COPPER AND STEEL CYLINDRICAL SHELLS CONVERGENCE UNDER EXPLOSIVE CIRCULAR LOADING

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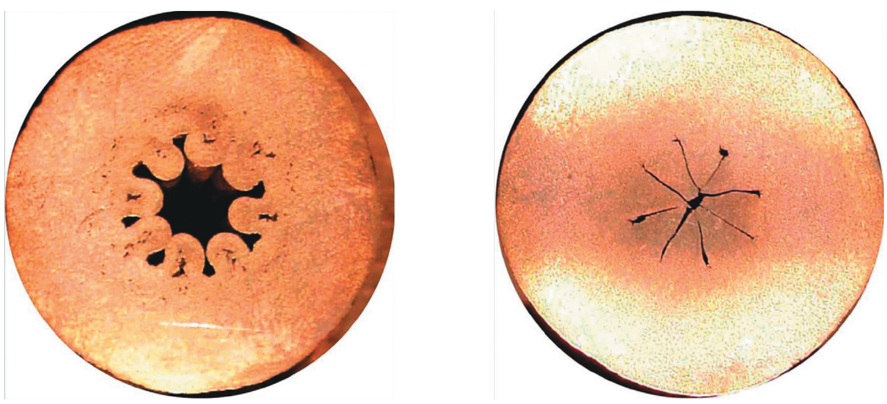
Experiments on the explosive loading of M1 copper shells, 60 mm in diameter, with a wall thickness of 8 mm, as well as 12Kh18N10T steel shells, 57 mm in diameter, with a wall thickness of 7.5 mm, were carried out. The shells were surrounded by a high-explosive (HE) layer. HE was initiated at eight points evenly spaced around a circle. Figure 1 shows the cross-sections of the explosively loaded copper shells under incomplete and complete convergence.

In case of incomplete convergence, the ejection formation is registered (Fig. 1, *a*). The ejections are plastic (cumulative) jets that arise due to Mach waves generated under the collision of shock waves propagating from adjacent points of initiation [1, 2]. The convergence of shell is completed due to expansion and closure of ejections at the center of this shell (Fig. 1, *b*). Since the material of the shell is characterized by viscous fluid properties, namely, fluidity and continuity, let us call this convergence mechanism a fluid-dynamic one.

Figure 2 shows the cross-sections of loaded steel shells under incomplete and complete convergence. In case of incomplete convergence, the shell is divided into eight similar fragments (Fig. 2, *a*). Such fragmentation is of a spirally twisted character due to shear deformation and additional compression in the direction perpendicular to radius.



a *b*

Fig. 1. Converging copper shells cross-sections under (*a*) incomplete and (*b*) complete convergence

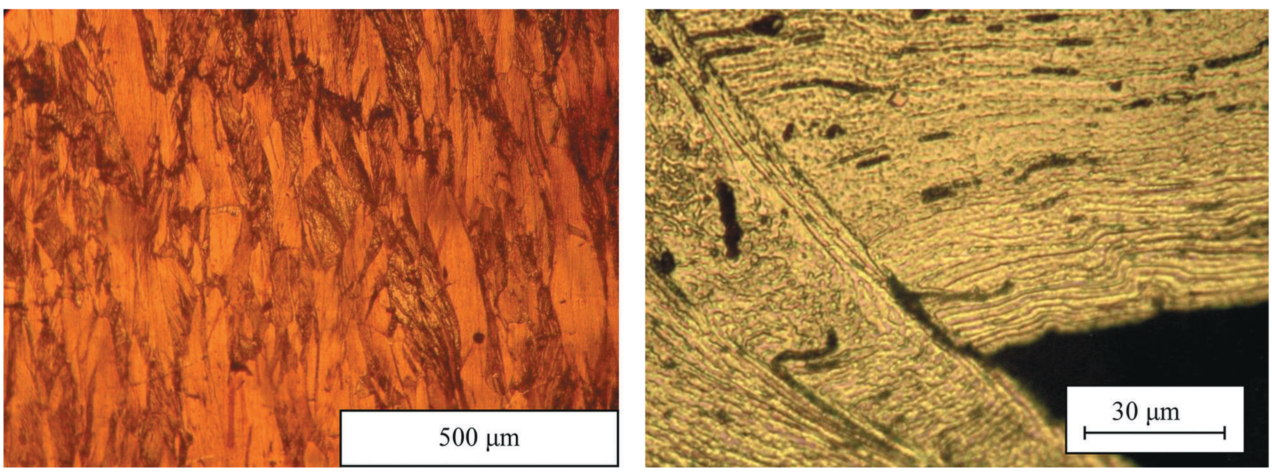
a *b*

Fig. 2. Converging steel shells cross-sections under (*a*) incomplete and (*b*) complete convergence

Shell converges because the fragments are deformed as they move towards the center of the shell (Fig. 2, *b*). Deformation of fragments takes place due to shear and leads to formation of teeth at the shells surfaces. Let us call this convergence mechanism a solid-state one since the properties of viscous fluid, namely, fluidity and continuity, are not observed. It is important that high strain rate deformation is accompanied by the shear band formation.

Metallographic analysis revealed a significant difference in the structure formation under different mechanisms of shell convergence. Three regions having different microstructures were found in the collapsed copper shell [1, 2]. Figure 3, a shows the microstructure of the outer circular (main) region. This structure is uniform and represents the alternating bands having different degrees of deformation (Fig. 3, *a*). The deformation twinning prevails in strongly deformed bands, while the slip deformation behavior prevails in weakly deformed bands. In the middle circular region, the deformation is random in character due to spallation voids recovery. In the central region, new recrystallized grains are observed to be formed, which is the evidence of a local temperature increase up to ~500–600°C.

The steel shells structure is extremely nonuniform. In weakly deformed regions, the original grain boundaries remain unchanged and stain-induced martensite and twins are formed in grains. In strongly deformed regions, shear bands are observed (Fig. 3, *b*), the original grain boundaries are destroyed by the localized flow, spallation voids remain nonrecovered (Fig. 3, *b*).



a *b*

Fig. 3. Microstructure of (*a*) completely converged copper shells and (*b*) partially converged steel shells

Thus, the experiments on the cylindrical shells convergence under the action of an explosion initiated at eight points demonstrated that convergence can have two essentially different mechanisms, namely, a fluid-dynamic one (for soft shells) and a solid-state one (for rigid shells).

This work was carried out as a part of a State Order No.122021000033-2 of Ministry of Education and Science of the Russian Federation on the topic "Struktura".

References

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