electromagnetic acceleration of plate liners at high current density and related phenomena

V.P. Bahtin1, M.P. Galanin2, E.V. Grabovskiy1, N.M. Efremov1, A.M. Zhitluhin1, M.K. Krylov1, A.P. Lototskiy1, A.S. Rodin2, Y.N. Sulimin1, and G.N. Homutinnikov1

1Troitsk Institute for Innovation and Fusion Research, Troitsk, Moscow oblast, Russia  
2Keldysh Institute of Applied Mathematics, Russian Academy of Sciences, Moscow, Russia

In the thermonuclear experiments with adiabatic compression of plasma the open edges of the cylindrical liner are used for filling of volume with deuterium plasma. At the same time in Z-pinch configuration with the fixed ring contacts a high electrical currents with value up to 10 MA flow through these edges. Under the magnetic field pressure of the longitudinal electrical current the cylindrical liners should shrink toward the center with radial speeds of 4-6 km/s, keeping full tightness and conductivity. The specified conditions demand the profiling of liner thickness near the ends of compressing area. Thus it is desirable to minimize the length of the edge with transitional section as it is excluded from the main process of plasma compression.

In view of rather wide range in which the power of experiment on plasma compression varies, and respectively, the entry conditions, electrical currents and the sizes, it is desirable to have rather reliable settlement tool for the design of the liners. The calculations programs for the central part of the liner are developed and are widely used. To create algorithms and calculation programs for the optimization of the transitional area, the experiments with the tape liner with the density of the current up to 200 kA/cm were carried out. In these experiments at excess by current of the critical value of 400 kA the longitudinal stratification of a metal aluminum shell on 2 independent parts was revealed. The similar mode at acceleration of the copper liner led to more difficult picture of splitting of conducting covers. The division mechanism which is indirectly confirmed by calculations is discussed.

In the series of experiments with subcritical currents the profile of section of aluminum plates near the fixed ring contacts which allowed to avoid breaks of the accelerated tape on its full length was empirically picked up. All experiments were made with high-speed filming. With a certain degree of an assumption such plate may be considered as an element of the cylindrical liner. In the course of development of adequate algorithm solution of the edge parts of the cylindrical liner dynamics the results of these experiments were used for comparison with calculated data. Also in the report the main algorithm and preliminary results of calculations for the deformation of profiled edge of cylindrical shell with a diameter 100 mm at pulse currents of 10 MA are given.

The work supported by Federal program (contract No. H 4 X 44.90.14.1109) and by RFBR (project No. 15-01-03073, No. 14-01-31496)