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The Influence of Some Factors on Maximum Depth in Electrohydraulic Forming

The paper presents the results of the author`s experimental research concerning the influence of discharge voltage of condensers battery, condensers battery capacity, discharge axis - plate distance and electrode gap on the shock wave maximal pressure and, implicit, on maximum drawing depth which can be realized to the plate, in the case of electrohydroimpulses drawing in the high voltage domain, between 20...50 kV, in a cylindrical universal discharge chamber. Are presented some considerations regarding the influence of gas bubble pressure.

Keywords: *drawing depth, electrohydraulic forming, voltage, distance*

1. Introduction

Electrohydroimpulses drawing is based upon the so-called technique of high energies-bearing impulses. Are known studies being done on the parameters which influences the size and the distribution of pressure in discharge chamber, for discharge voltages under 15 kV. But for high voltages, the studies are in small number and, in a large measure, incomplete or contradictories.

From this reason, for discharge voltages between 20…50 kV, has been examined those parameters which are considered to be of great importance from technological point of view and which, due to the construction of the deformation equipment, can be set in certain limits. Nevertheless, working in both mono and multiimpulse regime, these parameters are:

- the charge voltage of condensers battery;
- the condensers battery capacity;
- discharge axis - plate distance and electrode gap;
- the material, the diameter, the length and configuration – planar or spatial – of the exploding wire;
- the material, the geometry and the diameter of the used electrodes.

Present paper wishes to study the dependence of shock wave front maximal pressure on the parameters listed on the first three above points.

2. Experimental research

In some of the author's previous papers [1,2] had been presented the construction parameters of the own designed universal discharge chamber used in the experiments and also, of the electric system whereon the chamber was coupled (russian origin, model GIT 50 – 5x1/4C). A general view of the discharge chamber is presented in fig 1. The sensing device system for the shock wave front pressure measurement was also designed and manufactured by the author (fig. 2).

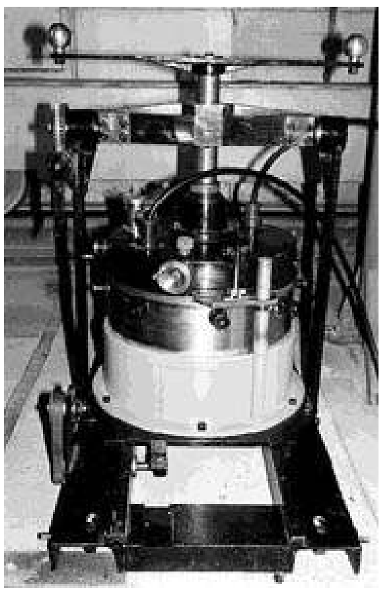

Figure 1. General view of the discharge chamber

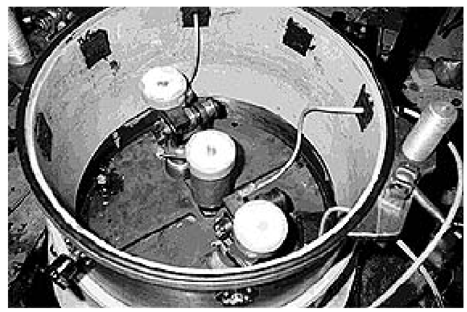

Figure 2. General view of the sensing device system for the shock wave front pressure measurement

The variation of shock wave pressure relative to discharge voltage of condensers battery was presented in fig. 3 and 4, for different combinations of discharge circuit parameters, to a capacity equal with 8 μF (where **h** - discharge axis - plate distance; **l** - electrode gap; $\mathbf{U_0}$ - discharge voltage of condensers battery through spark discharger; $\mathbf{P_{us}}$ - shock wave maximal pressure; **C** - the condensers battery capacity; there were is no specification, the indicated dimensions for **h** and **l** are given in mm).

In fig. 5 are presented the dependence diagrams of pressure related to the discharge voltage, for three values of condensers battery capacity. The capacity was modified by conecting or disconecting some groups containing two condensers from the generator unit.

The dependence of pressure related to the discharge axis – plate distance h, is presented in fig. 6 and 7, for different values of discharge voltage and electrode gap.

In fig. 8 and 9 are presented in comparision the pressures on shock wave and gas bubble, for two values of the charge voltage of condensers battery. The experiments [1] shown that, at increasing of voltage, to the same values of electrode gap, the pressure of gas bubble tend to be equal to that of shock wave. This explains [1,3] the intense increasing of the maximum drawing depth values, for distances h ≈ (1...1,3)· l.

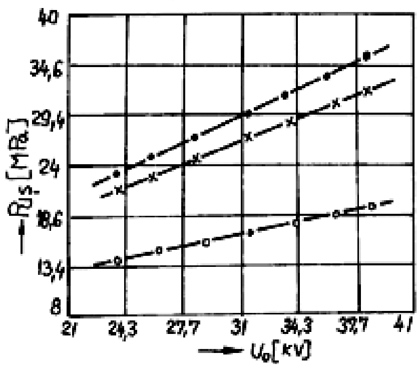

Figure 3. The variation of shock wave pressure relative to discharge voltage of condensers battery.
h = 200; • l = 50; ° l = 35; x l = 80

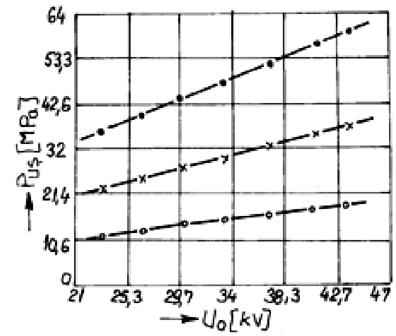

Figure 4. The variation of shock wave pressure relative to discharge voltage of condensers battery.
l = 40; • h = 90; ° h = 250; x h = 160

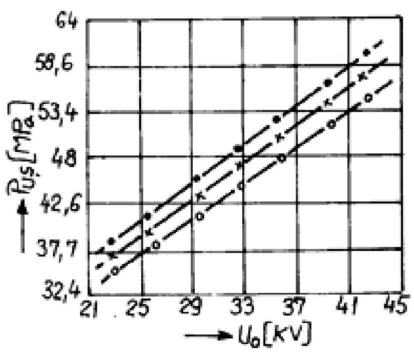

Figure 5. The variation of shock wave pressure relative to discharge voltage of condensers battery.
h = 80 mm; l = 50 mm
• C = 8 μF; ° C = 4 μF; x C = 6 μF

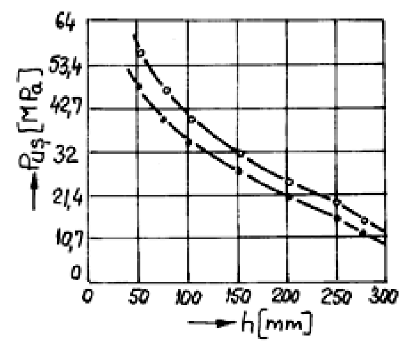

Figure 6. The variation of shock wave pressure relative to discharge axis – plate distance.
l = 50 mm; • U_0 = 23,6 kV; ° U_0 = 30 kV.

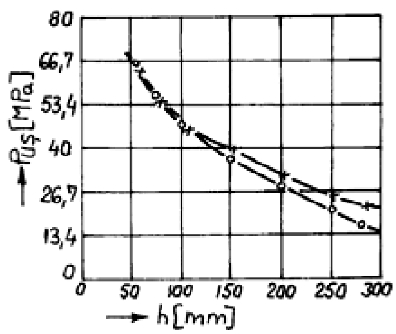

Figure 7. The variation of shock wave pressure relative to discharge axis – plate distance.
U_0 = 36,4 kV; • l = 65 mm; ° l = 50 mm

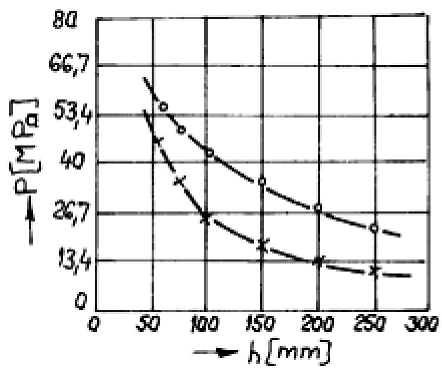

Figure 8. The variation of shock wave pressure relative to discharge axis – plate distance.
l = 60 mm; U_0 = 33,2 kV; ° shock wave; x gas bubble

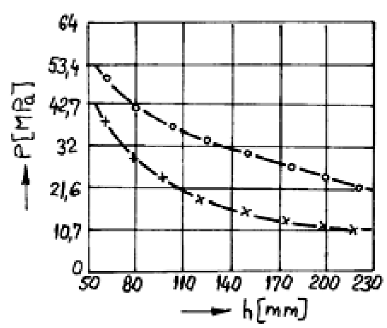

Figure 9. Variaţia presiunii undei de şoc în funcţie de distanţa dintre axa descărcării şi semifabricat.
l = 60 mm; U_0 = 28,4 kV; ° undă de şoc; x bula de gaz

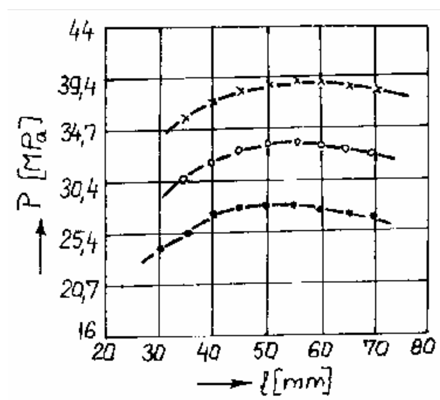

Figure 10. Diagram **P = f (l)**.
h = 140 mm; • U_0 = 23,6 kV; ° U_0 = 30 kV; x U_0 = 36,4 kV.

3. Conclusions

The experiments pointed out that, in a large measure, the rules from low voltages keeps their validity in the domain of high voltages, but for all that, some differences occurs. The passage below try to point only some of these differences.

As can be observed in fig. 3 and 4, the variation of pressure related to discharge voltage is quite quasilinear for the considered domain of voltages, although in certain conditions, it could differs from this rule. Thus, these deviations occurs for short electrod gaps and higher voltages ($l < 30$ mm and $U_0 > 30$ kV), because the discharge is approaching to the short-circuit regime, and also in the long electrode gaps domain and lower voltages ($l > 80$ mm şi $U_0 < 25$ kV), due to high dissipation of energy in the "pre-lider" stage (spark development). From this reason, the calculus relations for the pressure presented in paper [1] must be carefully applied, being necessary to identify the causes of likely differences bigger than those given by the recommended correction coefficient.

Regarding to the dependence in fig. 5, it is to be noticed that, when the capacity is modified than, in an implicit way, is also modified the discharge circuit inductance, due to the modification of that component linked by the own inductances of the condensers. Anyway, for the chosen values domain of capacity, the pressure dissipation due to capacity decreasing prevails on the pressure rise due to decreases of discharge circuit global inductance.

For the variation of pressure related to the discharge axis – plate distance h, presented in fig. 6 and 7, it is to be noticed a higher influence of voltage modification in comparision with the influence of electrode gap, on the pressure in shock wave. The influence of electrode gap is much stronger at long h distances, due to the modification of shock wave front shape and to a quick attenuation of pressure at lower values of electrode gap l. Related to this last aspect, it is to be noticed the nature modification of the electrode gap influence in the case of high voltages, reported to the nature presented in the case of relative low voltages - where the pressure follows more quickly the modification of this parameter. Also, it is to be noticed the quasilinear variation of pressure on shock wave front, for values $h / l = 1…2$, this leading to the conclusion that, in the values combinations domain of electrical and geometrical parameters, interesting from the maximum technological effect point of view, is possible to find some polynomial mathematical models in order to predict the values for pressure, maximum drawing depth and drawing part shape.

Regarding to the variation of pressure relative to electrode gap l it is to be noticed that also in this domain of high voltage exists optimal values of l, for which both drawing depth and pressure has maximal values. But, due to slow dependence of the pressure on distance l, the conclusion is that, from technology point of view, is more adequate to speak about a domain of optimal values instead of a determinate, unique value.

The experiments performed in parallel to determinate the influence of the same parameters on pressure obtained on shock wave front [1] proved that influence of l distance is more important at high h distance, due to the modification of shock wave front shape and quickly decreasing of pressure at lower l distances.

In order with this last aspect, it is to be noticed the modification of the influence character of electrode gap at high voltage, by comparison with that presented to the lower voltage, where pressure follows more rapidly the variation of this parameter.

In conditions of constancy of the others parameters values, both increasing voltage and increasing discharge axis-plate distance has like effcet increasing of optimal electrod gap. It is to be mentioned that this optimal value can be hardly reach, due to the correlations of this three parameters: voltage - electrode gap - discharge axis-plate distance and to a double restriction for the electrode gap. So, working with high voltage impose to choose long electrode gap (to avoid discharges in short-circuit regime) but, in the same time, low distances between discharge axis and plate leads to even lower electrode gap (to avoid contour discharges).

References

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