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ANALYSIS OF THE EVOLUTION FACTORS AND REQUIREMENTS IMPOSED ON TECHNOLOGIES AND INSTALLATIONS OF SUPERFICIAL TREATMENT WITH ELECTROMAGNETIC FIELDS

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Abstract: *The article makes references and appreciations regarding the technologies of surface thermal treatments with electromagnetic fields and the specific treatment facilities. Their development has grown in recent years due to factors of an economic, technical and ecological nature. As such, the large construction diversity determines the classification of these facilities according to a large number of criteria, but a common requirement is the technological flexibility, in conditions of increased productivity and quality. The article also highlights the features of a superficial optical pulse treatment method used by one of the authors in an extensive experimental program.*

Keywords: **superficial thermal treatments, optical radiation pulses, productivity, technological flexibily.**

1. Introduction

The impressive global evolution of unconventional technologies at the production or laboratory level was only possible through the parallel research and development of the technological methods and processes, as well as the equipment necessary for their realization.

Due to the constantly changing dialectic nature of conventional and unconventional concepts, the technological methods and processes have gone through different stages, either from unconventional to conventional, or being at a stage where the two concepts are intertwined.

Unconventional technologies are considered the technologies developed on the basis of new principles or the conventional technologies applied in a modern or non-specific manner to conventional fields, with the reduction of materials and energy consumption, increasing the speed at which processes are carried out while reducing the number of technological phases and improving the product quality.

In unconventional processing, the working energy is in the form of electrical, chemical, electro-magnetic, electro-chemical, thermal, radiant, bio-chemical, etc., or their combinations, and is applied in a concentrated way in very short or relatively continuous impulses, at high energy levels.

Within this framework, a special place is occupied by the technologies and equipments meant to carry out superficial thermal treatments with electromagnetic fields.

Representatives from this point of view are the plasma installations, electron fluxes and lasers.

2. Factors determining the development of equipments and technologies for superficial treatments with electromagnetic fields

Classical thermal and thermo-chemical treatments require a great amount of

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working time, high energy and workmanship, subsequent mechanical processing, etc. In addition, a number of restrictions limit the applicability of these treatments: the complexity of the constructive form of the component parts, the application of the treatment in hard-to-reach areas of the parts, the local treatment of certain surfaces, etc. Some types of treatments pollute the environment.

The emergence of methods and processes of surface treatment with electromagnetic fields required the development of installations and equipments, which currently have the capacity to heat any type of piece or material, imparting to the parts characteristics of hardness, mechanical or chemical resistance, roughness, imposed by the construction and operation of assemblies and sub-assemblies within some cutting-edge areas of modern industry, such as car manufacturing, fine mechanics, electronics, automation, etc.

Thus, the following factors can be specified in determining the current and future development of the technologies and equipments of thermal treatment with electromagnetic fields:

• high accuracy of shape and dimension of the component parts;

• high mechanical and chemical resistance of the component parts;

• high productivity of thermal treatment technologies;

• high degree of automation and robotization of the working processes, some of which can be fully automated (laser);

• performing of local surface treatments without any thermal damage of the adjacent areas and ensuring a precise character of the processed surface;

• performing thermal treatments in hard-to-reach areas, difficult or impossible to carry out through classical technologies;

• low costs of processing;

• the short duration in the mechanisms of structural transformation of the material of the component parts;

• the running of working processes without any environmental pollution, etc.

The totality of these factors is closely interdependent with the current level of technological development, with the requirements of the competitive market, in order to give quality, reliability and maintainability to the component parts.

These desired goals can be achieved today with installations and equipments of thermal treatment with ultra-fast heating.

3. Types of equipments for superficial treatments with electromagnetic fields and the requirements they have to meet

The wide variety of technologies of thermal treatment with electromagnetic fields involves a wide range of installations and equipments, some of which are used only for surface or volume treatments while others can also be used for different technologies of thermal treatment of materials (cutting, welding, drilling, etc.).

Depending on the way of transmitting the energy to the surface of the parts, the sources for surface thermal treatments with electromagnetic fields are divided into two categories [1, 4, 6, 7, 8]:

I. External sources transmitting energy to the surface of the parts by radiation or convection, this category including the installations and devices with:

a) plasma;

b) electron beams;

c) ion beams;

d) photon beams (laser);

e) gas discharge lamps;

II. Inner sources, where the energy develops in the surface of the parts, being represented by:

a) resistive electrical heating by contact;

b) induction heating (CIF).

Depending on the heating speed of the superficial layer of the parts, the equipments for electromagnetic field treatments are divided into two groups [2, 3, 5]:

a) equipments for rapid heating (10^2-10^3 degrees/s);

b) ultra-fast heating equipments (> 103 degrees/s).

The cooling of the parts after the heat treatment in order to obtain the hardening structures is done in two ways. Correspondingly, there can be distinguished:
a) equipments provided with systems for cooling the parts in liquid medium (oil basins, water showers, water jets);
b) equipments for cooling the parts in the environment where the heating took place (air, vacuum).
According to the degree of technological flexibility, there can be distinguished [4, 6]:
a) equipments specialized on one type of heat treatment;
b) flexible heat treatment cells consisting of a treatment installation (processing center - the example of a two-head laser) and a handling subsystem (loading, unloading, transport);
c) flexible heat treatment lines, which are technological systems made up of several simple or multiple processing stations connected by an automatic transport system (robot).
The current state of technological development in the field of car manufacturing requires that the design and construction of equipment for the surface treatments with electromagnetic field is intended to meet the following requirements:

- loading/unloading operations be automated;
- allow reaching the required temperature in a very short time;
- • the temperature in the workspace be as uniform as possible and be adjusted with great precision; if necessary, vary according to a predetermined schedule;
- high thermal efficiency;
- high productivity;
- the occupied space be as small as possible;
- be as simple as possible, with convenient maintenance;
- ensure the protection of the environment and operators.

4. Possibilities of automation and integration of equipments of thermal treatments with electromagnetic fields in flexible lines of processing

The technological flexibility is the ability of a system to quickly and reliably adapt to different production tasks, both in terms of the shape and size of the product, and the technological process to be carried out, under conditions of increased quality and productivity, as well as economically advantageous.
The advantages offered by the modern thermal treatment lines consist in:

- high productivity;
- rigorous control of treatment parameters;
- superior quality of the treated parts;
- maximum automation;
- optimal working and maintenance.

The automation of the equipment within the flexible heat treatment lines addresses several aspects:
a) automatic measurement of parameters
The automatic measurement has the following functions: measuring the process dimensions, their remote transmission, indicating and recording them. These operations are performed according to the functional scheme shown in fig. 1.

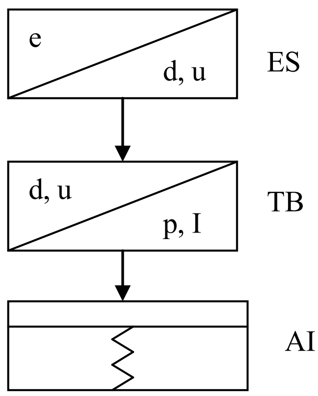

Fig. 1.The functional scheme of automatic measurement

The "e" size measured with the sensitive element ES recording the variation of this physical magnitude and transforming it into a "d" displacement or "U" voltage.

The parameter is fed into the base TB transmitter which converts it into a convenient form. In unified systems, this is the intensity I with values between 0 ... 50 mA (electrical systems) or P pressure with values between 0.2 ... 1.0 atm (pneumatic systems). At the same time, the basic transmitter amplifies this size of power to be transmitted remotely.
Finally, the indicator and recorder apparatus "I" again converts the output of the base transmitter into a fast or ultra-fast recording signal, such as the amplitude of the acoustic wave (oscilloscope), the electric field intensity (micro ammeters), the electromagnetic spectrum (pyrometers), etc.
The automatic measurement of temperature is made with sensitive elements, such as thermocouples, heat resistors, pyrometers, etc.
The automatic measurement of the fluid flow (gas, cooling water, etc.) is realized with the following types of flow meters: variable pressure drop, constant pressure drop, acoustic, electromagnetic, etc.
The automatic measurement of the pressure in the fluid pipes, in different installations and enclosures is done with manometers and vacuum cleaners.
The automatic determination of the chemical composition of the gases is determined by spectrophotometers.
The automatic measurement of the angular position of some mechanical parameters is done with selsins, which convert the angular displacement into electromagnetic force that they transmit at a distance, and the measurement of the rotation speed is generally done with electrodynamic transmitters (tachometers).
Other parameters specific to thermal treatments are added to these basic parameters of the technological processes.
b) automatic control of the equipments
The equipments for surface thermal treatment with electromagnetic fields have control elements for positioning the parts during processing (support tables), for moving the working heads (plasmatron, laser head) etc.
Their displacement is achieved along the axes (X, Y, Z), usually by means of a servomotor controlled by a control unit. The motor moves the support table or work head so that the piece is conveniently positioned, observing the working position of the electron beam, laser or plasma jet, depending on the information in the computer.
c) controlling the equipment and thermal treatment lines with the computer.
The automated complexes of thermal treatment include a top-level computer designed for adaptive programming and routing of all component systems: transportation and concentration of work energy, routing of the technological station and the robot, the corresponding network, etc.
d) automatic adjustment of the working regime
The flexible thermal treatment lines provide a self-regulation of the electro-technical parameters. For this, different energy components are used as reference data, such as:
- the electron beam current, namely the backscattered electron current;
- the current taken over by the piece and the penetration current - in the case of electron beam treatments;
- the intensity of the current in the plasma jet;
- the plasma gas flow - in the case of plasma jet treatments;
- the laser beam power;
- the intensity of the radiation distributed on the surface of the piece;
- the duration of the impulse;
- the duration of irradiating the piece in continuous processing;
- the physical-optical properties of the material of the piece - in the case of laser treatments.
Based on the processing of the reference data, the control system intervenes in the process by acting on the beam or jet power, on its focusing and on the working speed.

5. Conclusions

The functional and constructive complexity of the flexible lines involves the solving, in the design process, of the various categories of problems, not only technical but also economic-organizational. Thus, the issues related to designing flexible lines consist in:

a) Establishing the line functioning:

- in terms of quality - line precision, quality of parts, reliability;
- in terms of quantity- hourly production, line flexibility;

b) Determining the line characteristics:

- of design - degree of innovation, degree of typification, modularization of the construction;
- of exploitation - the degree of automation, the size, the maximum weight of the parts;

c) Establishing the line structure:

- designing or choosing (from existing projects) the technical means for all component subsystems;

d) Determining the optimal line configuration (Architecture):

- location of the technical means of the component subsystems.

The realization and implicit introduction of these flexible lines in the productive practice, as well as their automation has the following effects:

- *Technical-economic effects:*

- Increase in productivity ;
- Reduced cycle for the processing of pieces;
- Reduction of the space consumed in the section as a result of the increased productivity and the significant decrease in intermediate stocks;
- Minimization of pieces through rejected pieces as a result of the introduction of the automated control system within the flexible line;
- Low energy consumption.

- *Social effects:*

- Ergonomics and workplace comfort. The successes of introducing new techniques and technologies result from the interaction of technological, economic, organizational and psychological factors. Robust, monotonous, repetitive operations are avoided, physically demanding for the worker in particular, introducing operations that highlight the operator's creative potential and stimulate his own initiative;
- Multiple qualifications, increasing the level of staff qualification. The automation of a number of basic, auxiliary and service activities leads to a decrease in the number of operators directly involved in the process, along with the substantial increase in the nomenclature of the professions involved. It substantially increases the level of engineering activities in the realization of projects and their execution, in the development of programs.

- *Scientific effects:*

- Flexible systems have created and developed an entire industry of programs for ordering industrial machinery and robots, for constructive and technological design, for controlling, launching and tracking manufacturing, for economic management, and for computer-assisted production.

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