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STUDY OF CUTTING PRESSES IN DESIGNING A WOMEN'S COSTUME FOR HOSPITALITY INDUSTRY

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Розглянуто проблеми дизайн-проектування сучасного тематичного жіночого костюму для закладів гостинності. Розроблено експериментальний вимірювальний стенд для дослідження характеристик вирубувальних пресів. В результаті аналітичних та експериментальних досліджень встановлено раціональні конструктивні, енергетичні та технологічні параметри пресового обладнання. Розроблено практичні рекомендації щодо вдосконалення електрогідрравлічних вирубувальних пресів готельно-ресторанного господарства та підвищено коефіцієнт корисної дії

Ключові слова: електрогідрравлічний вирубувальний прес, деталі жіночого взуття, дизайн-проектування, заклади гостинності

Рассмотрены проблемы дизайн-проектирования современного тематического женского костюма для заведений гостеприимства. Разработан экспериментальный измерительный стенд для исследования характеристик вырубных прессов. В результате аналитических и экспериментальных исследований определены рациональные конструктивные, энергетические и технологические параметры пресового оборудования. Разработаны практические рекомендации по совершенствованию электрогидравлических вырубных прессов гостинично-ресторанного хозяйства и повышен коэффициент полезного действия

Ключевые слова: электрогидравлический вырубной прес, детали женской обуви, дизайн-проектирование, заведения гостеприимства

1. Introduction

There is an observed tendency at present to improve quality of tourist services in the leading countries in this segment. Recreational resources are building up their potential by using a harmonious combination of such components as features of geographical location, natural environment, historically ethnic heritage of the region, modern design concepts and innovative technologies. Under conditions of correct and integrated use of these factors, it is possible to enhance tourist attractiveness and competitiveness of the hospitality industry of a specific territory. It is an increasingly difficult task for designers to impress a demanding customer of today. Hotel and restaurant complexes of leading resorts and tourist destinations compete with one another, implementing characteristic legends into real life, making a visitor plunge into appropriate atmosphere and

causing a whirlwind of emotions. In this case, designers create the required environment using specific designs and entourage. In this system, the emphasis is placed on a costume, which is developed in detail by a designer. Costume design involves creating such elements of an ensemble as clothing, footwear, accessories, hairstyle, and make-up [1–4]. At present, clothes design is the focus of attention in many studies, but such a significant component of the image as footwear is little explored in the context of designing and building up an image for the hotel-restaurant complexes taking into account basic technological aspects of its implementation. As we know, Paris, Milan, London, and New York are considered to be the world's fashion capitals today. It is these cities that give rise to the main trends of fashion clothes, accessories, and shoes. That is why it is inappropriate for contemporary designers to ignore design ideas, demonstrated on their catwalks.

Therefore, it is expedient to create a tandem of a designer and a technologist for a joint accomplishment of the set goal and to develop conceptually new thematic images, which are finalized by a perfect match between the costume and the proposed idea. This approach is likely to implement creative solutions that will encourage a visitor to participate in a thematic show and will make an unforgettable impression on him.

Development of the service sector in general is not possible without improvement of the components, one of which is the various equipment that includes cutting presses.

Technological operation of cutting details of clothing and footwear not only plays a significant role in the process of manufacturing products for hospitality industry, but also significantly affects the quality and cost of these products.

The specified operation is performed mostly on electrohydraulic pressing equipment [5, 6]. Such equipment has been quite effectively used in hospitality industry for many years. However, modern market and energy conditions require its updating in terms of enhancing the quality of performing operations, decreasing power costs for their implementation and improving efficiency.

From experience, we are aware of a number of shortcomings of such equipment in the context of the specified problems [7–9]. Modern methods of experimental research provide accurate measurement of kinematic, dynamic and energy parameters of equipment, which will make it possible to identify the causes of drawbacks of its operation.

Research into determining rational parameters of cutting presses will allow us to establish effective ways to remove the specified shortcomings, which is a relevant task aimed at improving cutting presses in hospitality industry and cutting operations as a whole.

2. Literature review and problem statement

The first problem to address is to determine the optimal range of chronological samples of modern fashionable women's footwear models as an analog range for designing. Paper [10] considers alternation indicator for footwear models (in thousands of pairs), which was adapted to the requirements of a manufacturer. However, it does not take into account customer's requirements and cannot be a reference point for a footwear designer in the process of designing new models.

Article [11] presents graphical models of formation of clothes, in which basic identity cycles (pattern repeatability), ranging from 10 to 20 years, are specified. Since similar works of analytical character in term of determining models of footwear formation are missing, it is advisable to choose the minimum range for subsequent studies within 10 years.

Analyzing a number of publications on the issue of footwear design and technology, we can trace the tendency of its manufacturing of the following materials [12]: leather, artificial leather, lacquered leather, and fabric. The main emphasis is made on the design development of footwear patterns. There is almost no information about the ranges of optimal technological parameters of operations of cutting footwear details for advanced or modern pressing equipment [13].

Analysis of review of presses of foreign companies-manufacturers showed that at this stage, the energy factor occupies the main place in development and improvement of the specified equipment. That is why to achieve the economic effect,

manufacturers choose the way of maximum automation, optimal use of equipment, a decrease in downtime and an increase in service term of cutting equipment.

Today, development of cutting equipment is aimed at computerization, maximum simplification of the drive (hydraulic and mechanical parts), reduction of power consumption, which substantially increases its effectiveness.

In the process of cutting on electrohydraulic presses under the influence of large cutting and inertia forces, there occurs deformation of the system «table – cutting plate – cutter – striker – rod» [7]. As a result of this overload, parallelism of the bench plane and the striker of the press is broken. This leads to an increase in incomplete cuts, dullness, deformation and even destruction of the cutter, the cutting plate, and therefore, to rapid wearing out [8]. In addition, at cutting small parts, we observe occurrence of excessive overloads and significant deepening of a small-perimeter cutter in the plane [9]. The problem of improvement of durability of cutting plates can be solved by creation of depreciation plates or other devices that eliminate the mentioned shortcomings in operation of presses.

Analysis of the drawbacks of electrohydraulic pressing equipment indicates the possibility of its subsequent improvement in terms of increasing efficiency by reducing overloading, weight, dimensions, power consumption and improving the quality of cutting.

The aforementioned shortcomings need to be eliminated through the use of new technologies, methods of measurement and modern element base.

Operation of cutting footwear details is a kind of operation of cutting, a particular case [14]. The main aspects of the theory of cutting, as well as the results of experimental research, are presented in many works, the most important of which are papers [5–9].

The research conducted in [14] takes into account only dynamics of hydraulic drive of cutting presses. A significant disadvantage is the lack of analysis of dynamics of the electric drive combined with the hydraulic drive and influence on the technological operation of cutting and on pressing equipment on the whole.

Among the above works [5–9, 14], little attention is paid to the quality of the cut parts. No studies of determining of the impact of a cutting press on deviation from the reference line of leather cut were found, which is a significant drawback. In production, a detail that is being cut is to match the contour of the control template, which is set by the specialist. The quality of the cut details has a direct impact on the finished product, that is why taking into account deviation from the cut line in the process of cutting on presses is an important task.

It was also found that the problem of improvement of electrohydraulic presses in hospitality industry is not studied enough in terms of decreasing electric power consumption. There are no studies of determining of the impact of the mechanism of turn and lift of the striker on operation effectiveness of presses. Existing mathematical models of cutting do not take into account the power balance and the influence of engine – flywheel – pump system on the electrohydraulic pressing equipment. There is no perfect method of choosing the optimal energy parameters of this type of equipment.

Relevant ratio of basic performance characteristic of pressing equipment will make it possible to improve performance, durability, power efficiency and enhance the quality of the process of cutting.

3. The aim and objectives of the study

The aim of present research is to study cutting presses in the design of women’s costume for hospitality industry through conducting experiments on determining the rational characteristics of electrohydraulic pressing equipment.

To accomplish the set aim, the following tasks had to be solved:

- to conduct analysis of modern trendy women’s footwear and materials used for its manufacturing;
- to design an experimental measuring bench for research into energy and power indicators of cutting presses and diagnostics;
- to conduct experimental research to determine rational operation modes of electrohydraulic cutting presses for hospitality industry;
- to identify the ways of enhancing technical and economic indicators of electrohydraulic pressing equipment, such as: increasing efficiency, reducing power consumption, enhancing the quality of performance of technological operations of cutting.

4. Analytical and methodological aspects of studying the process of cutting details of women’s footwear in costume designing for hospitality industry

4.1. Analysis of modern fashionable women’s footwear and materials used for its manufacture

Footwear, as an element of women’s thematic and image costume may be either dominant or may be a continuation of a form and an idea. Most common is high-heeled footwear, with a massive or a concave heel and of unusual shape. Leather is often used for manufacturing such footwear, while lacquered leather, fabric or PVC are used not so often.

Having processed an array of information [1–4], we determined a modification of the shape of women’s shoes, presented on catwalks of four fashion capitals for the period from 2005 to 2014 (Table 1).

Using the obtained modification of the shape of modern women’s shoes, we determined its main characteristics, which affect the shape, and therefore, the entire image as a whole.

Table 1

Characteristics of modern fashionable women’s shoes

Year	Fashion capital	Kind of footwear	Kind of sole	Color pattern	Toecap shape	Heel shape	Decoration	Material
1	2	3	4	5	6	7	8	9
2005	P	boots	–			–	lace	leather
	M	shoes	wedge			wedge	buckle	leather
	L	sandals	–			–	–	fabric
	N	summer boots	heel			wide	–	leather
2006	P	shoes	flat			–	spikes	leather
	M	sandals	wedge			figure wedge	bamboo	leather
	L	shoes	heel			–	–	fabric
	N	shoes	heel			figure concave	belts, flowers	leather
2007	P	shoes	heel			cowboy	–	leather
	M	sandals	heel			wide concave	buttons	lacquered leather
	L	shoes	–			–	feather	fabric
	N	sandals	wedge			figure wedge	–	leather
2008	P	boots	heel		–	cone-like	metal elements	leather
	M	sandals	heel		–	figure	flowers	leather
	L	shoes	–			–	belts	leather
	N	sandals	–			–	fur	–
2009	P	sandals	heel			figure wedge	belts	lacquered leather
	M	sandals	heel			wide	belts	leather
	L	shoes	heel			wedged	metal elements	leather
	N	sandals	wedge			figure wedge	–	leather
2010	P	ankle boots	heel		–	stiletto	–	leather
	M	sandals	heel			wide	–	PVC
	L	ankle boots	–			–	belt	leather
	N	sandals	flat			wedge	–	–
2011	P	semi-boots	heel			stiletto	fastening	leather
	M	ankle boots	wedge			wedge	decorative elements	lacquered leather
	L	ankle boots	–			–	lace, weave	leather
	N	sandals	heel			–	–	leather

Continuation of Table 1

1	2	3	4	5	6	7	8	9
2012	P	semi-boots	wedge	■	⤿	–	fur	leather
	M	sandals	heel	■ □	⤿	stiletto	ribbon	leather
	L	summer boots	heel	■ □	⤿	–	–	leather
	N	sandals	wedge	■ ■ □	⤿	figure wedge	rubber	leather
2013	P	sandals	heel	□ ■	⤿	wedged	metal elements	PVC
	M	summer boots	wedge	□ □ ■	⤿	–	ribbon	fabric
	L	summer boots	wedge	■ ■ □	⤿	–	–	leather
	N	sandals	wedge	■ □ □ ■	⤿	wedge	decorative elements	leather
2014	P	sandals	wedge	■ □ ■	⤿	wedge	ribbon	leather
	M	sandals	heel	■ ■ ■	⤿	cone-like	–	PVC
	L	sandals	–	□ □ ■ □	⤿	–	application	leather
	N	sandals	heel	■ □	⤿	wide	metal elements	lacquered leather

Note: P – Paris, M – Milan, L – London, N – New York

Analysis of the main characteristics of modern women’s footwear revealed that sandals and shoes, made of leather or lacquered leather were the most typical kind from 2005 to 2014. In addition, round toecap shape, a heel, a wedge and decoration in the form of belts and metal fittings are most common in modern footwear.

The materials, described above, are cut on modern cutting presses in catering establishments.

4. 2. Description of the equipment used during experiment

The studies were conducted on electrohydraulic cutting presses of the console type PVG-8-2-0. For this, the experimental measuring equipment, which consists of pressing equipment and measuring devices, was developed.

The measuring equipment was powered by a two-phase network with alternating current, in this case, power of magnitude +5 V was supplied to the current sensors with simultaneous supply of the unit of galvanic isolation of voltage of +15 V and subsequent connection of ADC to PC. For measurement, we used sensors of current ACS704ELC-015, produced by company ALLEGRO, with the range of measuring currents of ±15 A. Calibration of the current sensor was performed using a voltmeter and an amperemeter with 0.2 precision class. In this case, obtained data for each stage of operation of the press were registered. The found calibration coefficients were used to determine actual values of currents and voltages.

Measuring equipment operates by the principle of analog-to-digital conversion of the current signal, consumed by electrical equipment of the press, using high-precision current sensor and ADC with subsequent display of experimental data on the screen of the personal computer (Fig. 1).

The designed unit for measuring equipment consists of the system of power supply, current sensors, and control elements.

The unit of galvanic isolation is designed to convert the input DC signal into the normalized galvanically isolated output DC signal.

In order to obtain precise data of technical parameters of the pressing equipment, we use ADC NI USB-6009, pro-

duced by the company National Instruments (USA). Data, obtained with the help of the measuring unit, were transmitted to ADC, which converts into appropriate digital values of measuring characteristics.

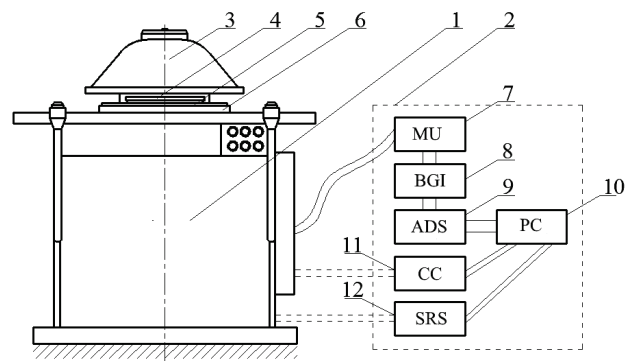


Fig. 1. Experimental measurement equipment based on press PVG-8-2-0: 1 – pressing equipment; 2 – measuring equipment; 3 – striker; 4 – cutter; 5 – material; 6 – cutting plate; 7 – measuring unit; 8 – block of galvanic isolation HL-7B30; 9 – analog-to-digital converter (ADC), NI USB-6009; 10 – personal computer; 11 – camcorder Canon SX120 IS; 12 – shaft rotation sensor

In order to carry out research, the program for obtaining the main technical indicators of electrohydraulic pressing equipment in the environment of LabVIEW was developed [15–18].

Developed measuring equipment allows obtaining various graphic dependences. They are instantaneous values of currents and voltages of three phases, as well as power consumption, as well as RMS – root mean square value of voltage and frequency of revolution of the engine drive shaft with a simultaneous connection to the revolution sensor.

To automate the process of cutting, software in LabVIEW environment was developed that makes it possible to control the cutting press, as well as to process and store the data, obtained from ADC (Fig. 2).

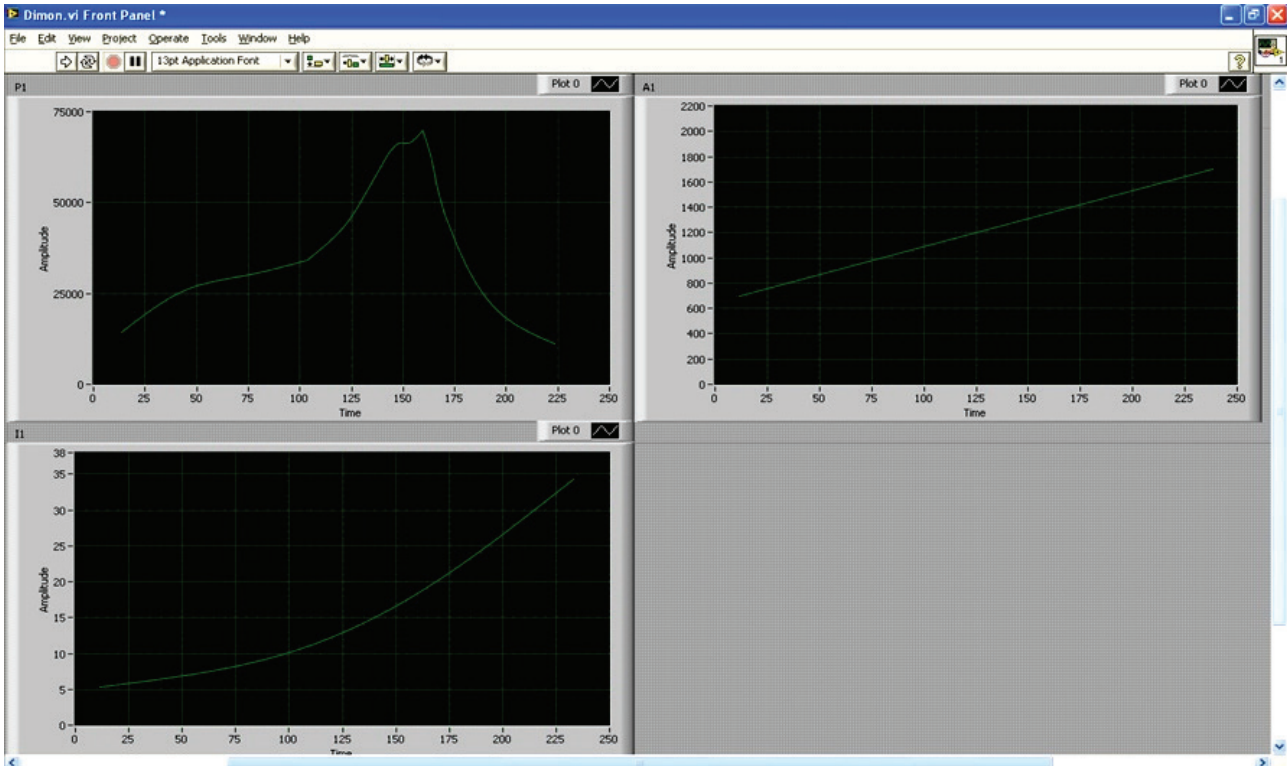


Fig. 2. Faceplate of the program for obtaining basic technical indicators of electrohydraulic pressing equipment in the LabVIEW environment

For the experiments, we used a sharp cutter with perimeter of $L=0.6$ m with two-sided symmetrical sharpening with the sharpening angle of 25° , as well as the cutting plane, made of PVC. As a material, we used soft genuine leather of the upper part of footwear of thickness $\Delta = 1$ mm.

4. 3. Technique for conducting the study

To conduct the study based on the press PVG-8-2-0, a number of structural changes were performed. An adjustable throttle valve with two-position valve distributor was included to low pressure feed line of the press. In addition, the time relay was mounted in the end switches of the striker's rotation mechanism. The attachment point of the striker of the plunger's hydro cylinder was altered with mounting of the radial-thrust bearing. Changes to the electric and hydraulic circuits of the press were made.

The improved striker's rotation mechanism differs by the fact that the adjustable throttle valve with the two-position valve distributor was included in the low-pressure feed line of the press. It is closes during the turn of the striker to the operating position within the time interval of 0.3...0.75 s. It slows down the motion of the piston of rotation cylinder of the striker at the end of the turn to operating position, thus reducing hydro shocks and oscillations of pressure in the system and in the press as a whole.

The time relays of end switches of the striker's rotation mechanism are mounted so that working stroke of the striker should be delayed (0.2...0.4 s). This contributes to a complete stop of the striker after turning to operating position and better execution of the cutting operation due to decreasing of probability of lopsided cutting of material.

The air from the cavity above the piston of the plunger's cylinder was replaced with oil (with appropriate connection with the hydro system of the press).

Cutting was carried out as follows. After the press was started, the buttons of cutting control were pushed, and the striker was turned to operating position by hand. Then, the technological process of cutting was going on until the striker lifted, after this the press was switched off.

During the research, we took numeric values of power consumption by the pressing equipment during performance of technological operation of cutting with simultaneous control of the magnitude of oil pressure in the system. Motion of the press striker was recorded with the help of video equipment that provided control and monitoring of the whole process and possibility of obtaining reliable data on the quality of cut details. All necessary information was displayed on the personal computer and processed in appropriate software environments. Results of the experiments were processed with the help of the known methods [19, 20].

5. Results of research, aimed at determining the rational operation modes of electrohydraulic cutting presses for hospitality industry

The first stage of the experiments was to study the impact of the striker's rotation mechanism on the quality of cutting.

Experimental studies showed that the use of oil pressure for lowering and lifting of the striker after cutting enhances the character of striker's loading. From the moment the striker started to lower to its contact with the cutter, the load character was smoother than in the existing presses PVG-8-2-0, which indicates a more efficient use of the drive.

Measurements of the force that is required to perform rotation of the striker were made on the correspondent pressing equipment. Based on a series of experiments, it was found that the force required to perform rotation of

the striker of press PGV-8-2-0 is 16 N, for PgV-8-2-0 with improved attachment point of the striker – 11 N). Conducted studies indicate more effective operation the striker's rotation mechanism with the new bearing node.

Based on the conducted research, we plotted the graphs of changes of the strength of current, consumed by cutting presses and of oil pressure in the system depending on its operation time and motion of the striker. Relationships of obtained characteristics and influence on performance of technological operation of cutting and the state of equipment were established (Fig. 3).

An analysis of results of the conducted experiments enables us to judge about the impact of the improved mechanism of striker's rotation on efficiency of cutting presses during cutting operations.

Considering obtained experimental graphic dependences of oil pressure in the system (Fig. 3), it is possible to argue about a decrease in dynamic effect after making specified changes. As a result, there is a decrease in loading of the cutting press.

An important component of products manufacturing on presses is quality of cut details. During operation of presses PGV-8-2-0, non-parallelism of the planes of the striker and the cutters was observed, which affects durability of the press, cutters and cutting plates [7–9], as well as the quality (cut accuracy) of the cut parts. For this purpose, as a result of a series of experiments with the use of video equipment, carried out on the press PVG-8-2-0 and on corresponding improved equipment, we determined the impact of the improved mechanism of the striker's rotation on the quality of cut parts, the results of which are presented in Fig. 4.

As we can see in Fig. 4, due to conducting the above described structural changes, we observed improvement of leather cut accuracy, which affects the quality of the finished product, as well as press overloading as a whole. Automatic rotation of the striker in the existing presses causes deviation from the reference line of the leather cut t due to occurrence of shock loads, oscillations of oil pressure in the hydro system and of the press as a whole (Fig. 4, *a, b*).

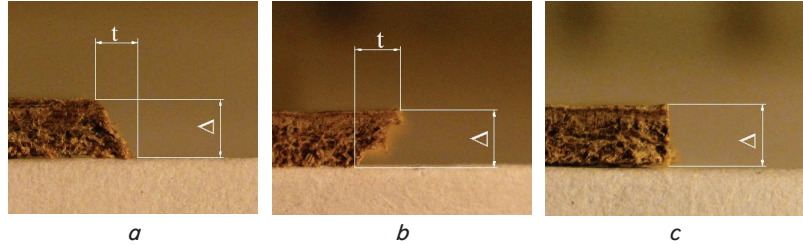


Fig. 4. Photographs of the cut of genuine leather: *a, b* – automatic rotation of the striker; *c* – improved rotation mechanism of the striker; Δ – leather thickness; t – deviation from the reference line of leather cut

A particularly important problem is quality of the finished products during footwear manufacturing from cut details with visible edges, which increases requirements for footwear manufacturing.

The next stage of the experiments was to study the influence of motion of the striker on efficiency of the hydraulic pressing equipment. As a result of the performed experiments, we plotted graphic dependences of a change in power consumption N of the pressing equipment on its operation time t .

Due to abovementioned structural changes made, efficiency of cutting presses increases.

Sections *AB* and *A1B* correspond to the stage of lowering of the striker up to the moment of contact with the cutter, and section *CD* is the analytical curve of the striker's lifting by oil pressure energy. As we can see from the acquired graphs, changes in power consumption N depending on operation time t , use of oil for lifting the striker is more appropriate in presses, which decreases loading in the course of cutting (Fig. 5).

Areas S_1 and S_2 correspond to power economy, which will be possible to achieve by changing the rotation mechanism of the striker and the way the striker is lifted and lowered. This magnitude is within 10...16 %, which is quite significant given the cost of modern power carrier.

Section *AB* is characterized by more rapid growth of power consumption than section *A1V*. This is explained by significant influence of resistance of compressed air on operation dynamics

of electrohydraulic pressing equipment, especially within the time interval from the moment the striker begins to lower to the end of cutting. Because of high air pressure, which must be overcome in order to perform cutting, oil pressure in the system increases and, therefore, so does power consumption.

Experimental studies showed that usage of oil pressure energy for lifting and lowering of the striker improves the character of loading on the striker of the press, decreases overloading and press vibration.

The next stage of the research was to determine reliability of the performed theoretical assumptions and analytical calculations taking into account all factors of the process of cutting.

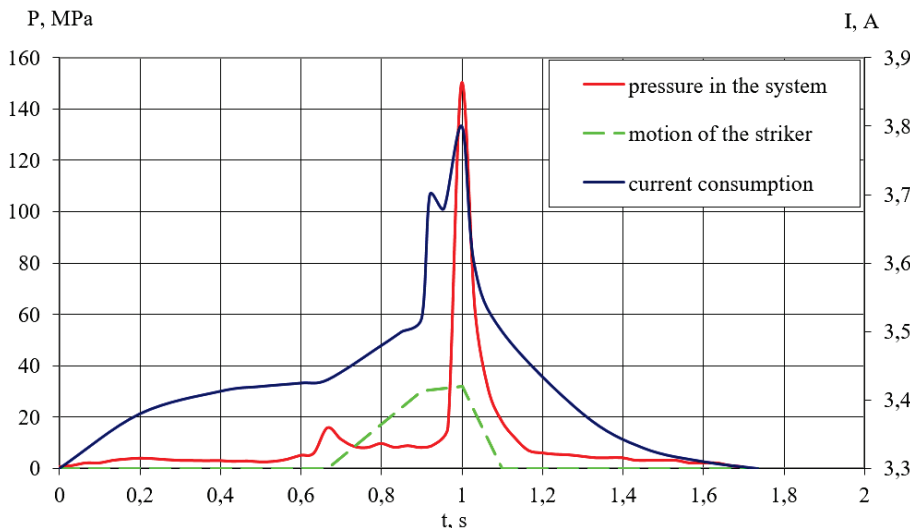


Fig. 3. Graphic dependence of changes of current strength I , consumed by electrohydraulic pressing equipment, and oil pressure in system P on its operation time t and motion of striker s

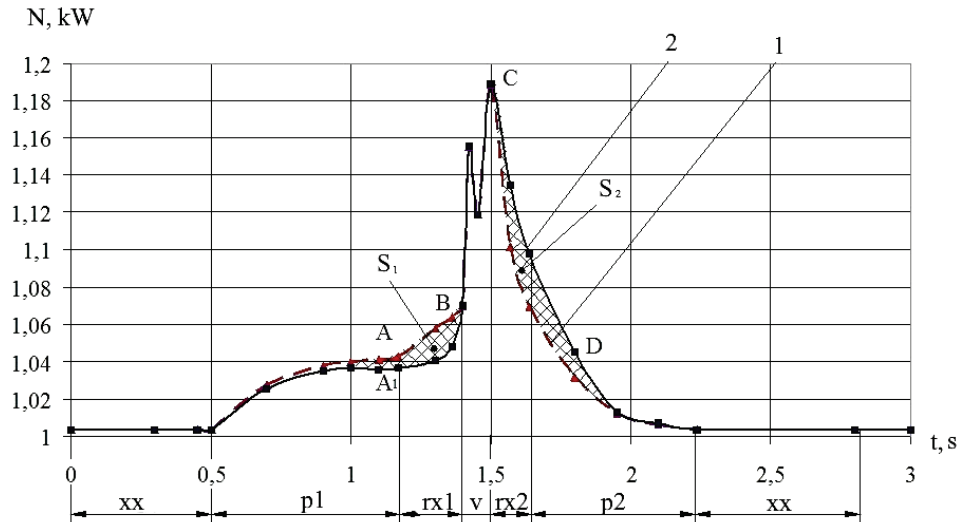


Fig. 5. Graphic dependences of changes of power consumption N on operation time t for the following structural schemes of implementation of the press PGV-8-2-0: S_1 – power economy; S_2 – power economy; 1 – existing pressing equipment; 2 – improved pressing equipment

As a result of a series of experiments, we plotted graph of changes power consumption N by electrohydraulic pressing equipment depending on perimeter of the cutter L for different materials. Graphic interpretation of obtained data is shown in Fig. 6.

An analysis of resulting graphic dependences showed that under conditions of the use of improved equipment (Fig. 4), power consumption from the network is within $N=1.03...1.06$ kW for all used materials, which is 15 % less than in existing pressing equipment. Based on obtained experimental data, dependences of change of power consumption N on the perimeter of the cutter L were plotted. For each graph, degree of approximation reliability and reproduction accuracy of actual dependences was established (Fig. 7).

Based on theoretical and experimental data, graphic dependences of changes in energy consumption on the perimeter of the cutter and motion of the striker and inertia moment of the flywheel were plotted (Fig. 8).

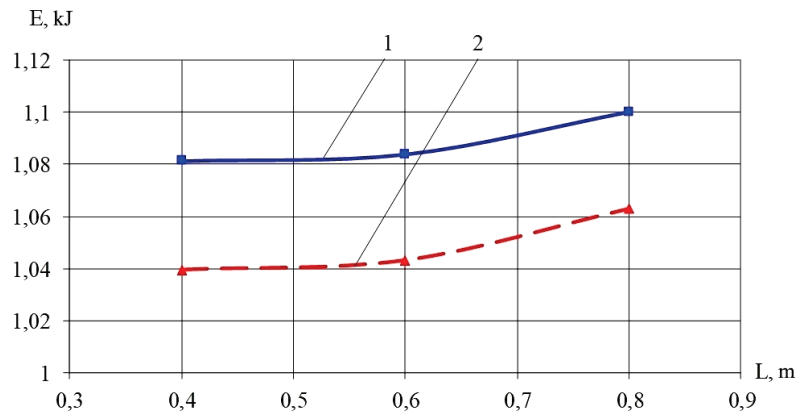


Fig. 7. Graphic dependence of changes of energy consumption E on perimeter of cutter L : 1 – theoretical curve; 2 – experimental curve

After research, the error between theoretical and experimental curves was calculated. Analysis of resulting dependences of change in energy consumption E on motion of the striker s (Fig. 8) showed that total error between theoretical and experimental curves is within permissible 5 %. It attests to reliability of performed analytical and experimental research.

The next step was to determine technical and economic indicators of existing and improved electrohydraulic pressing equipment of the console type. To do this, we performed cutting of genuine soft leather of the upper part of footwear with thickness $\Delta=1$ mm. For guaranteed cutting, technological contact was set to magnitude of entering the cutting plate of 0.5 mm. Measuring equipment was connected and actual values of power consumption were registered. In addition, magnitudes of motion of the striker were video registered. Taking into account conducted studies to determine the rational parameters of electrohydraulic presses, it was proposed to mount a less powerful electric

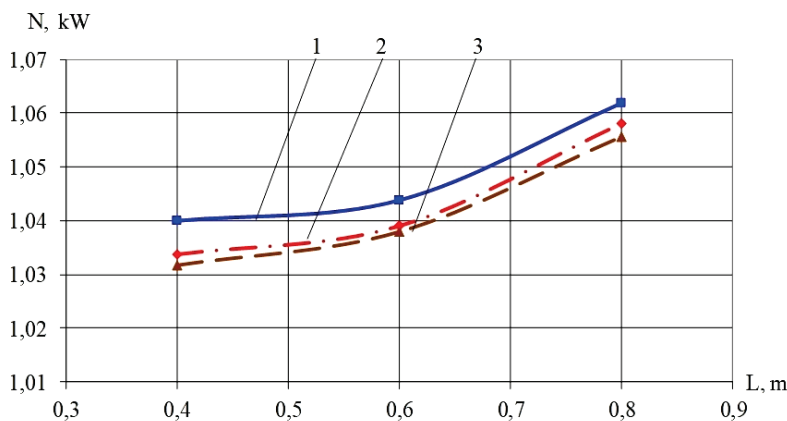


Fig. 6. Graphic dependence of changes of power consumption N on the perimeter of cutter L : 1 – genuine leather of upper part; 2 – synthetic leather of upper part; 3 – shoe cardboard

motor ($N=0.75$ kW) on the pressing equipment. Checking of permissible loads on the engine with the use of the developed method proved the theoretical assumptions made.

Experimental research with the mounted electric motor demonstrated that its use is appropriate, since power consumption at idle running, decreases by 30 % in comparison with existing equipment, and this is a significant factor that affects energy efficiency of the press as a whole. Therefore, implementation of proposed solutions will make it possible to improve energy efficiency of cutting presses without significant decreasing operation reliability.

Studies were conducted on the press PGV-8-2-0, the improved press based on PGV-8-2-0 and the German press C06.01, made by the company Compart.

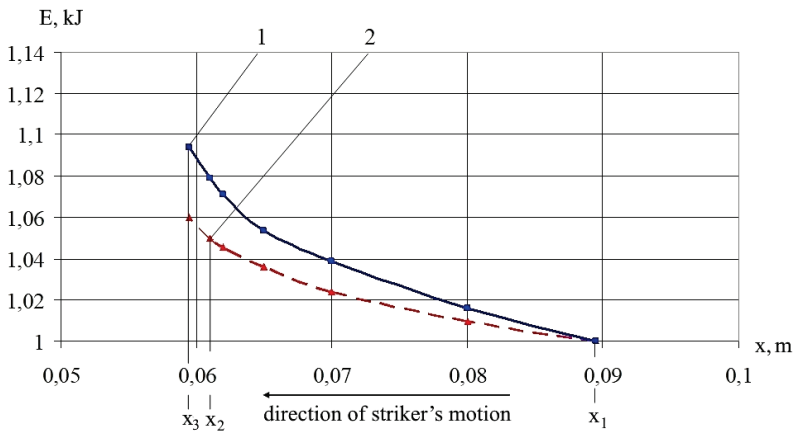


Fig. 8. Graphic dependences of changes in energy consumption E on motion of striker s at $L=0.6$ m and $J_f=0.446$ kg·m²: 1 – theoretical curve; 2 – experimental curve

Knowing dependence $N(t)$, we found the following characteristics:

- used work, i. e. energy consumption of pressing equipment from network W_{el} ;
- effective work, i. e. the work which is used for cutting detail W_{vur} .

To determine effectiveness of application of the improved electrohydraulic pressing equipment, its techno-economic indicators were compared with those of existing equipment.

To assess the degree of an increase in efficiency of the improved electrohydraulic pressing equipment, as well as to compare its techno-economic indicators with those of existing presses, a number of assessment criteria were used (Table 2).

The first criterion is coefficient of relative mass of press k_M . The lower this coefficient, the more effective the pressing equipment.

Coefficient of relative mass of the pressing equipment was derived from the following formula:

$$k_M = \frac{G_n}{F_{vur}}, \tag{1}$$

where G_n is the total mass of the pressing equipment, kg; F_{vur} is the maximum cutting force, created by the press, N.

Based of the performed calculations, coefficients of relative mass for the researched equipment were derived. Calculation results are listed in Table 2.

The second criterion is coefficient of energy consumption k_E , which takes into account energy consumption of the press per 1 running mm of a cut detail. The lower this coefficient, the more energy efficient the pressing equipment.

Coefficient of energy consumption k_E of electrohydraulic pressing equipment was derived from the following dependence:

$$k_E = \frac{W_{el}}{n \cdot L}, \tag{2}$$

where W_{el} is the amount of electric power, consumed by electrohydraulic pressing equipment, Wt; n is the number of cut details, pcs; L is the perimeter of the cutter, m.

The amount of electric energy, consumed from the network in one hour with a maximum number of cut details was determined for each press. Based on obtained data, we made appropriate calculations, results of which are shown in Table 2.

If we consider coefficient of correspondence of cutting forces, created by presses, coefficient of power consumption for the press Compart will be 2.73 W/mm.

For comparative evaluation of dynamic loads on electrohydraulic pressing equipment, we used the third criterion, coefficient of dynamics k_D , which takes into account the degree of press overloading as a whole.

Coefficient of dynamics of pressing equipment was derived from the following equation:

$$k_D = \frac{F_{vur}}{G_n}. \tag{3}$$

Based on performed calculations, we determined dynamics coefficients for researched equipment (Table 2).

To determine degree of set power consumption of the electric motor and the hydraulic pump, we used appropriate coefficients – coefficient of set power consumption of the electric engine k_{dv} and hydraulic pump k_N .

Coefficient of set power consumption of the electric engine k_{dv} was derived from the following formula

$$k_{dv} = \frac{F_r \cdot s}{N_{dv} \cdot t_{rx}}, \tag{4}$$

where F_r is the driving force, N; s is the motion of the striker (operating pistol), mm; N_{dv} is the nominal capacity of the electric engine, W; t_{rx} is the time of working stroke, s.

Technical and economic indicators of electrohydraulic pressing equipment

Criterion of comparison	PGV-8-2-0	Improved press based on PGV-8-2-0	C06.01 of «Compart» company
Coefficient of relative mass k_M , kg/kN	11.22	11.22	4.06
Coefficient of energy consumption k_E , W/mm	3.22	2.19	2.73
Coefficient of dynamics k_D , Wt/kg	0.09	0.09	0.25
Coefficient of set power consumption by electric engine k_{dv}	0.63	0.85	0.81
Coefficient of set power consumption of hydropump k_N	0.53	0.53	0.36

Table 2

According to results of experimental research into power consumption for cutting presses, we calculated coefficients of set power consumption of electric engines k_{dv} (Table 2).

Coefficient of set power consumption of the hydraulic pump k_N was derived from the following dependence:

$$k_N = \frac{F_r \cdot s}{N_{nom} \cdot t_{rx}}, \quad (5)$$

where N_{nom} is the nominal capacity of the hydraulic pump, W.

Based of the conducted studies and calculations, appropriate coefficients of set power consumption of the hydraulic pump were determined (Table 2).

It was established that according to coefficient of relative mass k_M , the developed equipment is similar to the serial samples of presses PGV-8-2-0 and approaches press C06.01 Compart (Germany, company «Compart»). The specified coefficient is 11.22 for press PVG-8-2-0 and for the improved pressing equipment based on PVG-8-2-0; it is 4.06 for press C06.01 Compart.

Low coefficient of relative mass was observed in press C06.01 Compart, which is explained by much larger maximum cutting force that is created and lower weight of equipment, compared with the improved pressing equipment.

By the basic indicator (coefficient of energy consumption k_E), the improved pressing equipment is equal to existing samples of modern cutting presses – 3.22 for press PVG-8-2-0; 2.19 for the developed pressing equipment based on PGV-8-2-0 and 2.73 for the press C06.01 Compart.

A decrease in coefficient of energy consumption was achieved by mounting a less powerful electric engine and setting the press to rational operation parameters, taking into account all possible factors that affect the process of cutting. Due to aforementioned improvements, we managed to decrease energy consumption by 35 % compared with the press PGV-8-2-0. High coefficient of energy consumption by press C06.01 Compart is explained by existence of a more powerful electric motor with possibility of creating significant work forces. If we consider coefficient of correspondence of maximum working forces that are created during cutting, the improved equipment consumes by 14 % less electricity from the network compared with press C06.01 Compart.

To determine degree of press overloading, we used dynamics coefficient k_D . Specified indicators for presses that were investigated are: 0.09 for press PVG-8-2-0 and for the improved cutting equipment based on press PGV-8-2-0; 0.25 for press C06.01 Compart.

To determine the degree of power consumption of the electric motor and the hydraulic pump, the appropriate coefficients were applied.

Coefficient of set power consumption of the electric motor k_{dv} for the studied equipment is: 0.63 for press PVG-8-2-0; 0.85 for the developed pressing equipment based on PVG-8-2-0; 0.81 for the press C06.01 Compart. Coefficient of set power consumption of the hydraulic pump k_N is: 0.53 for the press PVG-8-2-0 and for improved pressing equipment based on PVG-8-2-0; 0.36 for the press C06.01 Compart.

Conducted studies show that the set power of the electric motor of the drive is most fully consumed in the improved press, which indicates its high energy efficiency.

6. Discussion of results on improvement of hydraulic pressing equipment for hotel and restaurant business

Conducted analytical and experimental research has allowed improvement of the process of cutting and the appropriate equipment, described above. Implemented subsequent design changes of the specified equipment provided an increase in its power efficiency and operation reliability. The following studies for determining of magnitude of energy consumption within the cutting cycle for presses made it possible to establish the nature of its power consumption and overloading (Fig. 9).

Analysis of resulting graphic dependences of change in power consumption N and oil pressure in system P in the process of cutting (Fig. 9) indicates a complex relationship of the obtained characteristics. Due to making the above improvements, we managed to decrease power consumption of the pressing equipment in compliance with permissible loads on the press within the norm.

Power consumption of presses within one cycle of cutting, was as follows: 1.98 kJ for the press PVG-8-2-0, 1.35 kJ for the improved cutting equipment based on PVG-8-2-0 and 1.3 kJ for the press C06.01 Compart.

Within one cycle, the improved press provides significant economy of energy resources, which is 5.12 kW compared with press PVG-8-2-0 and 11.72 kW compared with the press C06.01 Compart.

Thus, as a result of the conducted research, we managed to improve the process of cutting and electrohydraulic pressing equipment in hospitality industry. Efficiency of the improved pressing equipment increased by 11 % compared with that of the existing press PVG-8-2-0. Efficiency of presses was: 22 % for the press PVG-8-2-0, 33 % for the developed pressing equipment based on PVG-8-2-0, and 35 % for the press C06.01 Compart.

Based of conducted analytical and experimental studies of the process of cutting footwear details on the electrohydraulic pressing equipment, as well as with the view to enhancing effectiveness of its use, the following recommendations were made:

1. In order to improve energy efficiency of pressing equipment at the stages of its design, it is advisable to choose rational power parameters of cutting presses according to the results of conducted studies, which allows us to optimize the basic operation characteristics and to decrease power consumption from the network.

2. In order to increase operation reliability of cutting presses, it is advisable:

- to remove the hydropump from the zone of oil tank;
- to place magnetic valves and control valves in closed hermetic cases.

3. During cutting, it is necessary to create an automated control system in order to provide high-quality cutting of material, as well as to control the position of the striker and the cutter relatively to the cutting plate.

4. Based on the developed experimental measuring equipment, it is advisable to create a measuring complex, which will make it possible not only to control the state of cutting operation progress, but also to influence the assigned parameters using a PC.

5. Improvement of the mechanism of auto-rotation of the striker contributes to improvement of the quality of cutting details by reducing the impact of inertia of the striker and possibility of lopsided cutting.

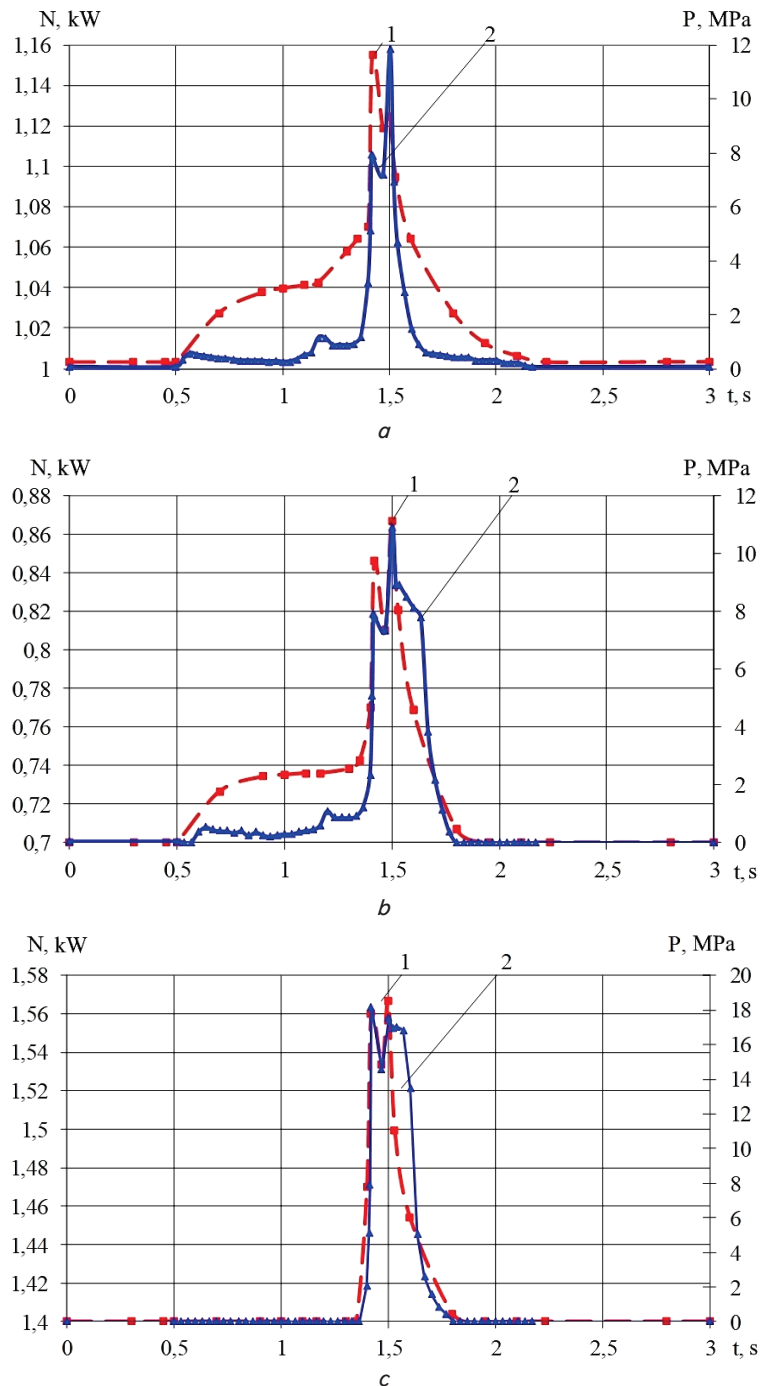


Fig. 9. Graphic dependences of change in power consumption N and oil pressure in system P in the course of cutting:
 a – for the press PVG-8-2-0; b – for improved pressing equipment based on the press PVG-8-2-0;
 c – for the press C06.01 Compart; 1 – power consumption; 2 – oil pressure

7. Conclusions

1. We analyzed the analog range of contemporary women’s footwear on the catwalks of the four top fashion capitals and found that the most common kinds include boots, sandals and shoes made of genuine or lacquered leather. It was also established that the round shape of the toecap, a heel, a wedge and decoration in the form of belts and metal elements are most often found in the contemporary women’s footwear.

2. We designed the experimental measuring bench that allows conducting research to determine energy and power

indicators of cutting presses and their diagnosis taking into account actual load peaks of the drive in real time.

3. Experimental studies were conducted and rational design, energy and technological parameters of cutting presses were established, based on which we plotted dependences that enabled us to analytically calculate power consumption depending on the perimeter of the cutter for different types of material and moments of inertia of the flywheel. In this case, efficiency of the improved pressing equipment increased by 11 % compared with that of PVG-8-2-0.

4. Establishment of rational indicators of the improved electrohydraulic pressing equipment both increased its efficiency and reduced power consumption by 35 % compared with the press PVG-8-2-0 and by 14 % compared with C06.01 Compart. In this case, power consumption by presses within one cutting cycle was as follows: 1.97 kJ for the press PVG-8-2-0, 1.35 kJ for improved pressing equipment based of PVG-8-2-0 and 1.3 kJ for the press C06.01 Compart.

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