THE METHOD OF THE DISCHARGE CURRENT INCREASE IN SUB-MJ PLASMA FOCUS

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The analysis of experimental data of last years received on mega-joule plasma focuses shows, that falling of growth of a neutron yield in this range of energy is accompanied by falling of growth of a current. In this work the ways of current increase are considered, and also the rather inexpensive method of the current increase on already existing installations is offered

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INTRODUCTION

In our recent works [1,2] it was shown that the observable neutron yield saturation of Plasma Focus (PF) at MJ level is connected with current saturation and the current neutron scaling ($\sim I^4$) continues to be carried out in this range. For this range of stored energy the dependence between the maximum current [A] and the main parameters of discharge were determined:

for Mather type of PF:

$$I_{\max} \approx 30Ur/\Delta, \qquad (1)$$

for Filippov type:

$$I_{\max} \approx 10^8 U/V_h, \qquad (2)$$

where: U – operating voltage [V], r – anode radius [cm], Δ – anode-cathode gap [cm], V_h = h/t – the speed of the pinch length increase during the radial movement of the current sheath (t – a quarter of discharge period, h – pinch length) [cm/s]. These dependences agree satisfactorily with experimental data received at the installations PF-1000 (IPPLM), 1 MJ Frascati and PF-3 in Kurchatov Institute. The main result of (1) and (2) is: in the MJ range of energy the current amplitude depends on operating voltage, but not on stored energy in capacity bank. This conclusion is shown on Fig.1 for parameters close to installation PF-1000.

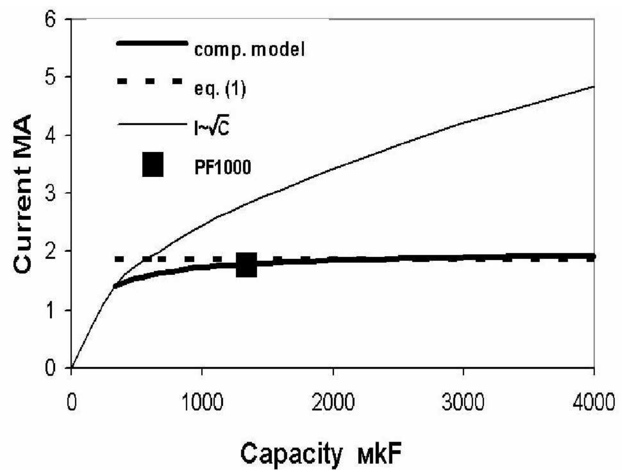

Fig.1

DISCHARGE EQUIVALENT ELECTRICAL CIRCUIT

In view of importance of the above conclusion we show one more way of deducing of equations (1, 2). Let's start with the general equation of an electric circuit (Fig.2) of the discharge:

$$\frac{dLI}{dt} + IR = U_0 - \int_0^t Idt/C\,. \qquad (3)$$

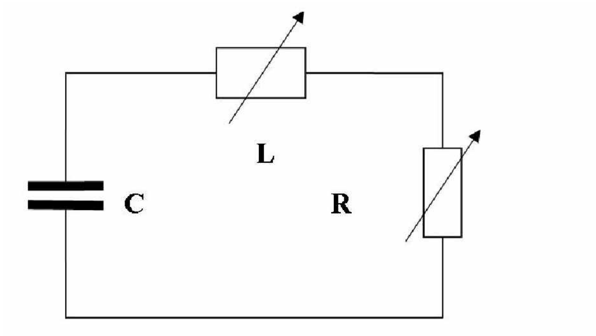

Fig.2

We suppose that in mega-joule range the capacity of battery C→∞; also we neglect ohmic resistance of the discharge R→0 at the run-down phase, in the end of which the current is close to a maximum. Then the equation (1) takes the simple form:

$$\frac{dLI}{dt} = U_0\,. \qquad (4)$$

In the linear approximation of the current and the inductance the amplitude of the current is:

$$I_0 = U_0/2\pounds\,. \qquad (5)$$

Inductance of the discharge in the mega-joule range, obviously, is defined by pair: current shell – chamber. So, $L = 2l\,ln(R/r)\cdot 10^{-9}$. For the Mather type installation l is the length of the way passed by the current sheath along the anode, R is cathode radius, r is anode radius. For Filippov case l = h which is height of the current sheath, R is the same and r is the neck radius. For Mather type at the run-down phase:

$$\pounds = 2V_z \ln(R/r) * 10^{-9} \approx 2V_z r/\Delta * 10^{-9},$$

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$\Delta = R - r << R$ and we get eq.(1) at usual V_z~10^7cm/s. For Filippov type ln(*R/r*) = 2 - 4, then $\hat{E} \approx 5V_h$ and we get Eq.(2).

DISCUSSION

Equations (1), (2) are interesting to that in an obvious view show the ways of the current increase:

-by voltage increasing;

-by reduction of the gap between electrodes;

-by decrease in height of current sheet.

In the last case it speaks that so called “X-ray regime” of Filippov type plasma focus, when the current sheath slides along the anode surface, is more preferable.

For Mather type installation “Poseidon”, “Speed” the increase of voltage does not give remarkable results; probably, it is connected with the high ratio of energy to the surface area of the insulator [3]. For the Filippov type, with the larger surface of an insulator, such experiments were not known.

PROPOSAL

In this work the method of the increase of the discharge current of sub-MJ PF "TYULPAN" in Lebedev Physical Institute is proposed. The main idea of the method is that the traditional formula of calculation of the discharge current amplitude

$$I_0 = U_0\sqrt{C/L} \qquad (6)$$

does not work, as the current ceases to depend on capacity of the battery, see Eq. (1), (2).

So let’s increase twice the operating voltage by dividing capacity bank on two equal parts. Each part is connected to the electrodes of plasma focus with opposite polarity, see Fig.3. The operating voltage is increased twice, the discharge inductivity increases also, but slightly, as it is basically determined by the collector inductivity. This method leads to the considerable increase of total current. Moreover, because the capacitance of the condenser bank decreases in 4 times, so it is possible to reduce diameters of the anode and discharge chamber accordingly, that is important for great sizes of Filippov installation.

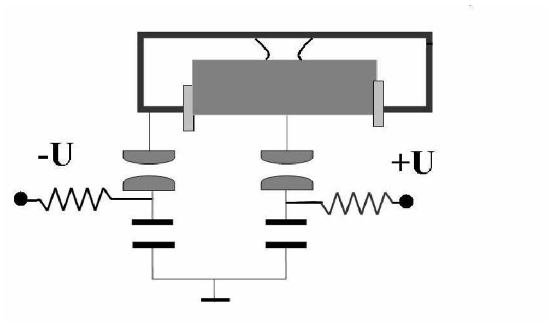

Fig.3

CONCLUSIONS

Now the transition of a parity (6) in (1), (2) with growth of capacity is not analyzed in details It is necessary to lead computer calculations to define expediency of such offer for the given power of installation. Let's notice, that for more powerful installations, like PF-1000 (Poland), a profit on a current should be more significant.

ACKNOWLEDGEMENTS

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СПОСОБ ПОВЫШЕНИЯ ТОКА РАЗРЯДА МОЩНОГО ПЛАЗМЕННОГО ФОКУСА

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Анализ экспериментальных данных последних лет, полученных на мегаджоульных плазменных фокусах показывает, что падение роста нейтронного выхода в этом диапазоне энергии сопровождается падением роста тока установок. Рассмотрены пути повышения тока, а также предложен сравнительно недорогой способ увеличения тока на уже существующих установках.

СПОСІБ ПІДВИЩЕННЯ ТОКУ РОЗРЯДУ МОГУТНЬОГО ПЛАЗМОВОГО ФОКУСА

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Аналіз експериментальних даних останніх років, які отримані на мегаджоульних плазмових фокусах показує, що падіння росту нейтронного виходу в цьому діапазоні енергії супроводжується падінням росту струму установок. Розглянуто шляхи підвищення струму, а також запропоновано порівняно недорогий спосіб збільшення струму на вже існуючих установках.