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Mechanical properties of steel gun barrel processed by cold radial forging with stepped mandrel under different forging ratios

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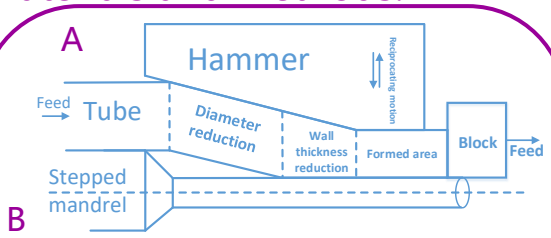
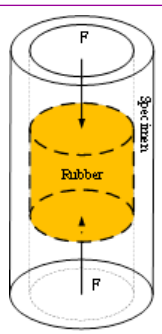
Introduction:

Radial forging is an open process to produce tubes and shafts. According to the appearance of the mandrel surface, radial forging also can create internal features of tubes, for example, the rifling of gun barrels. During the process, the diameter and thickness of tube blank will decrease under the pressure of four high-speed hammers. This work focused on the mechanical properties of 30SiMn2MoVA steel gun barrel processed by cold radial forging with stepped mandrel under four forging ratios to explore the effect of radial forging on the mechanical properties. Tensile test and bulging test were applied to obtain the axial and circumferential mechanical properties of forged tubes. Meanwhile, electron microscope was employed to check the inner wall of forged tubes to analyze the deformation of material.

Materials and methods:

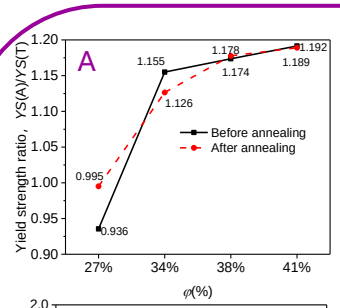


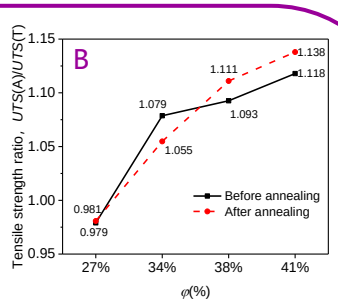
R_0 /mm	R_1 /mm	R_1 /mm	R_2 /mm	φ_1/%	φ_2/%	φ/%
15.075	5.825	12.235	2.885	27%	0	27%
		11.640			10%	34%
		11.340			15%	38%
		11.015			20%	41%

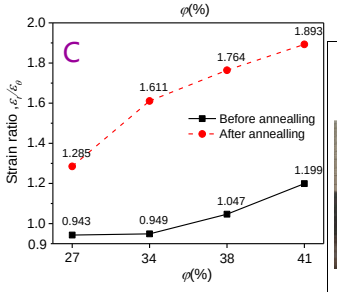


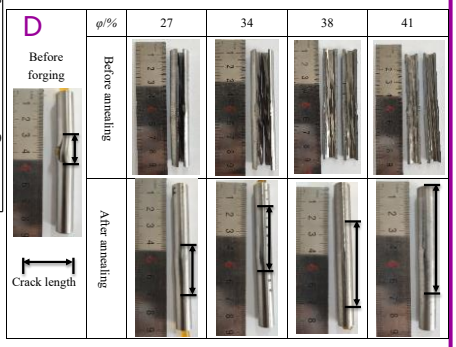
A:The diagrammatic sketch of radial forging process with stepped mandrel;
B: Dimension parameter of different forging ratios;
C: Tensile test specimen;
D: The schematic diagram of bulging test.

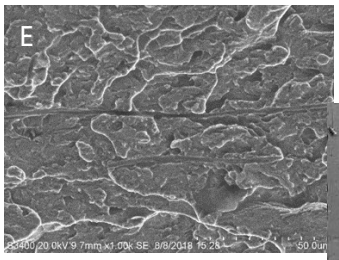
Results and discussion:

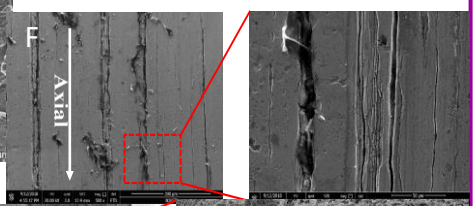


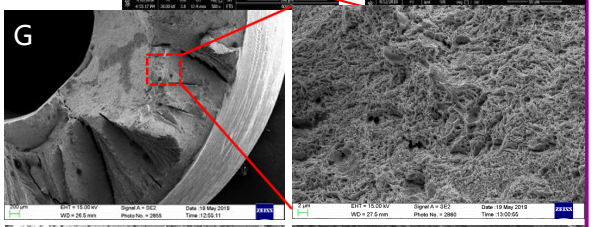


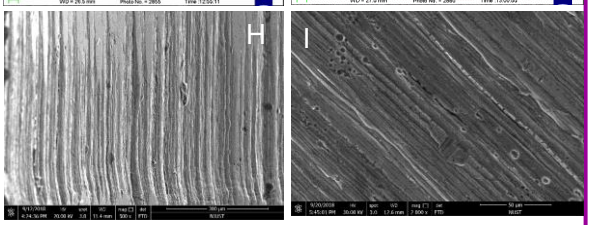












A: The axial and circumferential yield strength ratio;
B: The axial and circumferential tensile strength ratio ;
C: The axial and circumferential stain ratio ;
D: The failure state of specimens after bulging test;
E:The fracture morphology of bulging test specimen;
F:The inner surface of bulging test specimen;
G: The fracture morphology of tensile test specimen;
H: The wrinkles on the inner surface in diameter reduction stage;
I: The cracks and winkles on the inner surface in wall thickness reduction stage.

Conclusions:

(1) With the increasing of forging ratios, the anisotropy became obvious whether before or after annealing. The circumferential strength was inferior to the axial.

(2) After annealing, the circumferential elongation was 30%～50% lower than axial. With the growth of forging ratios, the strain ratio became larger.

(3) The fracture morphology of bulging test specimen was quasi cleavage fracture while the fracture of tensile test specimen was dimple fracture. The axial wrinkles and cracks were observed on the inner surface of the forged gun barrel which showed that the radial forging with stepped mandrel may result in the detects of forged gun barrel.