ALTERNATIVE SOURCES FOR TREATMENTS WITH ELECTROMAGNETIC FIELDS BASIC PARAMETERS FOR THE CHOICE OF THE SOURCE TYPE

Ioan VIRCA[1], Victor NEDERITA[2]

ABSTRACT

The development and the perfecting on a large scale of the electromagnetic sources for the various thermal processing of metals (cutting, welding, piercing, etc), as well as the achieved results and the technical-economic advantages permitted the use of the respective sources and in applications of superficial treatings or in volume. A vast domain within the field these electrotechnologies is held by the processings that have the plasma, the electron fascicles and the photon fascicle (the laser). The present paper studies the adoption of new alternative sources from the same energy class as the ones mentioned above, that is the impulse discharge lamps and we try to analyze the main parameters that influence the choice of the source type in order to make certain superficial processings.

KEYWORDS: *impulse discharge lamps, electromagnetic fields, alternative sources*

1. INTRODUCTION

One of the fairly recent applications of the technologies of thermal processings with electromagnetic fields is represented by the superficial treatings done on metal parts. The results showed the great energetic and technological possibilities of the concentrated energy sources, especially in the case of lasers and of electron fascicles.

The respective sources can be classified according to more criteria like the way of transmitting the energy on the surface of the piece, the heating rapidity of the superficial layer of the pieces, etc., the most used sources being the following [1]:

- Heating by high frequency current induction;
- plasma;
- electron fascicles;
- photon fascicle (laser).

Due to the ever growing level of the constructive-functional requirements needed for the pieces used in the automotive domain, the purpose is to design and find sources for the superficial treatings with elecromagnetic fields to have the following characteristics:

a) the temperature in the working space should be as uniform as possible and it should be possible to adjust it with great accuracy and, when needed, it should vary according to a pre-established schedule;

b) it should allow the reaching of the imposed temperature in a very short period of time;

c) the occupied space should be as small as possible;

d) great thermal efficiency;

e) great productivity;

f) it should have a simple construction;

g) it should necessitate reduced maintenance;

h) it should ensure the protection of the surrounding environment and of the operators.

i) It should allow the automatization of the loading-unloading operations, etc.

The lasers present a particular interest due to the great energetic and technological possibilities, because they are sources that emit coherent electromagnetic radiations. Their construction can have the most diverse typology from the existent energetic sources. One of the important components of lasers is represented by the impulse discharge lamp, having the role of a source that achieves the optical pumping for part of the lasers with an active solid or gaseous element.

These impulse discharge lamps represent the alternative sources of energy chosen for the present study.

2. THE GENERAL PRESENTATION OF IMPULSE DISCHARGE LAMPS

The lamps in this class have the following common features [2]:
a) The discharge tube is made of quartz, having an extension at both ends through which the metallic strips that connect the power source and the electrodes are inserted;
b) A pair of electrodes set at little distance one from the other;
c) The high luminescence of the discharge space, which leads to an internal pressure of several atmospheres and to a temperature of the tube of approximately 900ºC, and due to these we understand the necessity of taking safety measures when using these lamps;
d) The necessity of an setting in voltage of the discharge and of a charge resistance that should limit the functioning current of the lamp at nominal value;
e) The functioning of the lamps in conditions of absolute hygiene and at nominal parameters in order not to shorten their life cycle.
The impulse breakdown lamps differ from other radiant sources by a high level of luminosity and a high intensity of the radiant energy. The means that lightens is the plasma that is formed when the neutral gas that is placed between the electric electrodes penetrates. The voltage at the terminals of the electrodes is formed at the discharge of a block of condensers of high voltage. These lamps, which are some balloons of melted optical quartz and which allow an irradiation in a wider range of wavelengths (λ=200÷1000 nm), were studied at a pretty high level and are ensured with electronic apparatuses of advanced conducting and functioning, at the same time fulfilling the main conditions required by the a thermal processing [3]:
a) short periods of irradiation, $\tau = 0{,}1\cdot10^{-6}$ s ÷ $0{,}5\cdot10^{-3}$ s;
b) high intensity of the radiant flux, $E = 8\cdot10^{4}$ J;
c) wide interval out of which in the in the optical spectrum: λ=200÷1000 nm;
d) high energetic efficiency, η = 70%.
These lamps have a high efficiency of transforming the electric energy into radiant energy. The loss of energy when heating the lamp gas, its electrodes and when irradiating, absorbed by the quartz wall of the lamp balloon, that is the irradiation with waves with a length lower than 180 nm and greater than 3500 nm, does not exceed 25% of the energy that enters the lamp [4].
The lamps can be filled with neutral gases (Xe, Ar, Kr, Ne) or with mixtures of these. They are usually filled with xenon, because it ensures superior performances of the light emission and of the irradiation compactivity, these characteristics being in close connection with the low potential of ionization of this gas and the big atomic weight. As thin sheet of molybdenum is used as a current inductor which is stuck, in vacuum on the quartz ends of the lamp. Due to the fact that the sheet has a high ohmic resistance, part of the energy is lost for this resistance, thus there can appear conditions that can lead to a melting of the sheet on a certain portion and to the destruction of the integrity of the quartz balloon or to the interruption of the electric contact.
In the case of impulse construction lamps with lids, these represent simultaneously exterior contacts, current inductors and conductors of the functional electrodes. The resistance of the lids is extremely low, but their thermal stability depends on the particularities of the components with which the walls of the quartz tubes are stuck.
The impulse lamps can have the following geometrical shapes (fig. 1): spiral, coaxial, tubular, U-shaped.

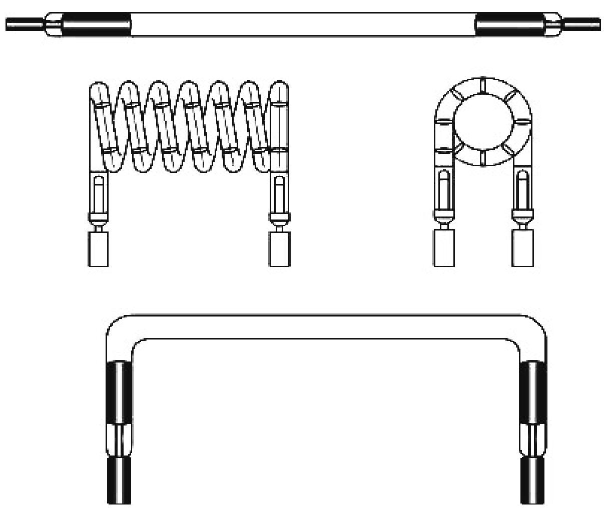

Fig. 1. The geometrical shapes of the pulsed pamps

In the present constructions tubular lamps are more widely spread. They use lamps whose electrodes have the length varying from 40 mm up to several meters, with the interior diameter of the tubes from 2 up to 30 mm. The optimum pressure of the xenon from the impulse lamps, which can be used with separate impulses, is between the limits 300-600 mm barometric column.

3. BASIC PARAMETERS UTILIZED FOR THE CHOICE OF THE RADIANT SOURCE TYPE

The basic electric parameter is the working voltage of the supply that is limited at the limit inferior by the ignition voltage U_a, and at the limit superior by the self-breakdown voltage U_s. For some small diameter lamps the discharge extinction voltage U_{st}, is also relevant. When the impulse energy is insignificant, when the discharge channel does not dilate on the whole section, U_s becomes comparable with U_a. For the big lamps, with a large discharge tube, at sufficient energies for the filling of the section with plasma, the value $U_s << U_a$, that is the size U_s can be neglected.

Another important electric parameter is the ignition voltage. The ignition impulse is adjusted for the forming of the ion plasma between the lamp electrodes, which possesses a certain conductibility through which the main strong discharge takes place. The characteristics of the ignition impulse, the amplitude of the maximum signal (when the high frequency impulse appears) and its duration, are described in the manual of every lamp. An important role for the elaboration of the lamps that work continuously is played by the voltampermetric characteristics. The same characteristics are important when designing correctly the ignition diagrams, especially of the diagrams for the arcs and for the prevention of the situation of continuous arc of impulse lamps. These qualitative characteristics are typical for most gas discharge lamps. For the portion in the interval of maximum and minimum values of standardized current density from 100 up to 10000 A/cm^2 the following specific resistance dependence of the lamp ρ_l with impulse of current density j [3]:

$$\rho_l = 1{,}15 \cdot j^{-0{,}5}\,[\Omega\text{cm}] \qquad (1)$$

The corresponding formula for the lamp resistance according to the instantaneous value of the current will be:

$$R_l = 1{,}3 \cdot \frac{l}{d} \cdot i^{-0{,}5}\,[\Omega] \qquad (2)$$

in which l is the distance between the electrodes of the lamp; d – the interior diameter of the lamp. According to the experimental data [3], when j= 1000÷8000 A/cm^2, the expression:

$$\rho_l = (0.8 \div 0{,}9) \cdot j^{-(0{,}55 \div 0{,}50)} \qquad (3)$$

corresponds to the dependence of the specific resistance on the current density. And when the current density j=9000÷15000 A/cm^2, the resistance specific to plasma depends on the current density. Because when the current density increases the specific resistance of the lamp decreases, the maximum charging regime will correspond to a certain impulse length; when this is surpassed the lamp can stop functioning. As a criterion for the appreciation of the lamp charge we can use the electric power corresponding to an irradiation surface of the lamp. In [3] it is shown that in the big section lamps the specific power will be higher than in the small section lamps, at the same current density. That is why, in order to achieve equal conditions for the dissipated power, the maximum density of the current must be lower when the lamp diameter is increased and, correspondingly, the specific resistance must decrease. Concordantly with the data obtained in an experimental way having in mind the purpose of determining the parameters of the maximum charging regime in the case of diverse section lamps, one can conclude that the minimum specific resistance of the lamps must increase by 0,0068 Ω·cm for every centimeter the diameter of the lamp increases:

$$\frac{\Delta \rho_{l\,\min}}{\Delta d} = 0{,}0068\ [\Omega\text{cm/cm}] \qquad (4)$$

For the impulse lamps, having an interior diameter of 0,7 cm, the minimum admitted resistance is 0,014 Ω·cm at the impulse length, specified by the technical conditions of the lamp. Knowing the minimum specific resistance with a small section, one can determine ρ_{min} for the big section lamps, for example for IFP-20000 lamps (d=1,6 cm):

$$\rho_{l\,\min} = 0{,}014 + (1{,}6 - 0{,}7) \cdot 0{,}0068 = 0{,}20$$

[Ω·cm] (5)

When utilizing the impulse lamps there appears the acute problem of viability. The value of the impulse energy has a considerable influence on the viability, to be more precise, the ration between the working energy E and the lamp energy E_{lim} that it can stand. The ratio E/E_{lim} is called charging coefficient. The limit superior of energy is established by the dimensions of the lamp, the duration of the impulse, established through the ratio of the parameters of the discharge electric circuit:

$$E_{\lim} = 1{,}2 \cdot 10^{4} \cdot d \cdot l \cdot \tau_i^{0,5} \quad (6)$$

in which E_{lim} is expressed in J; d in cm; l in cm; τ in s.

The ration between the exploitation period of the lamps and the charging coefficient, according to the data [3] is presented in table no 1.

Table 1

E/E_{lim}	The number of impulses
1,0	0 –10
0,7	10 -10^2
0,5	10^2-10^3
0,4	10^3-10^4
0,3	10^4-10^5

The greater the lamp productivity, the lower the part of energy radiated by the lamp form the total amount of accumulated electric energy. The decrease of radiated energy is conditioned by the increase of the losses in the construction elements of the lamps. As an effect of erosion on the interior surface of the lining of the lamp, deposits of micro impurities are formed which in the end lead to a decrease of the transparency of the balloon of the lamp and to the continuous increase of losses.

The products of the erosion of the electrodes plays an important role in the destruction mechanism of the balloon wall, especially for the high power lamps. One of the causes of lamp destruction, simultaneously with the thermal effect and the erosion action, can be the shock wave (at the average speed of current increase which is higher than 100 A/μs). The technical conditions are given as viability criteria for the impulse lamps, usually the admissible limit superior– the ignition voltage and the admissible limit inferior - the minimum limit of impulse irradiation.

When choosing the type of lamp and establishing their quantity one has to take into consideration the type of the irradiated material and the necessary output parameters, after which the necessary value of the radiation energy and the composition of the spectrum are established.

It is often necessary to use more lamps connected in series or in parallel. Choosing the connecting diagram of the lamp in each concrete case is established by the conditions coordinated by the lamp discharge with the accumulator, taking into account the losses of energy on the interior resistances and on the connection cables.

The experimental data [4] show that the transformation of the energy deposited at the condensers into radiant energy has a higher efficiency when connecting the lamps in series as compared to their connection in parallel. The cause of the decrease of the efficiency in the second case (1,5 times), is the redistribution of the useful energy and the energy of the losses in the area of the increase if the losses in the external circuit of the lamp.

4. CONCLUSIONS

The most important parameters of the impulse discharge lamps, which are used when calculating the electric diagram of the irradiation of metals are: the energy of the impulse ; the working voltage; the frequency of impulses; the minimum duration of the impulse; the duration of exploitation; the

ignition voltage; the self-breakdown voltage; the capacity of the accumulation condensers; the distance between the electrodes and the internal diameter.
The impulse discharge lamps present a series of advantages as compared to the sources of coherent radiations, in the composition of which elements of optical pumping, i.e. lasers, are used:
a) the efficiency of transforming the electric energy into radiant energy is approximately 50-70%, as compared to 1-3% for lasers;
b) technological possibilities of processing real surfaces of bigger dimensions as compared to the laser;
c) possibility of processing irregular geometrical surfaces easier, taking into account the fact that the source can be made under adequate geometrical shapes;
d) it presents foreground technological compatibility as compared to lasers, due to the complexity of the integration of lasers in the industrial technological processes;
e) it does not necessitate specially qualified personnel;
f) it does not pose a danger for the working personnel and as such it does not necessitate special norms of labor protection technique.

SELECTIVE REFERENCES

[1] N. POPESCU, C. GHEORGHE, O. POPESCU, *Tratamente termince neconventionale*, Editura Tehnica, Bucuresti, 1990.
[2] www.heraeus-noblelight.com
[3] Victor NEDERITA, *Studii privind imbunatatirea operatiilor si a instalatiilor din industria alimentara prin utilizarea impulsurilor ultrascurte de lumina de intensitate inalta,* Teza de doctorat, Galati, 1995.
[4] Б. Р. БЕЛОСТОЦКИЙ, Ю. В. ЛЮБАВСКИЙ, В. М. ОВЧИННИКОВ –*ОСНОВЫ ЛАЗЕРНОЙ ТЕХНИКИ.* Москва, Советское радио, 1972.

AUTHORS

1. Eng. Ioan VIRCA, Land Forces Academy Sibiu, Romania, virca_ioan@yahoo.com, 0724-289384
2. PhD. Victor NEDERITA, Lucian Blaga University Sibiu, Romania, Ned_vic@yahoo.com, 0745-329291