Characterization of SPD processed ultrafine-grained pure copper tubes via Tube Cyclic Expansion–Extrusion

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Received 18 May 2014, Revised 3 January 2015, Accepted 13 January 2015, Available online 15 January 2015

Highlights
- Tubes of pure copper for the first time were successfully SPD processed via TCEE.
- The initial grain size of 45 μm was refined to 200–300 nm after four cycles of TCEE.
- Notable increase in the strength and decrease in the elongation were documented.
- Good homogeneity in the microhardness distribution was recorded.

Abstract
Tube Cyclic Expansion–Extrusion is a severe plastic deformation method recently developed for cylindrical tubes. In this study, the principles of Tube Cyclic Expansion–Extrusion method and grain fragmentation mechanism during this process are explained. For the first time, tubes of pure copper were successfully processed by Tube Cyclic Expansion–Extrusion and remarkable grain refinement was achieved. The evolved microstructure of the processed tubes was observed using transmission electron microscope. Refinement of grain size to 200–300 nm was documented after four processing cycles of Tube Cyclic Expansion–Extrusion. The cell/sub-grain size was also extracted from X-ray diffraction line profile analysis. The microhardness of the processed tubes increased remarkably to 97 Hv after four cycles from an initial value of 55 Hv. Considerable increase in yield and ultimate strengths and decrease in uniform and total elongations were observed. The tensile fracture surface of the samples was also evaluated by scanning electron microscope.

Keywords
Tube Cyclic Expansion–Extrusion; Severe plastic deformation; Pure copper; Ultrafine grained; Mechanical properties; Fracture surface

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