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To the Question of Manufacturing High-Quality Perforated Detail Made of Fiberglass by Stamping

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On the basis of the analysis and preliminary studies proposed the effective method of punching holes in products made of fiberglass and getinaks the pneumatic-mechanical forming method. Experimentally are defined range of diameters and thicknesses of these materials that can be punched by the pneumatic-mechanical forming method. Dimensional accuracy of the stampings is in the field of tolerance drilled holes. Also are defined technological possibilities of the pneumatic-mechanical perforation method.

Keywords: forming; perforation; fiberglass; getinaks; foil; the pneumatic-mechanical forming.

Introduction

In multiproduct production with a small software release processes for the manufacture of foil fiberglass and getinaks are used limited. The main difficulties lie in poor mechanical machinability of these materials when retrieving a large number of holes or notches of various sizes (for example, on the workpiece size 160×160 mm can be placed up to 2000 holes from 0.5 to 2 mm operations), as well as the high quality requirements of the holes and the accuracy of their mutual arrangement.

1 Statement of the problem and analysis of recent research and publications

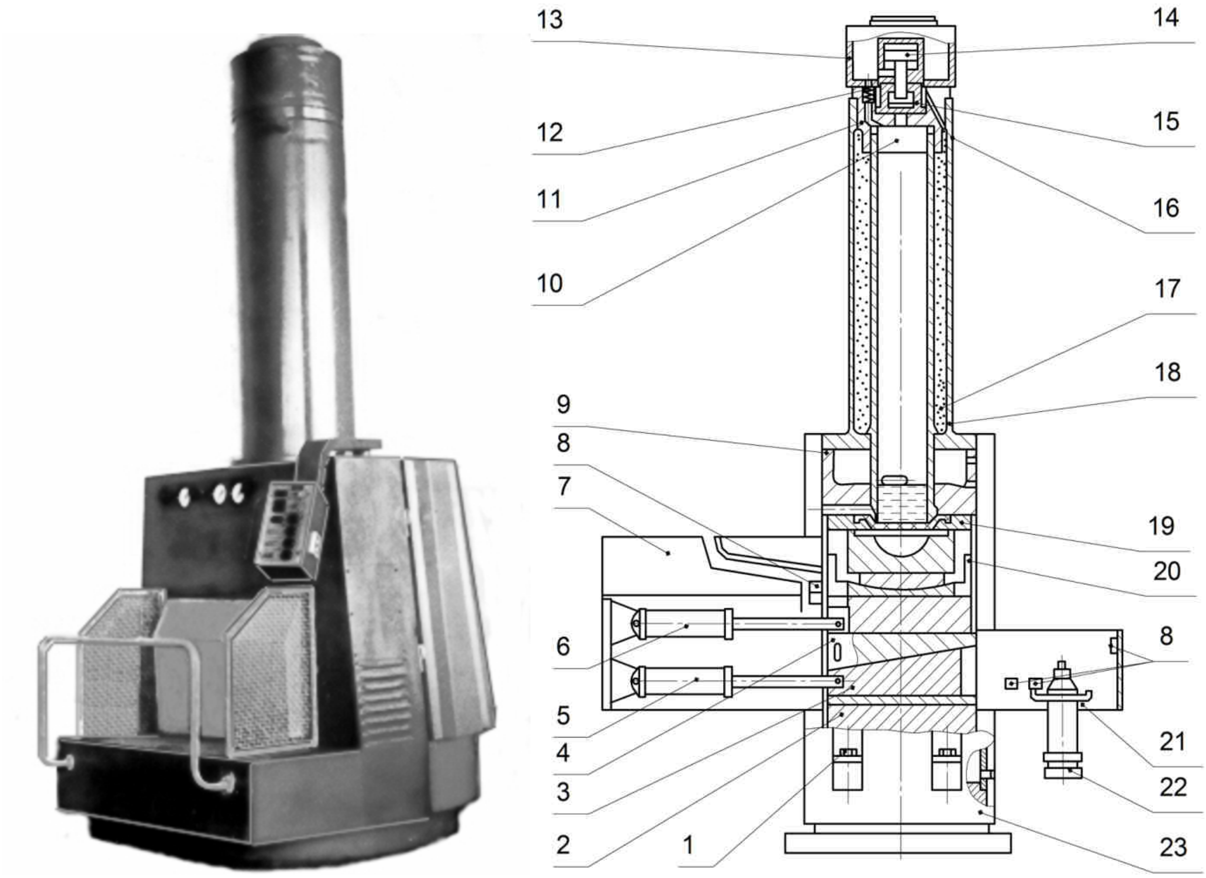
Currently the holes in the fiberglass and getinaks are usually extracted by drilling. Negative aspects of manual drilling are well known, and the efficiency of perforation plastics on high-performance multi-spindle semi-automatic machines with CNC [1] is limited cause of the shortcomings inherent in this most modern method of drilling. Among them: high auxiliary time for the installation of workpieces, tool changing due to the significant number of changeovers, the number of which is equal to the number of sizes of holes on the product; relatively low performance, since all the holes are drilled sequentially one by one; breakage and wear drills.

For increase productivity in the punching of holes in the fiberglass are applied and investigated various methods of group punching holes. The analysis of these methods shows that:

a) using of instrumental punches with hard punches and dies suitable for punching plastics in the thickness 1-2,5 mm hole diameters over 2.2–2.5 mm, as at smaller diameter of the punches are broken; in addition, for punching hard punches is characterized by the formation of burrs on the holes, there are radial cracks, delamination of the foil, and chipped with significant surface roughness, which complicates the metallization of the holes [2].

b) the imposition of ultrasonic vibrations on the punches at perforating improves the surface quality of holes, but completely avoid delamination of the fiberglass fails [2], the burn marks are observed, boiling the tar, the hairiness of the cut, etc. [3, 4], as well as increased wear of the tool;

c) using of rubber and polyurethane as an elastic group of punches for punching holes is impractical due to the necessity of using materials-satellites, and it's impossible to make the holes with a diameter less than 2.5 mm in a wood thickness of 1 mm or more, low resistance rubber and polyurethane [5, 6];



a) b)

Figure 1 –Pneumatic impulse machine with the camera for stamping hydroelastic environment T1324

a) utside view, b) machine design T-1324: 1 – bolt; 2 – entablature**;** 3 – wedge; 4 – counterwedge: 5, 6 – hydraulic cylinders; 7 – muffler; 8 – output ; 9 – working chamber; 10 – striker ; 11, 19 – flanges; 12, 15 – valves; 13 – cover; 14 – releaser; 16 – tongs; 17 – tube; 18 – accumulator; 20 – case; 21 – guides; 22 – pusher; 23 – jaws.

d) magnetic-pulse punching holes in the fiberglass requires the metallic satellites and transmission of energy through the transmission (e.g., elastic) environment, which complicates the process, does not provide sufficient performance and steadfastness of the transmission media and inductor [7];

e) punching hole explosion energy in the water is inefficient, requires special precautions, badly gives in to automation [8];

f) light-beam (laser), electron-beam and ion-optical methods of making holes is not productive, expensive, do not provide the necessary quality of holes (entrances and exits of the holes are blurred, there are influxes on the edges from ejection of material from the holes [9];

g) punching the holes by theenergy electric spark discharge in water or the laser radiation into a liquid requires large capacity, which leads to the installations of big dimensions that do not provide sufficient performance, reliability, and stability, on the workpiece are observed cracks as a result of "hard" hitting fluid [10].

The analysis are required the search for new ways of punching holes in the previously listed materials.

2 Statement of the problem

The aim of the research: to suggest and test a more efficient method of manufacturing high-quality parts made of fiberglass and getinaks in the unstable release of software programs.

3 The main material *Senior Researcher*

Studies have shown that the most effective pneumatic percussion group method of punching holes with using a metal matrix [11] on high-speed pneumatic-mechanical installation models T-1324 (Figure 1).

The essence of the method of pneumatic-mechanical forming that stamping parts implemented by high-pressure pulse,and created by the blow of the firing pin that is moving quickly in a closed volume of fluid (or elastic medium),that are filling the technological (working) camera of equipment. This method belongs to without Poisson's stamping, because as the snap there is only one part of it (the matrix), and the mating connector is part of the transmission medium (liquid, polyurethane).

Table1

The parameters of the pneumatic impact loading in the experiments

The main parameters	Variant of loading №1	Variant of loading №2
The applied pressure, MPa	≤ 600	≤ 1000
The volume of water in the trunk, cm^3	700	10; 20
The mass of the percussion piston (reduced), kg	≤ 25	1,0
The speed of the shock piston, m/s	≤ 26	≤ 51
The energy of the shock piston, kJ	≤ 32	1,28
Energy carrier	pressurized air	pressurized air
The pressure in the receiver before commencing acceleration of the shock of the firing pin, MPa	≤ 4,5	7,0
The diameters of the holes in the matrices, mm	0,92…1,78 1,19…1,2	0,54…0,69 0,67…0,7 0,7…0,72 0,8…0,9
The materials that make the way	Fiberglass СФ-1-50 (thickness 0,55±0,02 mm), Fiberglass СФ-2-50 (thickness 0,62±0,02 mm)	Fiberglass СФ-2-50 (thickness 0,62±0,02 mm)

Experimental studies have shown that foil-coated fiberglass СФ-1 и СФ-2 have a limit of shear strength τ=170 MPa when punching holes are punched with a low loading rate. Taking into account the hardening during rapid loading during hydro-pulse punching the limit of shear strength (dynamical) is $\tau_d \approx 1{,}5 \cdot t = 250 \div 260$ MPa. Then, for punching holes, you will need the pressure:

$$p=\frac{Q}{f}\cdot\frac{4\pi d\tau_d}{\pi d^2}=4\tau_d\frac{h}{d}=6\tau\frac{h}{d}, \qquad (1)$$

where Q – the effort of punching holes; d – hole diameter; h – the thickness of the workpiece.

From the formula (1) implies that when d=h the required pressure 1000 MPa, and when d=0.67h – 1500 MPa.

The main parameters of pneumatic impact loading in the experiments are shown in table 1.

Table 2

The estimated value of the pressure required to punch holes in foil fiberglass

The diameter of the punched holes, mm	The pressure p =10^-5 Pa when the thickness of fiberglass, mm							
	0,5	0,7	0,8	1,0	1.2	1,5	1,8	2,0
0,5	10 000	14 000	16 000	20 000	24 000	30 000	36 000	40 000
0,7	7 200	10 000	11 500	15 000	17 200	22 000	25 800	28 600
0,8	6 300	8 800	10 000	12 500	15 000	19 000	22 500	25 000
1,0	5 000	7 000	8 000	10 000	12 000	15 000	18 000	20 000
1,2	4 200	5 900	6 700	8 400	10 000	12 500	15 000	16 700
1,5	3 300	4 700	5 400	6 700	8 000	10 000	12 000	13 400
1,8	2 800	3 900	4 500	5 600	6 700	8 400	10 000	11 200
2,0	2 500	3 500	4 000	5 000	6 000	7 500	9 000	10 000
2,5	2 000	2 800	3 200	4 000	4 800	6 000	7 200.	8 000

Table 2 shows the calculated (rounded) value of the pressure necessary to punch holes in the foil the fiberglass. For the pressure p=1000 MPa the calculated values were confirmed experimentally with an error of no more than 10%. More precise evaluation requires special labor-intensive methods of measuring the values of impulse pressures.

Tested the schemes of punched holes:

1) on the workpiece are superimposed over matrix plate with pre-glued on its top surface from the water, a thin cellophane film that prevents the ingress of water into the holes not-matrix plate before impact.

2) on the workpiece are superimposed over matrix plate with pre-filled water holes in it (air from vents carefully removed);

3) on the workpiece are superimposed over matrix plate without preliminary preparation;

4) punching was carried out without on-plate matrix, but for better clamping of the workpiece is used the clamping rin.

In addition, in all four embodiments, the workpiece was placed on the matrix side as a foil and not a foil in the case of perforation at unilateral foil fiberglass.

The quality of the punched holes was evaluated visually using a microscope at 30x magnification and compared with the quality of the holes obtained by drilling.

In table 2 a thick line separated the range of diameters and thicknesses of foil materials that can be punched pneumatic-mechanical forming using matrices of the following tool steels brands: 8Х4В2С2МФ (ЭП761), 8Х4В3М3Ф2 (ЭП570), 6Х6В3МФС (ЭП569), having a limit of elasticity at compression of not less than 2150 MPa, impact strength of not less than 0,5 J/mm2.

Conclusion

Experimental studies have shown that:

1. In the one-sided foil fiberglass the quality of the punched holes is not inferior to the quality of drilled, if the workpiece is a foil side of the matrix is not cracked, chipped, debris, burrs. The difference in the quality of holes is not seen when previewing their schemes 1, 2.

2. When using on-plate matrix the quality of the punched holes is higher than when using a clamping ring.

3. A significant impact on the quality of the punched holes has the quality of manufacturing of the matrix, since all its defects are automatically transferred to the workpiece. Cleaning the holes from the fibers should be done the same way as it is done after drilling the holes.

4. Accuracy of punched holes is placed in the field of tolerance for their manufacture. The measurements of the holes under a microscope showed that the diameter of the punched holes by 0.01 to 0.02 mm smaller than the diameters of the holes in the matrices in the range of 0.67 – 1,78 mm. Larger deviation corresponds to a greater diameter. This pattern is observed both unilateral and bilateral foiled fiberglass plastics the investigated thicknesses.

5. For group punching holes of different size, the diameters should differ by no more than 20% to obtain good quality.

6. Analysis of the cross sectional surface of the punched openings when 30 - fold enlargement showed that in two-sided foil glass-plastics part of the workpiece facing the matrix, has a rough surface (zone spalling) at the exit, and the entrance hole has a discernible radius of curvature. This pattern is observed with a slight increase of pressure above the minimum required.

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К вопросу изготовления качественных перфорированных деталей из стеклопластика методом штамповки

На основании анализа и проведения предварительных исследований предположен эффективный метод перфорирования отверстий в изделиях из стеклопластика и гетинакса методом пневмоударной штамповки. Экспериментально определен диапазон диаметров и толщин этих материалов, которые можно пробивать методом пневмоударной штамповки. Точность размеров штампованных деталей находится в поле допуска просверленных отверстий. Рассмотрены различные схемы пробивки отверстий: с применением надматричной плиты так и без неё, а также с заполнением и без заполнения жидкостью отверстий в надматричной плите. Определены технологические возможности метода пневмоударного перфорирования.

Ключевые слова: штамповка, перфорация, стеклотекстолит, гетинакс, фольга, пневмоударная штамповка.

До питання виготовлення якісних перфорованих деталей зі склопластику методом штампування

На підставі аналізу та проведення попередніх досліджень запропонований ефективний метод перфорування отворів у виробах зі склопластику і гетинаксу методом пневмоударного штампування. Експериментально визначено діапазон діаметрів і товщини цих матеріалів, які можна пробивати методом пневмоударного штампування. Точність розмірів штампованих деталей знаходиться в полі допуску просвердлених отворів. Розглянуто різні схеми пробивання отворів: із застосуванням над матричної плити так і без неї, а також із заповненням та без заповнення рідиною отворів в надматрічной плиті. Визначені технологічні можливості метода пневмоударного перфорування.

Ключові слова: штампування; перфорація; склотекстоліт; гетинакс; фольга; пневмоударне штампування.