ECONOMIC EFFICIENCY OF TEXTILE MATERIALS CUTTING DESIGNER COSTUMES OF HOSPITALITY FACILITIES

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Abstract: *The cutting process of textile materials for costumes of hospitality facilities at the expense of use a new flywheel design is described in the article. A series of experiments was conducted, which allowed to explore the cutting process from point of view of equipment energy efficiency. Maximum values of energy consumption for layers from variety of materials for costume and coat fabrics were determined. Comparison of existing press equipment with improved allowed to establish the economic efficiency of its application.*

Keywords: *textile materials, cutting, frequency drive, cutting press, flywheel, hospitality facilities, costume.*

1 INTRODUCTION

Textile materials and fabrics are widespread in all spheres of human activity. They are irreplaceable in everyday life of people [1].

Textile materials include wide assortment of materials of various structures: fabrics, nonwoven and knit fabrics, felt, artificial fur. They are made of various types of fibers, threads and yarns. The main characteristics of fabrics quality is the structure and physical-mechanical properties [2].

Depending on the type of yarn distinguish cotton, mixed, woolen, semi-cotton, silk and linen fabrics of various types of interweaving. To get the desired thickness, produce duplicate or three-layer fabrics. Connection of layers is carried out by different methods. The most common types of fabrics are: cotton, mixed, wool, semi-cotton, silk, linen [3].

In industry, during the manufacture of parts from textile materials, use different equipment [4]. The most commonly used equipment is: hydraulic cutting plants; laser cutting complexes; cutting presses; cutting complexes using a knife, which varies with high frequency [5].

Each of the above equipment has advantages and disadvantages. Equipment for hydro-cutting of textile materials is characterized by high cutting efforts and a large number of floorings of fabrics, which can be cut out [6]. However, using a jet of water, which operates under high pressure, leads to a number of disadvantages: fabrics wetting which requires further drying of parts; uneven parts of details with a large number of layers, which make worse their quality; variability of detail edge due to specific conditions of work [7, 8].

Laser cutting complexes are characterized by a large number of advantages. First of all, this is the high quality and precision of details manufacture [9]. Also, great performance, small amount of waste when cutting, high technological capabilities and many others. The disadvantages include the high cost of equipment and slight deterioration edges quality of details during cutting.

That is known application of equipment for the laser cutting of fiber reinforced plastics [10]. A theoretical model is presented considering the spatial distribution of the laser beam, interaction time between the laser and the work material and also other parameters. The obtained results are in good agreement with theoretical calculations.

Cutting presses are the most common in the industry. This is explained to the following factors:

– construction simplicity;
– work reliability;
– equipment low cost;
– high performance characteristics;
– technological construct design of presses;
– final products low cost.

As a rule, they are characterized by a reliable construction of console type with a hydraulic drive. The cutting device returns by worker to required position and technological process of cutting is carried out [11]. For obtain the required detail form the cutters of a certain area are used.

The disadvantages of that specified equipment work are deterioration in the quality of cuttings at the end of cutters service life [12]. This specified disadvantage is eliminated either by replacing the cutter, or its exacerbation to the required level.

The next equipment, which is widespread in textile enterprises there are cutting complexes using a knife that fluctuates with a high frequency [13]. Such complexes characterized of high precision molding materials, wide programming possibilities and computer control of cutting parameters, high productivity and efficiency of work [14]. There are disadvantages such as: deterioration of quality manufactured details with a large number of materials layers; high cost of equipment.

From the above equipment for small and medium enterprises the most rational is the use of cutting presses of console type. Exactly, they provide execution of most operations with materials and correspond to the price-quality indicator.

However, one of significant disadvantages of such equipment is high electricity consumption during continuous work in the work time period. This worsens economic efficiency and increases the value of the final product. This leads to deterioration of economic efficiency and raises the cost of the final product.

Therefore, there is a need to increase economic efficiency of textile materials cutting on such equipment. It will also provide increase in demand on designer costumes of hospitality establishments. This must be taken into account of various factors which directly affect on the process, and also establish an economic effect from the proposed changes.

2 EXPERIMENTAL

2.1 Experimental equipment

Experimental investigations conducted on the Atom SE20C cutting press. This is the most commonly used press at many industries enterprises, which is characterized by high reliability and stability of work. It is also characterized by high-quality cutting of details from textile materials.

The basis of experimental research is the task to increase an economic efficiency of work of press equipment by improving its energy efficiency and durability of work, technical and economic indicators. This is done due to the application of a new flywheel construction and rational use of its kinetic energy.

For conducting researches used frequency converter Altivar 320 ATV320U15N4C by Schneider Electric with the following main characteristics: power 1.5 kW; voltage 380 V; number of phases 3; nominal current 4.10 A; maximum output frequency 600 Hz. The main advantages of using this device are: smooth start of press electric motor which provides reduction of its overload; reduction of electricity consumption from the network; increase of electric motor reliability; service life increase of electric motor; no starting currents.

The given task is solved by the fact that electrohydraulic cutting press with a rotary drummer additionally equipped by improved flywheel of a new design. The main elements of the research equipment include: body, hammer drill, turning mechanism of a striker, electrohydraulic drive.

The flywheel of a new design is placed in special case in vacuum. It provides reduction of friction during flywheel rotation and also accumulation of much more kinetic energy. There is also growing of efficiency coefficient of the drive, load reduction on electric motor and increasing its longevity of work.

Addition to construction of electro-hydraulic press a new developed flywheel allows to reduce drive load during technological process of details cutting. It also increases its energy efficiency due to accumulation and reuse of kinetic energy. It improves the economic efficiency of equipment.

To receive an accurate data of equipment work the measuring unit WB-1 is used [15-18]. It works on the principle of analog-digital signal conversion and obtaining accurate data of measuring values (Figure 1).

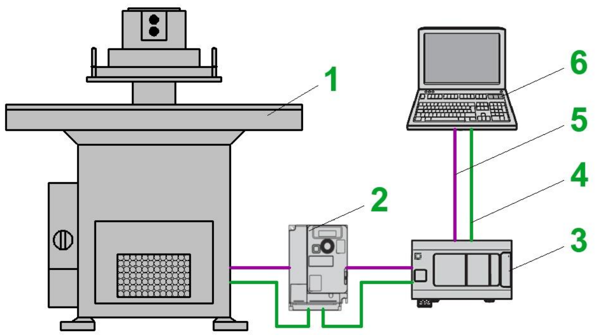

Figure 1 Experimental scheme for parameters investigation of press equipment: 1 – cutting press Atom SE20C; 2 – frequency converter Altivar 320 ATV320U15N4C; 3 – measuring unit WB-1; 4 - line of direct connection; 5 - line of feedback connection; 6 - PC

2.2 Methodology

For conducting experimental research, a suit and coat fabrics were used. Cutting efficiency for single-layer and multilayer flooring of specified materials was tested. In this case, in the case of significant deviation of the indicators, the average values of experimental data were selected. During experimental investigations cutting press worked as follows. When press is turned on, the pump motor does not work. That is, most functional systems work without a load on the network. With switches of control block the required mode operation of frequency converter ATV320U15N4C Altivar 320 and measuring block WB-1 was established. The entire measuring system is connected to a personal computer. It configures necessary software for collecting and processing the necessary data, which in the future will be obtained experimentally way. After that, they are processed in appropriate software products and received necessary characteristics.

Before performing a technological cutting operation, the necessary operating mode is selected, which depends on following parameters:

1) material (type of material directly affects on cutting process as it depends on cutting power);
2) sample form (larger area of detail, which will be cut off, requires more effort to be applied in cutting);
3) number of material layers (for a large number of material layers it is necessary to apply considerable effort, which can lead to deterioration of details).

When pressed on control buttons, the corresponding electrical equipment is turn on and electric motor and hydraulic pump are activated. The oil from hydraulic pump through the corresponding pipelines is sent to the working cylinder of press. After drummer turning into working position under action of oil pressure, the drum jumper drops down, cutting off given material.

At the same time, when cutting, work flywheel of a new design, which accumulates a large quantity of kinetic energy. This happens at the final cutting stage when cutter is immersed in material. When cutting a part of accumulated energy spent on reducing peak load on the drive and equipment as a whole. When cutting is completed, electrical equipment is turned off. The energy of the compressed oil, accumulated in the working cylinder, raises the drummer up. Oil from the pump moves through pipelines and appropriate distributor into the tank. The electric motor of hydraulic pump is turned off and system is ready for next operation (Table 1).

Table 1 Technical parameters of cutting technological process of textile materials

Technical parameter	Marking	One-layer	Many-layer
Cutting effort	N_{vr}	52-70 kH	74-220 kH
Cutting time	t	0.002 s	0.0027 s
Quality of cutting line of parts	k	0.99-1	0.97-0.99
Electric motor maximum power (with a usual flywheel)	W_{max1}	0.43 kW	0.71-0.78 kW
Electric motor maximum power (with a flywheel of new design)	W_{max2}	0.42 kW	0.70-0.76 kW
Efficiency factor of equipment use	α_{eq}	0.81	0.78

During next cutting cycle the flywheel accumulated energy will be reused. This reduces the load on electric motor and equipment, raises energy and efficiency of cutting press.

During conducted research a frequency energy converter Altivar 320 provided a significant improvement of equipment energy performance. At startup, there was a smoothing of peak loads, which reduced engine overload.

During cutting process provides press reliability and its protection from possible breakdowns through the use of following security functions (in accordance with IEC 61508 and ISO/EN 13849-1-2):

1) STO – safety moment shutdown;
2) SLS – safety speed limit;
3) SS1 – safety stop 1;
4) SMS – safety maximum speed;
5) SLS – safety door lock.

Thus, it was provided reliable work of electric motor and his protection from possible stops, breakdowns and failures.

3 RESULTS AND DISCUSSION

During the experiments economic efficiency of cutting textile materials of hospitality establishments' designer costumes was investigated. The results of experiments are presented on appropriate graphic dependencies (Figure 2).

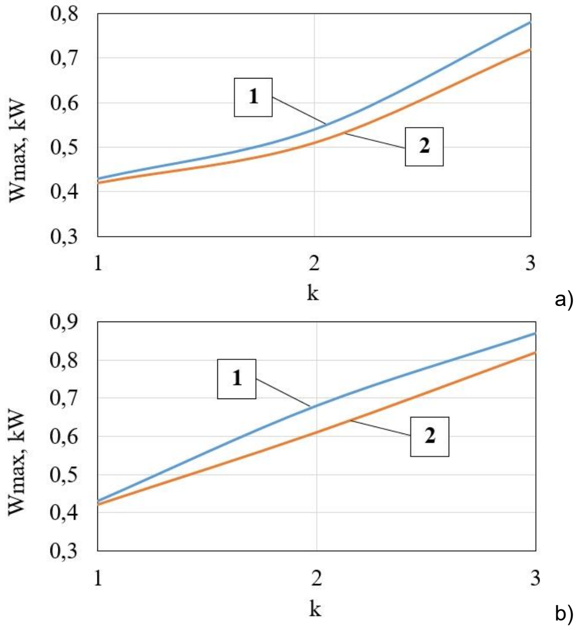

Figure 2 Graphic dependencies of changes the maximum energy consumption *Wmax* from the factor, that takes into account a number of material layers *k*: 1 - press equipment with a standard flywheel; 2 - press equipment with a new flywheel design; a) coat fabric; b) costume fabric

Conducted experimental studies allowed to determine the nature of change in the energy consumption of suit and costume fabrics, depending on flywheel design. We established that when increasing the number of material layers, the energy consumption increases to 2 times (Figure 2). This is explained by emergence of additional resistance forces in system drummer-cutter-material. They hamper the cutting process and impair quality of cut details.

The maximum values of energy consumption were determined: 1) for coat fabrics (W_{max1} = 0.78 kW and W_{max2} = 0.73 kW for a usual flywheel and flywheel of a new design respectively);

2) for costume fabrics (W_{max1} = 0.87 kW and W_{max2} = 0.82 kW for a usual flywheel and flywheel of a new design respectively).

Determined influence character of flywheel accumulated energy on total energy consumption of press equipment during cutting. It was investigated that with increasing the number of fabric layers, efficiency of flywheel accumulated energy increases to 93%. This explained by increased pressure on the press when cutting, especially with final cutter immersion into material.

The economic efficiency application of developed equipment provided with reduced power consumption in comparison with usual equipment. The economic potential of saving energy is 18% for coat fabrics and 15% for costumes.

But, we should note some of drawbacks of conducted researches. The research was carried out only for costume and coat fabrics, which limits the breadth of coverage of other materials. Also, a new flywheel design has an experimental character and requires further improvements from point of view reliability and stability of work. These disadvantages need to be solved in further studies.

4 CONCLUSION

A new flywheel design, which is used in electro-hydraulic cutting presses of console type, was developed.

Conducted experimental research and determined maximum values of energy consumption, which are: for coat fabrics W_{max1} = 0.78 kW for usual equipment and W_{max2} = 0.73 kW for developed equipment; for costume fabrics – W_{max1} = 0.87 kW for usual equipment and W_{max2} = 0.82 kW for developed equipment.

Completed comparison of developed equipment with existing and establish economic effect from its application. It was found that economic potential of saving energy is 18% for coat fabrics and 15% for costumes.

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