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COMPREHENSIVE MODERNIZATION OF THE TECHNOLOGICAL EQUIPMENT OF ELECTRO-POLISHING

The article presents a comprehensive approach to the development of technological equipment for electrospark polishing. An effective concept of automation of modern highly efficient and competitive technological equipment for electric spark polishing of high-tech products is proposed.

Key words: *an integrated approach, process equipment, automation of high-performance, competitive, high-tech products of electro-polishing technology.*

Presently, complex accretion of results of scientific and technical progress and an artistic image of objects and systems within the «operator-machine-operator» system is observed. Technological processes become more multi-operational as well as reduce in volume and square footage. When developing complex technological systems there is a need to solve a number of tasks which are outside of competence of the mechanical, electrical or software engineers – a group of developers who are not studying design, psychophysiology, ergonomics, functional coloring and psychophysiological perception of the color scale [1, 2]. An account for these additional factors provides not only physiological comfort and improved moral atmosphere of the operator during the contact with the equipment, but also increases their professional level, creates possibilities for esthetic perception of the production environment. A more careful consideration of form and shape building elements in the design of the apparatus harmonizes complex technological systems.

Electro-Impulse Polishing technology (EIP) which received broad industrial application is based on the use of physical and electrochemical processes that occur in a mixture of gas and steam during which the processed surface separates from the electrolyte [3]. The EIP technology is characterized by low number of stages, high stability and universality. This method has already been implemented by multiple manufacturers in our country as well as abroad and is recommended for high-quality polishing of complex surfaces; surface preparation before applying electroplated and vacuum plasma coatings; simultaneous removals of the burrs and sharp edges; cleaning of a surfaces of mineral and organic pollution. The polished surfaces have a low roughness (Ra = 0.3-0.04 microns) and high reflective ability. The EIP technology also allows finishing opaque surfaces. Non-toxic salt water solutions are used as electrolytes.

A replacement of traditional methods of surface finishing processes by EIP allows reduction in labor for polishing and removal of pollution by 1.5 to 12 times and de-burring by 4 to 25 times. In most cases EIP application considerably increases processing productivity, part and product quality and repeatability of the results. It also completely eliminates - manual labor which could not be previously replaced.

Since 1988 a variety of specialized semi-automized equipment and automized transfer lines (fig. 1) has been developed for industrial use of EIP technology. This equipment differs by specialization, extent of automation of technological process, configuration and productivity. A bathtub and a source of current with a control system are generally a part of the EIP installation. Bathtubs have working volume of 0.05-1.00 m^3 as well as necessary drives and systems needed for completion of the finishing process.

Characteristic for manufacturing processes constant flow of various unfinished parts creates difficulties for EIP automation. An analysis of known EIP designs as in [4-8] has revealed a number of their shortcomings. Bearing elements of EIP function only as support for apparatus modules and finishing parts.

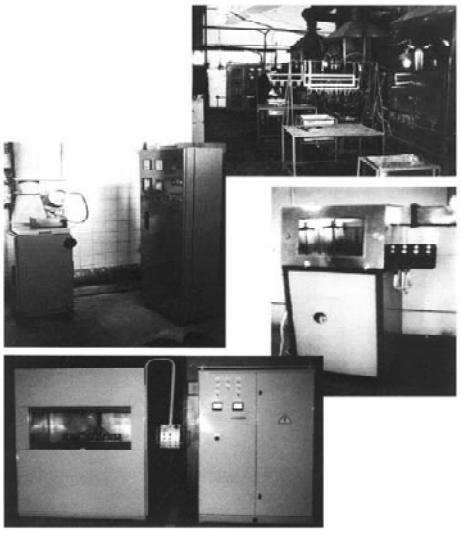

Fig. 1. EIP installations

Working zone service options and installation mechanisms do not consider ergonomic needs of the operator causing increased levels of fatigue. Apparatus cover elements and proportions have exclusively protective functions and do not consider a functionality of decreasing emotional load from appearance of the equipment. Color schemes bear purely esthetic aspect, without improving visual perception of large volumes of the design elements.

An analysis of the known designs in combination with the work algorithm at this development stage of the design project of the EIP apparatus (EPOL-6N series) allowed to formulate and solve the following main objectives:

- to create an integral art and design image of apparatus;
- to provide the most convenient operator access to a working zone and areas of the apparatus depending on ergonomic needs of the operator;
- to remove emotional loading from visual perception of the large volumes of the design elements;
- to create visual and functional comfort caused by the color scheme, psychological load and an operating mode of the apparatus;
- to define tendencies of future development of shaping systems for similar technological direction within the «operator-machine-operator» system.

Simplicity, diversity and speed of computer modeling as well as possibility of flexible change and easy presentation of the developed models, makes computer modeling preferable in comparison with traditional methods of design. The modern software allows to develop and create spatial models of objects of nearly unlimited complexity to forecast their performance during the estimated period of operation. Depending on the development goals the most weak elements of the design can be defined, simulated and optimized following by corresponding changes implemented in the shortest period of time. The possibility of obtaining a clear image of the object created on the computer allows to eliminate constructive defects of a design in advance as well as carry out calculation of various technical characteristics of the object and technological parameters of its production.

Preliminary configurations of basic elements of the EIP apparatus EPOL-6N series allowed to decide on a block-frame design. The materials and accessories corresponding to the specifications of this EIP design were chosen. The cross sections of the design elements and frequency of supporting and connecting elements where determined by calculating operating loads of the equipment. As the result a «skeleton» of the EIP apparatus was developed.

An important aspect of ergonomic design is a rational organization of the working space [9]. The authors of this project focused on providing an optimum comfort workspace for the operator when determining the locations of the active and passive zones. It was found necessary to allocate a field of vision in which the operator will receive the maximum quantity of information which will be analyzed to take correct steps. The developed configuration of monitors in combination with the service elements of a working zone while taking into account average anthropological characteristics of the operator (European 20-45 years old male) allowed to minimize quantity and frequency of movements of the operator in the course of operating this equipment (fig. 2).

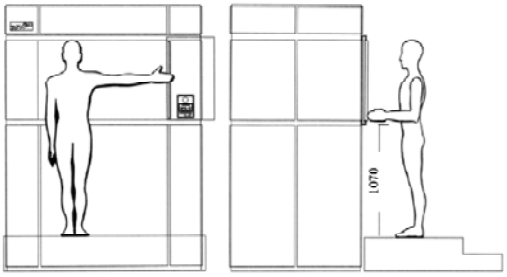

Fig. 2. Ergonomic zones of access

Taking into account rather massive size of a working zone a decrease in visual loading from large volumes was necessary. This was achieved by appropriate choice of proportions for cover panels, their thickness, dimensional harmony and quantity of elements in all locations of the work zone. Jointing of panels visually emphasized stability and integrity of composition, purity of appearance and simplicity of perception. A uniform shape and proportionality of all parts of the apparatus creates an image of the integral, complete product (fig. 3).

A choice of the optimum color environment is not accidental – it is a result of multiple objective factors [10]. Considering the high extent of technological process automation realized in the EIP of EPOL-6N series, visual attention of the operator is more directed towards perception of external color scale, rather than towards visual control of the occurring processes.

Application of a combination of light yellow and dark brown shades to the front planes of the apparatus is one of examples of the directed visual attention. The combination of these colors results in an interesting optical effect. Colors closely located on color scale supplement each other without creating the distracting contrast for the operator. A light tone of yellow color visually removes weight loading of large volumes, and dark tone of a framework defines steady fundamental nature of the whole composition.

Fig. 3. Prospect of the EPOL-6N installation

One important color nuance of the composition is in coloring of guides and levers near the window of a working zone. These elements of a design, as well as the operator console are two locations of the most frequent operator contact with the equipment. Therefore, the need for the opposite choice on the color scale of these elements is evident. In this case it is a light blue color. The contrast of a light yellow and blue color more specifically designates a location of the most operator effort in the work space.

«EPOL-6N» – the first series of the EIP apparatus which during design process organically absorbed the results of the creation of an appealing work space image. It allowed to lay the foundation of the corporate style of elemental composition or art and design imaging and the uniform color choices. An improvement in the esthetics of the apparatus was considered to be an inseparable part of the set of tasks directed to improvement in consumer interaction and competitiveness of this group of the processing equipment.

Design modeling was developed by means of a software package Pro/ENGINEER. Technological effectiveness of the design was analyzed by 3D- modeling. Optimization of the design durability of the bathtub and framework in EIP was carried out by Final Elements Method using software package ANSIS.

As a result of an integrated approach to development of processing equipment for EIP two apparatuses of the EPOL-6N, EPOL-6N-200 and EPOL-6N-500 series were designed. Appearance of the EPOL-6N-500 apparatus is shown in fig. 4.

EPOL-6N-200 and EPOL-6N-500 include the EIP equipment and the source of technological current. They can be completed with power sources of 63, 72, 100, 160 and 250 kW. The main technical characteristics of the EP0L-6N-200 and EP0L-6N-500 are given in tab. 1.

Distinctive feature of the EP0L-6N-500 apparatus is that for convenience of transportation and installation it is structurally executed in two sections – lower and upper. In the lower section located bathtub and systems for automatic maintenance of the set temperature and level of electrolyte. Heating of electrolyte is carried out by the electric heaters located in a bathtub with imbedded security system against current leaks.

In the top section the control unit located operator console, the suspension bracket drive executed on the basis of roller carriage by STAR, the transparent protective screen with the step drive and ventilation system. The control system is constructed using microprocessor equipment by SIMENS and includes the operator console with OR-7 panel, central processing unit S7-200 series, modules of analog input-output, a discrete output, the frequency converter and the power supply unit. Distinctive feature of a control system for the suspension arm is the use of the alternating current frequency converter allowing to carry out a «smooth» drive on/off switching and programmable speed regulation. This decision considerably reduces probability of losing grip on the finishing parts during their immersion in a bathtub and extraction from it, and also allows adaptive process control during polishing of large parts.

Fig. 4. General view of the EPOL-6N-500 apparatus

Table 1 – EIP Technical Characteristics

Characteristic	«EPOL-6N-200»	«EP0L-6N-500»
Installation type	Semi automatic	Semi-automatic
Power Sources, kW	160	250
Productivity lasting operation cycle of 6 min., m/h^2, no more	2,28	3,57
The area of the processed surface, m^2, no more	0,23	0,36
Electrolyte heating time, h, no more	1,0	1,0
Weight of a suspension bracket, kg, no more	20	20
Working volume of a bathtub, m^3	0,23	0,45
Abaritny sizes mustache tanovka, ShhGhV, mm	1644kh796kh1910	2140kh1205kh2550

Electric control is carried out by means of the control unit and operator console which are carrying out execution of the program and control of process parameters. Control system provides the following main functions:

- initial setting and regulation of the electrolyte temperature in a bathtub using PID controller;
- initial setting and control of the finishing time;
- tension control of the suspension bracket;
- current control of the suspension bracket;
- control and regulation of electrolyte level;
- control of electrolyte operating time;
- control of cooling liquid pressure;
- ventilation system control;
- control and diagnostics of emergency situations;
- control and operation of the protective screen drive;
- control and operation of the suspension arm drive;
- control and operation of the electrolyte cooling gate drive.

The control panel provides exchange of information between the central processing unit and the panel of the operator, displaying control information on the operator display screen, and also carries out a dialogue between the operator and apparatus. On the display screen it ti possible to view four windows: «Input of parameters», «Automatic mode», «Adjustment» and «Switching off». Programming of the operator panel is executed using software package of Pro Tool Pro CS.

A central processing unit accepts signals from sensors on starting position of the execution mechanisms and forms signals for their management, measures and regulates temperature and the level of electrolyte in a bathtub, measures the working tension and electric current in a power chain, and also carries out exchange of information with the operator panel. The central processing unit ensures functioning of apparatus in three modes: automatic, adjustment and automatic EIP switch-off. Programming of the central processing unit is executed using a software package of V 3.1 STEP-7 Micro WIN SP 1.

Software of a control system are stored in energy independent read-only memory storage unit. The system allows to have a set of the operating programs which are easily replaced using computer.

Conclusions

An integrated approach to development of processing equipment for EIP, and also an effective concept of automation and experience allowed to create a modern highly effective competitive processing equipment for EIP hi-tech products in Ukaine.

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Пономаренко А.М., Фенько І.І. Комплексна розробка технологічного устаткування для електроімпульсного полірування

Представлено комплексний підхід до розробки технологічного устаткування для електроіскрового полірування. Запропоновано ефективну концепцію автоматизації сучасного високоефективного та конкурентоспроможного технологічного обладнання для електроіскрового полірування високотехнологічних виробів.

Ключові слова: *комплексний підхід, технологічне устаткування, автоматизація конкурентоспроможний, високотехнологічний виріб, технологія електроімпульсного полірування.*

Пономаренко А.М., Фенько И.И. Комплексная разработка технологического оборудования для электроимпульсного полирования

Представлен комплексный подход к разработке технологического оборудования для электроискрового полирования. Предложена эффективная концепция автоматизации современного высокоэффективного и конкурентоспособного технологического оборудования для электроискрового полирования высокотехнологичных изделий.

Ключевые слова: *комплексный подход, технологическое оборудование, автоматизация высокоэффективный, конкурентоспособный, высокотехнологичные изделия, технология электроимпульсного полирования.*