# Study of a possibility to get spherical symmetry of a quasi-spherical liner implosion under the effect of axial magnetic field

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## Introduction

One of the known methods to study plasma is to use a liner ponderomotive unit (PU) as the energy releasing device [1]. The PU converts the magnetic field energy to kinetic energy of the axially-symmetric shell that realizes compression and heating of plasma. The so-called energy liner is a common member in different types of PU. In the simplest case it represents a cylindrical conducting shell imploding towards the axis under the effect of current flowing along the axis in this shell.

## Implosion of a cylindrical liner

In the studies of the process of implosion of a solid-body cylindrical liner intended for the liner compression, the gas-dynamic model [2] presented in Figure 1 was tested. In such device the cylindrical liner was driven under the effect of products of explosion of the HE charge. The geometry of the liner part of such model is shown in Figure 1.

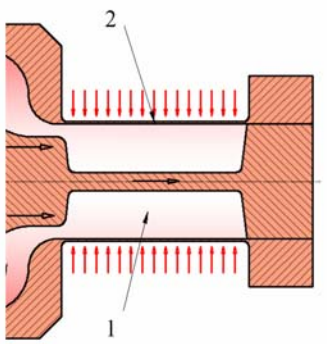


Figure 1. Cylindrical liner driven by means of a gasdynamic method.

1- plasma; 2 – cylindrical liner.

In the experiment the velocity of the inner boundary of the copper liner was 6,5 km/s, at this the diversity of the liner approach to the central rod was 0,76 мs (~ 9% of the total time of the liner flight to the central rod). The first stage without gasdynamic compression provided 1013 neutrons per pulse with duration of ~ 1 мs. The second stage according to the calculations at a small compression of plasma may provide 1015 neutrons per pulse [3].

Achievement of higher velocities of the explosively driven liner is limited by the speed of the detonation wave propagation. So, it is expedient to use the electromagnetic drive of the liner by a current pulse in order to get higher liner velocities and to improve the symmetry of its approach to the central post [4]. In case of liner acceleration by a current pulse the limitations related to finiteness of the detonation velocities are removed due to unpersistence of magnetic field. The motive force created by magnetic field is easily controlled and possesses reproducibility better than 1%. The electromagnetic field delivers the energy with light speed but without mass that minimizes side destructions of the studied constructions. In addition to a possibility to achieve high velocities the magnetic fields are attractive for studies as they are transparent to X-rays and visible light that is important for the diagnostic purposes. In the experiments with the cylindrical liner the obtained velocity of the shell in a condensed state was up to ~10 km/s.

**Implosion of a spherical liner**

According to calculations a change over from the cylindrical to the spherical or to quasi-spherical geometry of compression mitigate considerably the conditions of achieving high-temperature and plasma density, though the requirements to compression symmetry are still high. To answer the main question on a possibility or impossibility to get spherical symmetry of convergence of the shell under the effect of magnetic field with axial symmetry, a special PU was calculated and designed earlier. The scheme of one of the first PU of such type is given in Figure 2 [1]. The driven shell 2 with the shape of a body of revolution with complex profile of generatrix was located in conductors 1. To provide the required regime of acceleration, the profiled inserts 3 in the paraxial zones of the shell were placed, and insulator 4 was installed between the conductors. The shell was exposed to the action of magnetic field generated by current 6. The current was generated by the explosive magnetic source of pulsed power.

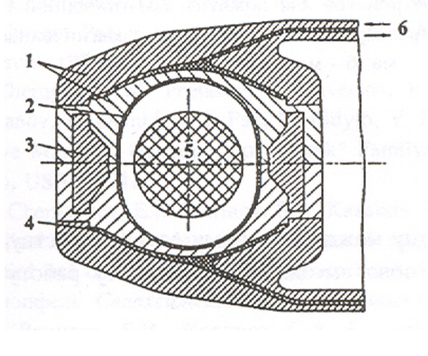


Figure 2. Scheme of PU to get spherical symmetry of the shell implosion.

Processing of the experimental results demonstrated that small asymmetry is observed only in the polar zones on the area of several percent of the total spherical surface.

Plasma compression with the use of a quasi-spherical liner allows using positive properties of spherical compression and having methodological possibilities of the experiment diagnostics applied, for example, in the studies of a cylindrical liner.

The scheme of the device to obtain the spherical symmetry of implosion of the quasi-spherical liner is presented in Figure 3.

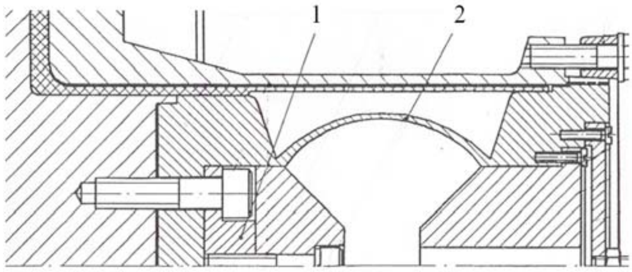


Figure 3. Scheme of PU with a quasi-spherical liner to get spherical symmetry of the shell implosion.1-system of the side electrodes mounting; 2- quasi-spherical liner.

The PU scheme shown in Figure 3, unlike the preceding scheme, allows placing the velocity and pressure measurement probes inside the liner (Figure 4). Due to this the technical level of the system can be broadened to diagnose the phenomena occurring at the implosion of the shells.

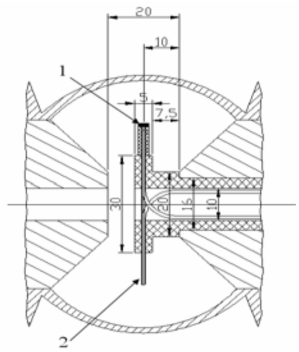


Figure 4. Probes to measure velocity of the inner boundary of the quasi-spherical liner: 1 – light pins; 2- electrocontact probes.

Usually in the process of the liner implosion under the effect of magnetic field the surface of the shell becomes rough due to Raleigh-Taylor instabilities. This effect can significantly deteriorate the process of plasma compression by the liner. For this reason the obtaining of objective information on the condition of the surface of the imploding liner is of great importance for plasma compression. X-ray imaging of the process of liner implosion gives additional information on the condition of external and internal boundaries of the compressed shell (Figure5).

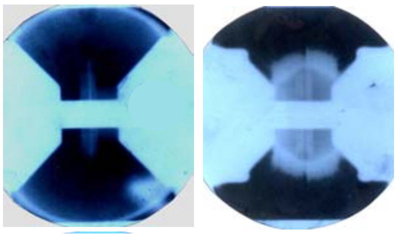

Figure 5. X-ray images of the liner: a-initial condition of the liner; b- liner compressed by magnetic field force.

The experiment conducted with similar PU confirmed a good agreement of the calculated and experimental data and allowed obtaining a real picture of condition of the surface of the quasi-spherical liner compressed under the effect of axial magnetic field. The velocity of the inner boundary of the quasi-spherical liner was ~ 9 km/s. The inner surface of the liner in the process of compression got approximately a spherical shape. By the present time when employing the axially-symmetric magnetic field to drive the quasi-spherical liner the obtained symmetry of its approach is at a level of ~ 1%.

## Conclusion

The experiments conducted with the use of the models to study the process of implosion of the liners of different configurations and the obtained results confirm a possibility of getting the spherical symmetry of implosion of the quasi-spherical liner under the effect of the axial magnetic field.

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