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Operational Experience of Electrohydraulic presses for stamping large-dimensional sheet parts

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Main distinctive features of electrohydraulic presses (EH-presses) for large-dimensional articles manufacturing are considered. It is shown that EH-presses demonstrate the maximum efficiency at large-dimensional articles forming. Direct scaling of conventional design presses with low level of saved energy for increasing their technological possibilities and saved energy isn't effective due to some reasons.

To ground theoretical knowledge about possibilities of temporary-spatial control, energy flows managing and saved energy increasing of EH-installations series of analytical, numerical simulations and natural experiments was done. These experiments were devoted to studying processes of transferring energy from the zone of discharge to the object of processing.

Generally, results of such research were adequate and complemented to each other. These results approved possibility of significant increasing (up to ten times) of energy that releases in a single discharge without crucial reduction of technological equipment resistance and increasing duration of technological cycle of large amount of released energy.

Scientific research devoted to energy transformation from its electrical form to mechanical work of plastic deformation allowed us to develop and realize practically multi-contour EH-press with saved energy up to 500 kJ. Experimental-industrial research for realization technology of consequent local loading was proved by some types of large-dimensional sheet articles. The quality of obtained articles was elevated; resources consumption was reduced. Results of improving process of articles forming and perfection of forming process parameters are shown. Results of experimental-industrial experience of technological processes of articles forming are analyzed. For such processes managing of loading field topology is quite necessary. The most crucial steps for perfectioning arrangement of energy releasing devices are developed.

This study was caused by the necessity of operational electrodes lifetime increasing because they are subjected to very intensive wear during operation.

Comparison of large-dimensional articles manufacturing efficiency with alternative manufacturing methods is given.

Goal of the paper is to expand knowledge of specialists with EH-presses having possibility both to form articles with elevated precision and quality and widen level of technological processes.

Main **tasks**: estimationof workability of multi-contour EH-press equipped with multi-electrode discharge blocks; estimationof possibilities of temporary-spatial control of loading in application to adding auxiliary nomenclature groups of sheet articles which can be produced by forming; determination possibilities of perfectioning of all elements of technological equipment to increase labor efficiency; comparison of technical-economic indexes for different technologies of forming for large-dimensional sheet articles;

***Key words**:* forming, large-dimensional articles, electrohydraulic discharge, process managing and control

Introduction

Multiple studies with quite reliable results of underwater high-voltage discharge (so-called "electrohydraulic effect" or "Utkin L. A. effect") for getting high forming technological pressures were conducted at the beginning of 1960th. Application of above-mentioned effects for metals forming, crushing of brittle materials, superficial cleaning from contaminants and other directions were considered.

There was a very actual demand for this effect application for EH-forming at that time. Existing mechanical and hydraulic with correspondent very complicated facilities had quite low efficiency for forming large-dimensional parts by financial and temporary consumption. The main attractive feature was the following: quantity of energy transformation stages to mechanical work (plastic deformation) at electrical discharge is reduced sharply, moreover, only single male- (or female-) die can be used for giving final shape to a part.

Special Design Bureau of Electrohydraulics was created in 1960^{th} in Nikolaev city (Ukraine) since first experiments of EH-effect application for metal parts forming have shown positive results and existing practice of large-dimensional parts manufacturing required novel approaches and processes. One of the main directions of this bureau research was the development of processes and equipment for sheet metal forming. After that, Laboratory of Electrohydraulics was founded in the Kharkiv Aviation Institute in frames of Problematic Laboratory of impulse energy sources for industrial application. The global scope was directed to solution problems of sheet metal forming for aviation enterprises.

At the same time several firms of USA (Cincinnati Shaper Co.), France, Japan (Janax) and other countries have started similar studies and developed innovative design of electrohydraulic equipment.

The main distinctive features of research and experimental-industrial development in all above-mentioned research centers were concentration of loads at local places, perfectioning of technological zones of presses and EH-installations, development of discharge chambers with advanced characteristics (as main units for energy transformation from electrical state to mechanical one with maximum efficiency) and also realization of high saved energy.

The goal of this paper is to observe results of creation and maintenance of electrohydraulic presses for large-dimensional (more than 1.0 m) sheet articles forming, increasing forming efficiency and articles quality, realization of novel effects of metals plastic deformations.

1 Literature sources review

The paper [1] is very well-known in the field Russian language scientists dealing with metal forming. This source contains comprehensive bibliography about processes ensuring electrohydraulic forming (EHF), design of EH equipment and components. The following conclusion is done- load-carrying structure of EH-presses is generally considered as vertical type press with discharge chamber (DC) as the essential unit. Paper [2] analyses possible structural options of DCs, electrodes used and required technological facilities.

One must note that above-mentioned papers describe and analyze the design of EH-presses, and their elements developed for forming parts with relatively small and moderate overall dimensions.

Paper [3] observes bibliography of later publications and covers design of EH-presses developed for large-dimensional articles forming. Attention is paid to presses of ПЭГ-series (ПЭГ25- ПЭГ250) developed by the designing team guided by of A. N. Horohovitch. The paper contains some conclusions devoted to practical operation of the mentioned presses. One of these conclusions is the following – the most effective presses are those having high saved energy (the numbers in the designation ПЭГ means maximum saved energy in kJ) and large dimensions of press operational table. For example, dimensions of operational table for ПЭГ150 are equal to 1.8×1.3 m. High efficiency of huge EH-presses can be explained by general absence of such equipment on majority of enterprises which produce large-dimensional articles and by low production volume (demand) of such articles.

The second important conclusion (mentioned in the papers [1] and [3]) is in increasing of efficiency (up to 10…20 %) of presses equipped with closed DCs in comparison with non-closed ones.

In the Eastern-European sector of scientific literature devoted metals forming one has to mention materials disposed on the site of Bmax firm [4].Majority of presses, shown on Bmax site, are fulfilled by vertical hydropress scheme and used for forming sheet bottoms with low dimensions. Power units of such presses have single electrical contour arrangement.

Paper [5] considers results of consequent local loading at box-like part forming. It is shown that control of zonal loading and energy released over given area guarantees quite high quality of articles. Local loading occurs on relatively small section of a blank that leads to extension of forming cycle at passing along article perimeter.

Positive results of EH-forming of decorative articles and bottoms with complicated shape and relatively small dimensions are analyzed in the [6]. It demonstrates quite thorough pictures of technological blocks of EH-installations. By their architecture they have conventional arrangement. The conclusion about efficient application of EH-presses with low saved energy for low-dimensional parts forming is done.

The same conclusions are also provided by authors of [7], which deals with experimental studies of duration of loading impulses influence on forming efficiency. The authorsdeclared 400 MHz (0.4 μs) band of energy releasing as an optimal one. But this band overexceeds the one obtained by authors of the current paper. To our opinion the mechanism of cavitation erosion of electrode core current-conductive rod isn't dominant for estimation of electrodes workability and service life. But these questions are under discussion currently because electrode breakage depends strongly on electrical discharge conditions.

Among English language literature sources devoted to application of impulse sources of energy (for example, for automotive panels production) the paper of S. Golovashenko [8] is well-known. In contains comprehensive review of world-wide scientific papers of metals forming, results of his own studies of EHF of automotive car body box-like parts on EH-installation of press type. Main attention is paid to the optimization of reciprocal location of operational electrodes with respect to female-die cavity. Results of natural experiments were compared with 3D computer simulations. The conclusion about efficiency of such kinds of presses and equipment application for forming automotive panels made of up-to-date steels is done. Recommendation for application of correspondent software and conditions of synthesis of mathematical models of forming process are given.

In the later paper [9] authors approves efficiency of electrohydraulic forming of low-volume parts for prototype production mode and give recommendation concerning composing of proper manufacturing processes based on practical examples. These conclusions were drawn up on conditions of wide application of LS Dyna software.

Next source must be mentioned is [10] published by Woo Mina at al. Authors suggest for observation results of technological process studying, including consequence of forming operations and selection of mathematical models for material behavior description. Main mean for this research is computer simulation. Exact distinctions of presses arrangement and their energy unit are considered in the less degree.

Based on objective reasons authors are restricted in observation but their analysis allows them to formulate practical recommendations. DC is the main unit of EH-press because it defines press efficiency, i. e. quantity of released energy at discharge, necessary quantity of discharges. DC must ensure required loading distribution along area of a blank. Electrodes installed in DC must be replaced easily because they are subjected to high wear. The most suitable level of saved energy per one pair of electrodes is 20…25 kJ. Overexceeding this level leads to sharp wear of electrode insulation. Some other practical recommendations are considered below.

2 General

Let's consider the typical representative sheet part with overall dimensions more than 1.0 m. For example, automotive wing panels (Fig. 1). Following three distinctive zones can be selected on this part:

– zone I – i. e. the angular conjunction of three surfaces. To calibrate this zone static pressure more than 90 MPa has to be applied;

– zone II – i. e. stiffener. To calibrate this zone static pressure more stan 60 MPa is required;

– zone III – zone with low curvature. To form this zone static pressure of 11 MPa is necessary.

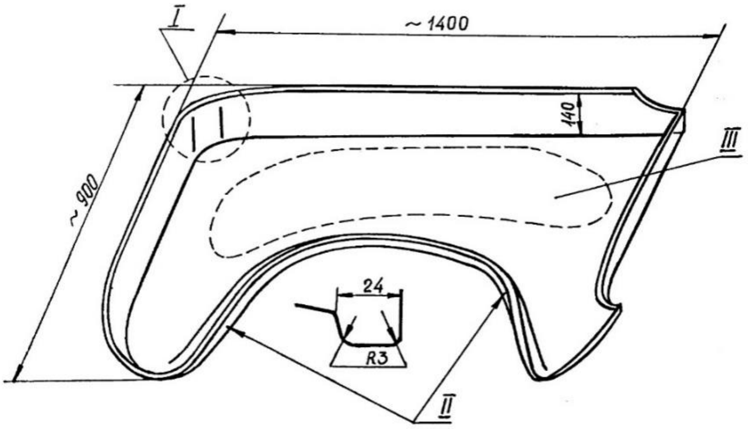


Fig. 1. Typical large-dimensional sheet article:
I, II, III – representative zones for calibration of which static pressure of 90, 60 and 11 MPa is required [3]

If one assumes that such kind of article is produced by classical hydraulic press with uniform pressure over article area equal to 90 MPa then it will require absolute force of 75.5 MN. But if we have the possibility to both vary and control applied forces in accordance with part areas and required pressure general absolute force is 26 MN. That is practically three times less than in the case of classical forming.

This example demonstrates the necessity of load control along and over blank surface. With increasing overall dimensions of a part, presence of irregularities, radii of curvature the positive effect of load control is significant.

Then we consider the scheme of energy transmission and loss in EH-presses (Fig. 2).

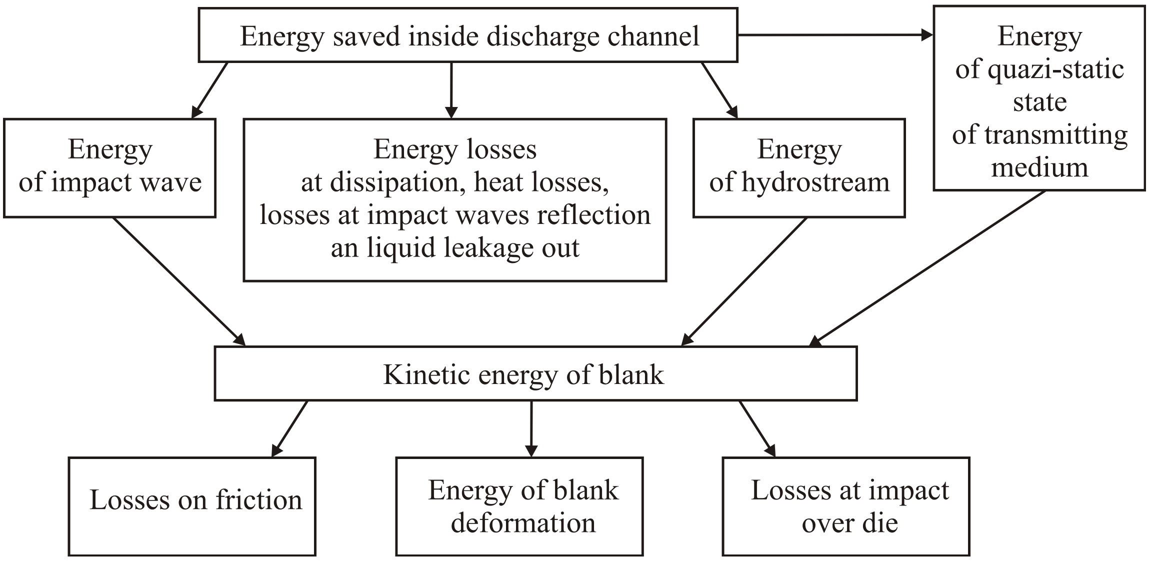


Fig. 2. Approximate scheme of energy transmission and loss at EHF

Experience of EH-presses operation and results of experimental studies are evidence of the following conclusion: main mechanism of energy transfer from the zone of electrical explosion to deformable blank is realized by impact wave (batch of impact waves) and by energy of hydro-stream expanding uniformly to all sides from the surface of steam-gas bubble. Relation of energy quantity transferred by these two mechanisms in conditions of closed DCs of high volume (more than 0.005…0.01 m^3) is near 1:1. In DCs of low volume (comparable with the volume of steam-gas bubble at its full expansion) the portion of energy transferred by hydro-stream is 1.5…2.0 times more than the energy of impact wave. Also, the energy of quasi-static pressure is added to the above-mentioned mechanisms. In non-closed DCs a major part of the energy released at EH-discharge is transferred by impact waves, and, consequently, efficiency of energy transferring is quite low (up to 10 % only).

In technical system of energy transferring from the zone of EH-discharge and its consequent transformation to useful work of plastic deformation is accompanied by following energy losses:

– related to elastic deformation of the volume of transferring medium (water), structure of DC and load-carrying structure of a press;

– related to energy dissipation on radiation of different nature and chemical reactions;

– losses on friction, related mainly to movable flanges of a blank and clamping devices of a die etc.

Analysis of mechanisms of energy transferring and energy losses one can make following conclusions devoted to increasing forming efficiency:

– to realize maximum rigidity of technological zone (DC, press load-carrying structure, its hydraulic or other type of system for clamping DC to technological dies);

– to minimize volume of transferring medium and quantity of gases inside of it;

– to redirect flows of energy to a blank side by means of rigid surfaces, wetted by transferring medium.

Considering these theoretical conclusions one can compare two following variants of DCs (Fig. 3).

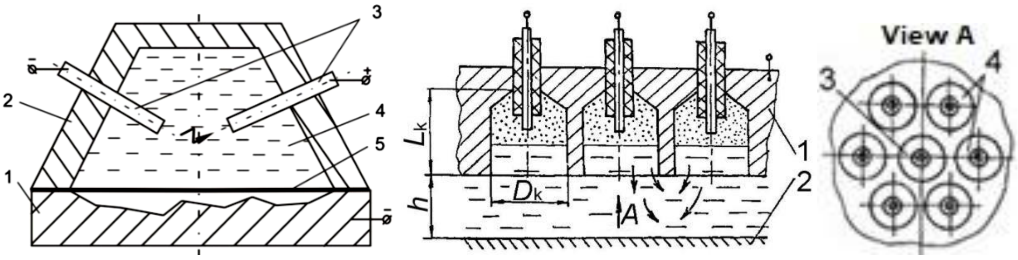


Fig. 3. Principal scheme of EH-presses discharge units:
a – DC with a single pair of operational electrodes: 1 – female die; 2 – DC;
3 – operational electrodes; 4 – transferring medium (water); 5 – blank;
b – multielectrode discharge block [11]: 1 – DC; 2 – blank; 3 – DC of reference discharge; 4 – six DCs for auxiliary discharges

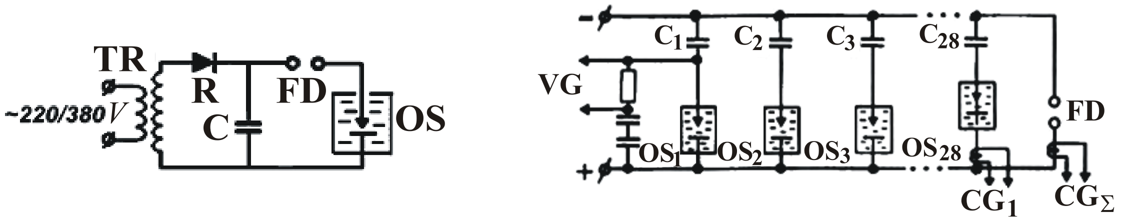
Fig. 3, a shows principal scheme of DC with opposite operational electrodes, electrical discharge occurs between these electrodes. Outer contacts of electrodes are connected with outer contacts of single-contour current impulses generator (CIG). Electrodes arrangement is the following: it contains central electrically conductive rod covered with high-voltage insulation. If look from the top DCs are mainly have round shape, rarely – rectangular. DC can have an extended shape equipped with several pairs of opposite electrodes. Such DCs can be used mainly for EH-presses with relatively low energy saved and for forming low-dimensional articles.

Fig. 3, b shows principal scheme of multi-electrode discharge block. It is produced from a thick metal plate with cavities. Distances between cavities are selected from the conditions of strength. Operational electrodes with high-voltage insulation are installed by the center of each cavity. Electrical discharge occurs between the bottom side surface of electrode and inner surface of a cavity. Steam-gas bubble appears at EG-discharge. This bubble pushes liquid located in the lower zone of cavity to the outer direction. This liquid creates so-called high-energy immersed liquid jet. The jet interacts with a blank making work of deformation. EG-discharges in neighboring cavities theoretically happen at the same time and similar jets continue their axial movement. Thus, high-efficiency loading is realized.

For energy releasingon operational electrodes in the above-mentioned schemes different methods of commutation of CIG operational contours is used (Fig. 4).

In the single-contour scheme of commutation (Fig. 4, *a*) forming discharger (FD) is connected to positive side of operational spacing (OS). In the multi-contour scheme of CIG forming discharger at attached in parallel way with operational contour. Only the required energy of electrical energy is reached in the CIG switching on of FD occurs and EH-discharge happens simultaneously in all OSs.

Special experiments were conducted to establish dependence between duration of pre-discharge (pre-breakedown) of discharge and the value of interelectrode spacing in DC. This spacing defines minimal diameter (D_k) of DC (Fig. 3, *b*). Distance L_k is defined from the condition of prevention of steam-gas cavities leaving of DC dimensions. Violation of these requirements leads to high energy losses.



a *b*

Fig. 4. Principal scheme of CIG commutation used in industrial EH-installations: *a* – single-contour; *b* – multi-contour with gauges allowing to vary and control discharge regimes; TR – high voltage transformer; R – rectifier; C – battery of capacitors; FD – forming discharger; OS – operational spacing; CG – current gauge; VG – voltage gauge

Results of experimental research have shown possibility of efficient control (delaying) of time of discharge beginning in neighboring cavities up to 300…350 μs.

By means of changing the value of time of discharge beginning in neighboring cavities one can control energy flows, i.e. energy concentration in narrow zones, rotate immersed jet in necessary direction, and the main – to prevent undesirable energy losses. To realize this control practically special analytical model was created and blank loading was studied by means of this model. Results of studies show that it is possible to realize blank vibro-impulse stress-strain state by means of combination of delaying/outrunning of energy releasing in neighboring cavities. This approach leads to accelerated relaxation of residual stress after forming at definite frequencies of discharges, i.e. globally it means increasing quality of forming.

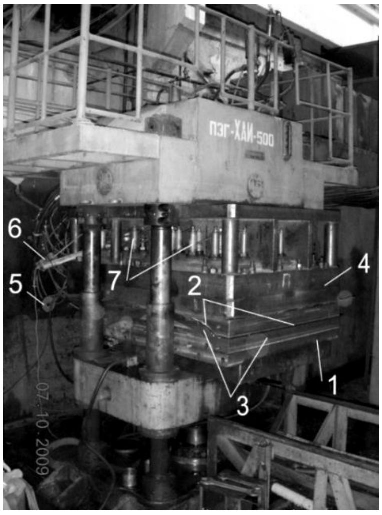
In case of multi-contour CIG application, it is quite easy to control the energy of released energy on a single discharge cavity by means of commutation to correspondent electrode pair of one, two or three discharge contours.

All the above-mentioned approaches allow us to realize very wide possibilities of spatial-temporary control on multi-contour EH-presses.

Quite deep and multi-purpose studies were conducted in the National Aerospace University “Kharkiv Aviation Institute” (Ukraine) for a many years. These studies allowed to develop high-energy electrohydraulic press ПЭГ-ХАИ-500 for large dimensional part forming. General view of technological block of this press and its brief characteristics are shown on Fig. 5. General view of two variants of multi-electrode discharge blocks (MDB) are shown on Fig. 6.

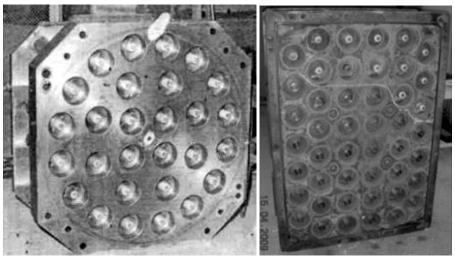
For the above-mentioned press assembling existing load-carrying skeleton of EH-press of ПЭГ-60 was used (without DC). It was equipped with two optional MDB. Also, authentical CIG with 28-electrical contours was developed, but the original pneumatic-hydraulic unit was rested.

At experimental operation technological processes of forming for different types of large-dimensional sheet articles were developed. Some units for electrodes installation and clamping, structure of FD, CIG and pneumatic pumps were perfected significantly.



Press technicalcharacteristics	
Energy saved, kJ	upto 500
Operational voltage, kV	upto 40
Spacing between columns, mm	1170
Max length of blank, mm	upto 1800
Average duration of a cycle, s	280
Equivalents tati cpressure, MPa	120
Quantity of discharge contours, pieces	28
Nominal capacity, kW	20

Fig. 5. General view of technological block of ПЭГ-ХАИ-500 press:
1 – female die; 2 – profiled part of clamping device (blank is shown with the light strip); 3 – special spacer; 4 – directing plate of MDB; 5 – Rogovskii coil (gauge for discharge current measuring); 6 – capacity-resistive voltage splitter; 7 – operational electrodes



a *b*

Fig. 6. MDB of round and rectangular shape:
a – block with 28 electrode pairs; *b* – block with 46 electrode pairs (dimensions 1580×1130 mm)

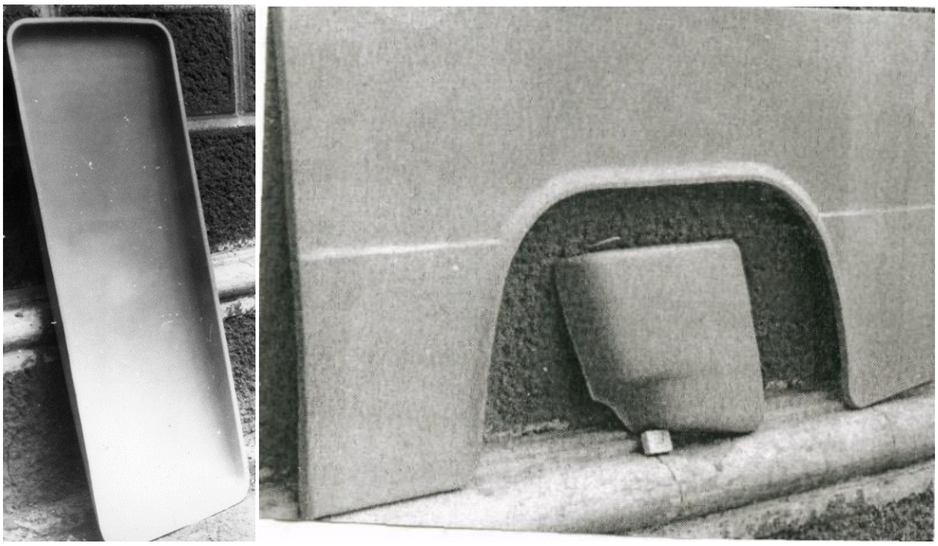
General views of several typical parts formed on ПЭГ-ХАИ-500 press are shown on Fig. 7-10.

a *d* *c*

Fig. 7. Parts appearance made on the ПЭГ-ХАИ-500 press:
a– high-precision parabolic mirrors for space communication antennas with a diameter 900 mm; *b*– element of the bulk products pneumatic transport system; c – side body panel

a *b*

Fig. 8. Panels of rigidity pressed by ПЭГ-ХАИ-500:
a – piece of large-dimensional panel with stiffeners made of AK-4 Al- alloy (thickness is 1.2 mm); *b* – rigidity panel of Al-alloy D16AM (thickness is 1.5 mm, bevel height is 16 mm)



a *b*

Fig. 9. Automotive panels of micro-bus “СУЛА” (Ukraine):
a – two united panels of the roof rear zone (1688×650 mm); *b* – side body panels (max dimensions 1410×760 mm), panel thickness 0.8 mm, material – steel 08Ю

a *b* *c*

Fig. 10.“Rear arc” part (car ВАЗ 2101), material – steel 08кп, thickness 0.8 mm:
a – the scheme of reciprocal location of active electrode pairs and die cavities at simultaneous forming of left-handed and right-handed parts; *b* – general view of a part; *c* – forming surface of female-die

All produced parts had high precision of shape and low after-forming warping. A typical example is the mirror of parabolic antennas. It had a diameter of 900 mm. Deviations of produced mirror from theoretical geometry of a die was 0.03…0.032 mm at the center and 0.05 mm at peripheral zones. The surface of a mirror didn't have any deplanation. Acoustic coefficient of amplifying was 39.7±1.2 dB at the frequency 12.2 Hz (at the width of orientation diagram equal to 1.8 degrees by level of 3 dB). It is very high index of precision. Authors can explain the effect of high precision by character of impulse loading with group EH-discharges.

Perfectioning of technological processes of forming at application of multi-contour discharge blocks has shown possibility of simultaneous forming of several articles (see Fig. 9, 10). It allows to increase forming efficiency.

Another positive distinction is controlling efficiency of loading over blank different zones. It is necessary to note that forming die (made of aluminum-zinc alloy АЦ-13) withstood near 2500 parts without any shape correction, and then 2000 parts more.

Efficiency of forming operation was increased crucially after perfectioning of the electrode clamping unit (Fig. 11).

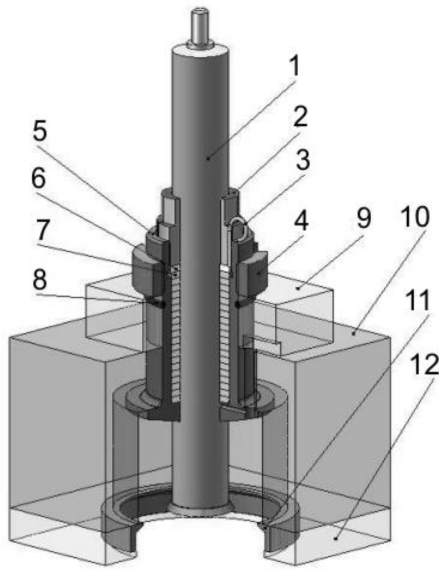


Fig. 11. Typical clamping unit for electrodes installation in MDB (developed in KhAI):
1 – operational electrode;
2 – tightening nut; 3 – pin;
4 – nut; 5 – unit case; 6 – washer;
7 – rubber ring (10…20 pieces);
8 – metal tightening ring;
9, 10 – drain and discharge plates; 11 – discharge ring;
12 – directing plate

Operational electrode consists of core steel rod (∅ 10…16 mm and length 400…600 mm) cover with glass-plastic insulation. An electrode is disposed in the case 5 and clamped with elastic washers 7 (10…20 pieces) by means of tightening nut 2. Required value of interelectrode spacing is reached by movement of operational electrode 1 with respect to discharge ring 11. In case of intermediate repair (electrode replacement) tightening nut is untightened and electrode can be removed freely from the batch of elastic washers.

At the tip of electrode special cap protects electrode body (first of all, glass-plastic insulation) from cavitation erosion up to 2500 discharges with energy 25…30 kJ. These parameters correspond approximately to 5 full working shifts of press operation. During the six-shift disassembling, repair and installation of new set of operational electrodes.

At the stage of technological block mounting special elastic diaphragm (rubber, polyurethan) is installed between clamping plate of technological die and lower side of MDB. This diaphragm allows to realize part "dry" forming.

Experimental-industrial operation of ПЭГ-ХАИ-500 press has shown necessity of application of interactive control systems of energy releasing and blank state (degree of blank contact with female-die surface). Schematically places of control gauges installation are shown on Fig. 4, *b*. Such devices (gauges) include:

– gauges of total electrical current CG_{Σ} control current passing though all active contours. On such oscillograms engineers have to read maximum amplitude of a current of and its duration;

– gauges of discharge current in each active contour CG_1-CG_n. If necessary, several gauges can be communicated to the most energy-saturated contours. These gauges read real-time current in each contour;

– gauge of discharge voltage VG. This gauge reads the duration of pre-discharge stage and the value of pre-discharge voltage losses.

Besides of mentioned gauges is necessary to connect discharge number counter.

Analysis of read discharge regimes has shown its efficiency for increasing forming workability.

To control the state of a blank it is suggested to use pneumatic gauges of distances (gaps) as the most resistible to electrical interference.

Accoustic methods of control for energy releasing system and blank position were also tested. Correlation between the level of discharge sound pressure and value of released energy at discharge and degree of blank contact with a die is established. It is shown, that changing of amplitude-frequency characteristics of acoustic signal strongly depends on different state conditions of technological system. These studies are under development yet.

Positive results of experimental-industrial studies for perfectioning and application of electrohydraulic forming of large-dimensional parts (at low-volume prototype production) have been delivered to manufacturing enterprises. There is the necessity in modernization of industrial universal hydraulic presses with maximum load 160…400 tons to equip them with multi-electrode discharge blocks. Documentation for such a project was developed, but due to economic crisis at the beginning of 2000^{th} has stopped practical realization of the project.

But Kharkiv Aviation Institute together with scientific teams of several other organizations developed the project of huge EH-press with energy saved up to 2700 kJ (Fig. 12).

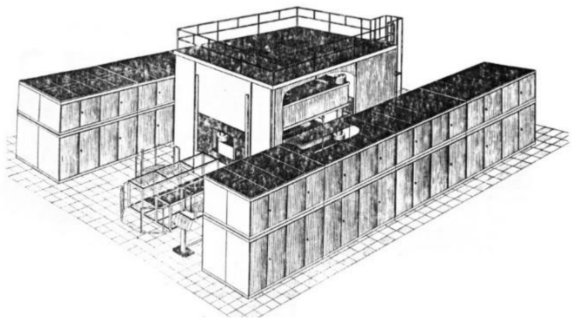


Fig. 12. General view of multi-contour EH-press with energy saved up to 2700 kJ and overall dimensions of operation table 2940×2100 mm

The project considered the possibility of forming parts with overall dimensions 2940×2100 mm and 156 operational contours of CIG. Operational voltage is 40 kV. Press was developed for sheet parts forming by schemes “to female die” and “to male die”. The modular principle was used for design of press arrangement. As the prototypes of each unite correspondent ones of the ПЭГ-ХАИ-500 press were selected (as well tested). Reducing acoustic pressure influence to ambient space technological block of the press was assumed to be disposed in sound-insulation box.

The press project assumed the possibility of simultaneous forming of large-dimensional left-hand and right-hand panels of the same geometry for vehicles or up to 12 parts of less dimensions. Also, some other distinctions were developed to ensure high forming efficiency and repairability. But economic crisis broke practical project realization.

3 Comparison parameters of recourses consumption for large sheet forming equipment

To get full information about the advantages and drawbacks of different equipment for sheet large-dimensional articles forming it is necessary to compare equipment indexes of recourses consumption. Objective comparison can be conducted by passport data of such equipment [11-15].

The following parameters were selected for analysis:

– energy consumption per unit area of operational table $\overline{E}$, kW/m^2;

– material capacity of equipment, related to the same area, $\overline{M}$, tons/m^2;

– workability of forming (including stages of installation and removing of forming equipment) related to the area of operational table, $\overline{T}$, s/m^2.

Results of comparison are shown on Fig. 13.

Comparison of parameters shows that EH-presses with high energy saved occupy medium position in the row of indexes for presses with the same technological possibilities. EH-presses have quite low indicator of duration and cost of technological preparation of production (3…6 time less in comparison with others, except of QUINTUS presses).

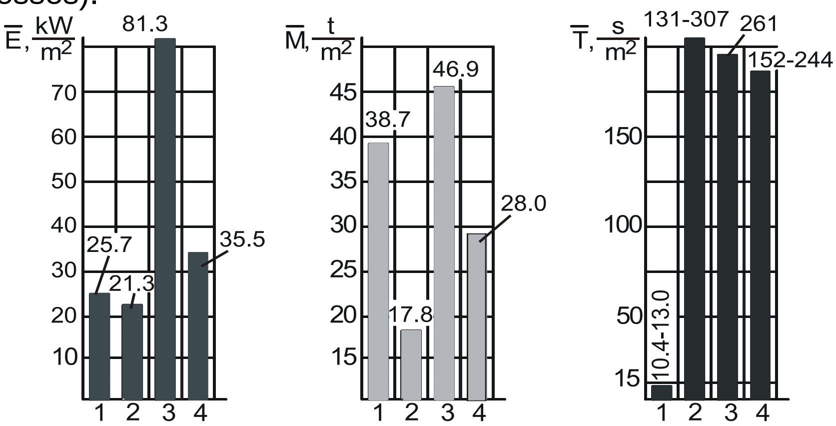


Fig. 13. Comparison of specific parameters of recourses consumption for forming of sheet large-dimensional parts on different types of presses:
1 – crank; 2 – hydraulic; 3 – forming with elastic or liquid medium on QUINTUS presses (Sweden); 4 – electrohydraulic

Majority of enterprises which use EH-presses mention high precision of produced parts. After-forming warping of such parts is significantly less. The possibility of spatial-temporary control of loading guarantees realization of other advantages, for example, reduction of required blank dimensions. This reduction is stipulated by more uniform thickening distribution over blank area.

The main drawback of EH-presses is the absence of their multiple production.

Conclusions

1. Electrohydraulic presses with high energy saved equipped with multi-

electrode discharge blocks and having the possibility of spatial-temporary control of loading are very effective in operation for prototype (experimental) sheet production for manufacturing of automotive parts, in transportation systems of bulk products, at forming of mirror antennas of space-, radio-communication and for other sheet articles with specific requirements.

In comparison with other sheet forming articles EH-presses have their own advantages and drawbacks, some of them are considered in the current paper.

2. To reduce temporal and material resources at stages of design and development of similar manufacturing processes one has to include following stages: developmentand synthesis of mathematical models for computational modelling for selectionof required consequence of loading fields for different configurations of articles; optimization of loading fields and their parameters as dependence on required articlesquality and goal of manufacturing.

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Досвід експлуатації електрогідравлічних пресів для штампування багатогабаритних листових деталей

Розглядаються коротко відмінності електрогідравлічних пресів (ЕГ-прес) для формування відносно багатогабаритних деталей. Показано, що ЕГ-преси демонструють найефективнішу ефективність при формуванні багатогабаритних частин. Просте збільшення масштабування конструкції пресів з низьким рівнем заощадженої енергії у напрямку збільшення технологічних можливостей та заощадження енергії не є ефективним через деякі причини.

Щоб обґрунтувати теоретичні уявлення про можливості просторочасового контролю, управління потоками енергії та підвищення егергоозброення ЕГ-пристроїв були проведено модельні, натурні дослідження та комп'ютерне моделювання процесів передачі енергії від зони розряду у напрямку предмету обробки.

В цілому, результати таких досліджень оказались сумісними та доповнюючими друг друга. Вони підтвердили можливості різкого збільшення енергії що виділяється за один розряд (до 10 раз) без суттєвого зниження стійкості елементів технологічної оснастки та тривалості часу технологічного циклу виділення більшого кількість енергії.

На основі досліджень перетворення енергії від її електричної форми до механічної роботи пластичного формоутворення пропоновано та реалізовано проект багатоконтурного ЕГ-преса з енергією до 500 кДж, що запасається. Експериментально-промислові дослідження реалізації технологій послідовного локального навантаження наведено на деяких типах багатогабаритних листових деталях. Якість отриманих деталей була підвищена, споживання ресурсів при їх формуванні було знижено. Показано результати вдосконалення процесу формування деталей та покращення виробництва процесу формування.

Наведено результати дослідно-промислової обробки технологічних процесів штамповки деталей, що характерні необхідністю для їх штамповки управлінням топологією поля навантаження. Отримано першочергові вдосконалення конструкції елементів виділення енергії.

Ці роботи були викликані необхідністю піддержання у робочому стані електродів, які підтверджені інтенсивному зносу у ході технологічного процесу.

Наведено порівняння ефективності виготовлення багатобаритних деталей в порівнянні з альтернативними методами виготовлення.

Мета статті – розширити знання фахівців з новим розташуванням ЕГ-преса та обох можливостей формувати деталі з підвищеним рівнем точності, якості та

формування процесів.

Основними **завданнями** є: оцінка працездатності багатоконтурного ЕГ-пресу, що оснащений багатоелектродними розрядними блоками; оцінка можливостей прострочасового управління напруженням у додаванні до штамповки листових деталей різних номенклатурних груп; визначення можливостей вдосконалення усіх елементів технологічної оснастки для підвищення продуктивності процесу; порівняння техніко-економічних показників різних технологій штамповки багатогабаритних листових деталей.

***Ключові слова*:** формування, багатогабаритні частини, електрогідравлічний розряд, управління та контроль процесу.

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