HIGH-SPEED VIDEO and thermography OF LARGE-SCALE PLASMA TOROIDAL VORTEX IN ATMOSPHERIC AIR

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The results of a high-speed video and thermography of the plasma toroidal vortex (PTV) in the atmospheric air are presented. Vortex was created as a result of synchronous injection into the air seven high-speed (10...15 km/s) plasma jets formed explosive cumulative generator with the stored chemical energy ~1 MJ (explosive mass - 0,2kg). A plasma-forming substances was aluminum. The characteristic time of the release of energy in the cumulative process ~15 μs.

Shooting was made from a distance of 300 m by high-speed digital camera with a repetition rate of frames: in the visible range (Δλ=0,4..0,8μm) - 600 fps, in mid-IR region (Δλ=3...5 μm) - 100 fps. Simultaneously photoelectron registration of optical radiation of PTV in different spectral intervals of range Δλ=0,2...1,1 μm was carried out.

According to the measurements, the maximum radiation power of the vortex was achieved at ~0,6mc from the moment of explosive initiation and was approximately 2 MWatt/sr; total pulse duration registered by the photo-detectors ~20ms. Color temperature of the vortex varied from 12...15кК in the initial stage of formation of PTV to 3.3...3,5кК in maximum radiated power.

Selected frames of high-speed video and thermography of PTV are presented in fig. 1 and 2.

Fig.1. High speed video footage of PTV.

 Time: *1*-1,5 ms; *2* - 10 ms; *3* - 200 ms.

Fig.2. Frames speed thermography of PTV.

Time: 1-10 ms; 2 - 20 ms; 3 - 120 ms.

***1***

***2***

***3***

***1***

***2***

***3***



**5м**

***1***

***2***

***3***



**10м**

***1***

***2***

***3***

Analysis of the results of high-speed video recording shows that after triggered explosive generator the long-lived (t ≥100ms) plasma structure in the form of a bright radiant sphere with a diameter of 4..5m, practically not changing in time, is formed in the atmospheric air. Plasma structure has vortex nature, which during its existence is veiled glow of the plasma and is manifested in cooling (~ 200 ms) in the form of smoky vortex ring (fig. 1-*3*).

The radius of the plasma orb at 10-th ms of this process (r~2...2,5 m) was comparable with the radius of the air shock (acoustic) waves formed by the explosion of a spherical charge of explosives same mass (0,2kg) - *Rsv*~ 2,5м. Average speed of explosive air wave is ~250 m/s.

The footage thermography diameter of luminous area (heat ball) at 10-th ms is about 16,5m (at 20ms - 20m), it begins to slowly decrease, reaching ~6 m to 300 ms. These measurements provide the average rate of expansion of the field of thermal perturbation of atmospheric air to 10-th ms ~825 m/s, which is 3,3 times more than the average rate of gas-dynamic pressure jump.

The possible mechanisms of the observed phenomenon report are discussed.