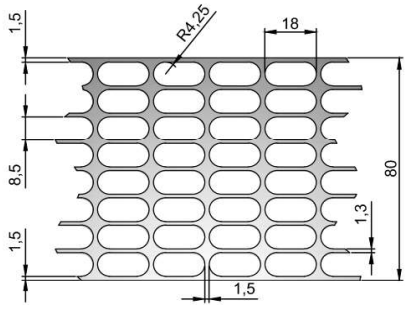


Figure 4. Technological wastes in the shape of perforated steel tapes (PST) (JSC 'DITTON Driving Chain Factory', 2018).

The technological wastes of the JSC 'Ditton' (Daugavpils, Latvia) – perforated steel tapes (PST) – received after stamping of the elements of driving chains for different apparatus were used in this research (Fig. 4).

Mechanical properties and geometrical parameters of PST samples (PST-1 and PST-2 types) used in current work are shown in Table 2.

Table 2. Mechanical and geometyrical parameters of PST-1 type and PST-2 type perforated steel tape, which were used for producing of scrapers

Parameter	Value	Tape representation	Tape geometry
designation	PST-1		
steel grade	08пс-ОМ-Т-2-К		
standard	GOST 503-81		
thickness, mm	1.50		
width, mm	90		
permeable area, %	75.32		
effective cross-sectional area, mm^2	26.43		
tensile load bearing capacity, kN	10.10		
tensile strength, MPa	406.81		
displacement, mm	2.25		
strain, %	1.21		
designation	PST-2		
steel grade	50-Т-С-Н		
standard	GOST 2284-79		
thickness, mm	1.20		
width, mm	80		
permeable area, %	70.50		
effective cross-sectional area, mm^2	14.44		
tensile load bearing capacity, kN	13.48		
tensile strength, MPa	933.43		
displacement, mm	2.43		
strain, %	1.40		

RESULTS AND DISCUSSION

As it was shown in the Table 2, the technological wastes in the shape of perforated steel tapes (PST) could be characterized as a material with high tensile strength (200–900 MPa) and surface hardness (about 1–2 GPa), as well as with sufficient plasticity for applying such material for producing flat or cylindrical tools like cutting edges and circular coronas etc. For instance, PST could be used for producing trowels for decorating works, tools for overlaying the glue or adhesives in the glaze mounting or tile paving works, etc.

The possibility of using pst for the manufacture of a rotating tool

When producing the circular cutting corona the PST was mechanically turned into tube (2) (Fig. 5, a), then welded and mounted on tool muff (1) (Fig. 5, b). Mounting inside the toll muff could be done by tube pressing from the outside (Fig. 5, c).

Obtained tools were tested on the vertical drill. The cutting properties and operability were in the focus of interest. Circular corona was produced with the diameter from 50 to 80 mm according to scheme presented on the Fig. 5, b from the PST with the thickness 1.2 mm. The aerated concrete and wood were chosen as testable materials. Testing parameters are shown in the Table 3.

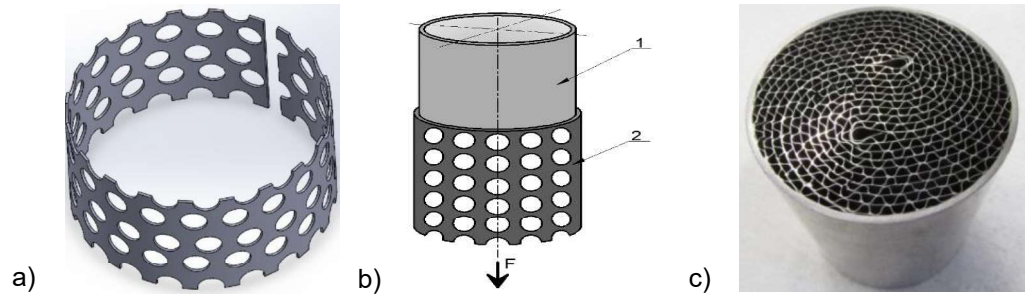


Figure 5. Cylindrical shape PST (a) and it's fixation outside (b) and inside (c) of tool muff: 1 – tool muff; 2 – PST; F – loading force.

Table 3. Regimes of material processing by cylindrical cutting coronas, produced from PST

Type of material	Rpm	Cutting depth, mm	External diameter of a muff, mm	Drilling time, min
Aerated concrete D350.	300	350	50	2.2
Aerated concrete D450	300	200	50	4.5
Pine tree	600	100	80	1.2
Aspen	900	100	80	0.8

The testing results prove the operability of the cylindrical cutting coronas, produced from PST. At that, the best results in processing were achieved during cutting wood materials.

The strength of the plate on compression and its elastic properties, geometry of tools and other factors have a great influence on the durability of the cutting element, what requires a separate in-depth study.

The possibilities of using pst for the manufacture of a flat blade tool

As the second variant the PST was used for producing the scrapers for the finishing building work (Fig. 6, a, b) and the tools for overlaying the glue in the ceramic glaze mounting (Fig. 6, c, d).

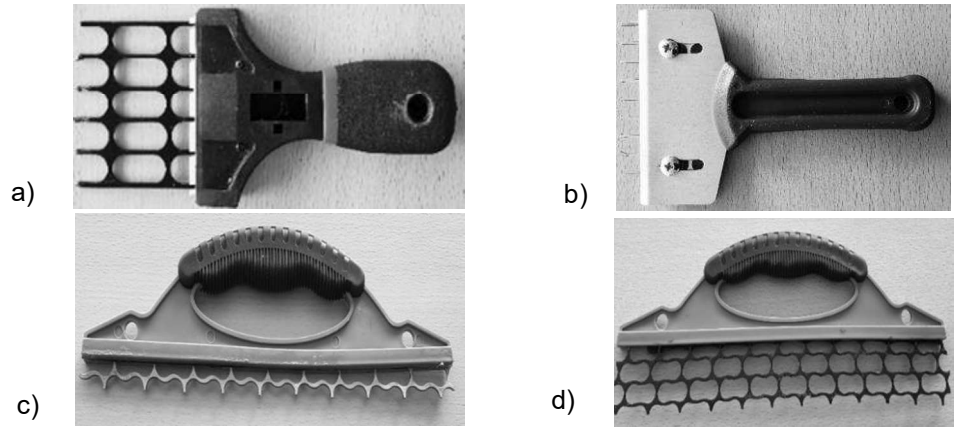


Figure 6. Tools for surface finishing works (a, b) and tiling (c, d) made from PST.

The approbation of both types of flat tools proves the appropriateness of using such tools for intended purposes. Thus, the tools for overlaying the glue in the ceramic glaze mounting provide the uniform and qualitative distribution of glue on the surface.

The experiment was conducted to evaluate the possibility of more effective application of glue or mortar to the cement base surface during tiling works. It is usually difficult to distribute adhesive masses of a given thickness using a solid plate spatula. In addition, experience shows that there is no need to apply glue or mass to the entire contact surface. Our experiments have shown that it is advisable to use spatulas with PST plates, which leave uniform voids in the mass. Using such spatulas, the largest coverage was achieved at a tooth height of h = 3 mm and step of 10 mm. This is 30–35% more than when using a spatula with a solid plate. The best quality of adhesive distribution was obtained at a tooth height of h = 1.5 mm and with a perforation step of 15 mm.

It is possible to apply glue coatings of various viscosities, using a different shape of the spatula teeth.

Strengthening of cutting tools by laser treatment method

It is clear that the hardness of surfaces of teeth is most important factor for providing operability and life time of cutting tools. For the increasing the hardness the Nd:YAG laser hardening was used according to the methodology described in (Mironov et al., 2017). Research done shown, that after laser hardening the micro hardness increases by 1.5–2.0 times and reaches 2.0–2.5 GPa in the surface layer with the depth 1 μm.

CONCLUSIONS

The new possibility for recycling of the technological wastes, i.e. perforated steel tapes achieved after stamping of fine parts, by producing from mentioned perforated tapes the building tools like scrapers for the finishing building work, as well as cutting edges and circular coronas for the woodworking is offered in the current work. The results of approbation of elaborated prototypes of the circular are offered as well.

A significant effect may be achieved by the use of perforated materials, especially waste tapes, for the manufacture of blade tools – in particular working plates spatulas for applying glue or mastic on the surface.

It was proven, that proposed innovative tools could be used effectively in building production and woodworking. For the hardening the surface of cutting teeth the Nd:YAG laser hardening could be used successfully.

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