Damage and fracture of gun barrel under wear-fatigue interactionn

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Introduction

Gun barrel, projectile and propellant are three basic components of a gun launching system (Fig.1). Wear and fatigue are two major modes of failure with the barrel. Micro-cracks can form, grow and coalesce on the gun bore surfaces (Fig. 2) and propagate along the radial direction (Fig. 3). The barrel's fatigue life is mainly determined by the crack propagation life. Launching safety of gun barrel is a critical problem because the unlikely events of barrel fracture happen occasionally with modern guns all over the world. This paper aimed to investigate gun barrel failure under laboratory conditions using a specially designed hydraulic test rig.

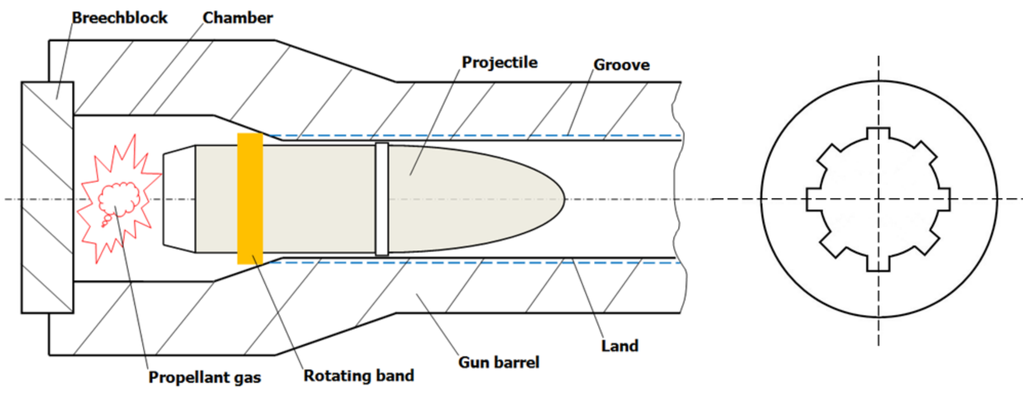

Fig. 1. Schematic of a launching system.

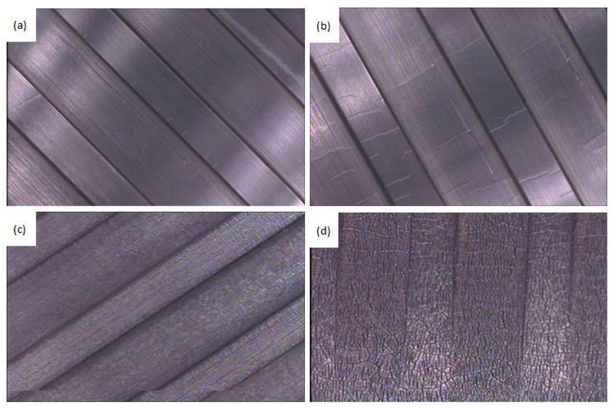

Fig. 2. Gun bore surface cracks.

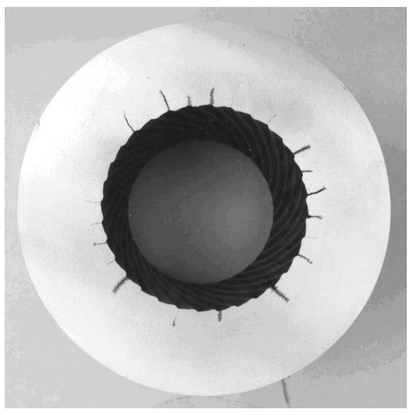

Fig. 3. Fatigue cracks

Experimental

Fatigue tests were conducted using a MTS 809 Axial/Torsional Test System (Fig. 4). Two kinds of tube samples were tested. One has a pre-machined semi-circle crack with radius of 0.3 mm and the other is perfect tube. The inside diameter of the tube was 32 mm and the thickness of tube wall is 1.5 mm. All tests were carried out at a frequency of 5 Hz with an R ratio of 0.1. Two strain gauges were mounted on the central outside surface of the tube to monitor hoop strain and axial strain. A pressure sensor was used to monitor the pressure of hydraulic oil during test process.

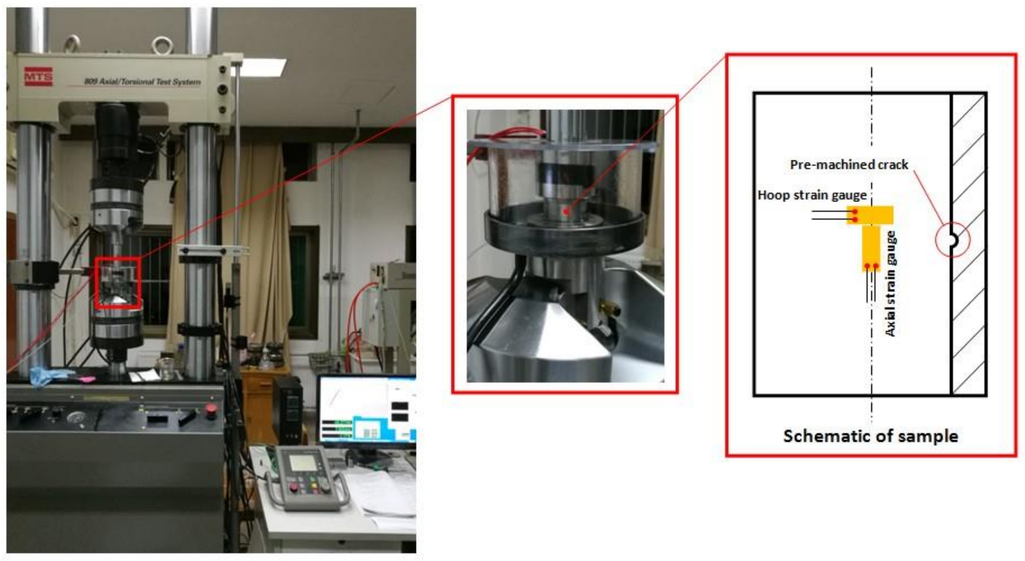

Fig. 4. Hydraulic fatigue tests on MTS

Results and discussion

Figure 5 shows four samples under different conditions. Figure 5(b) shows large plastic deformation of sample 2 and the test was stopped deliberately. Sample 3 was compressed directly to brittle fracture (Fig. 5(c)). It was also found that large plastic deformation occurred before fracture. However, a much smaller plastic deformation was observed on sample 4 which failed due to fatigue fracture in Fig. 5(d).

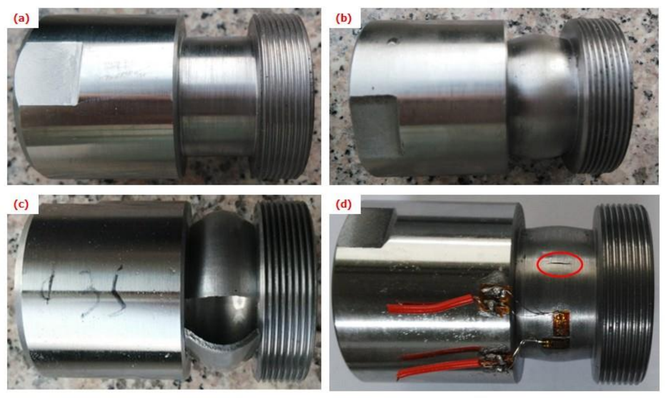

Fig. 5. Tested samples

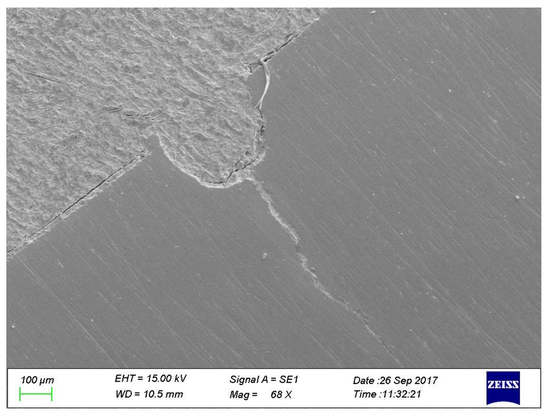

Fig. 6. Crack propagation.

Figure 6 shows the crack path of the pre-machined crack propagating along the radial direction under fatigue loading. A crack initiated at the tip of the pre-machined semi-circle crack where high stress concentration existed. Figure 7 shows the hoop strain variation process of sample 4. This fatigue test result suggests that the barrel health can be evaluated based on the monitored outside surface strain.

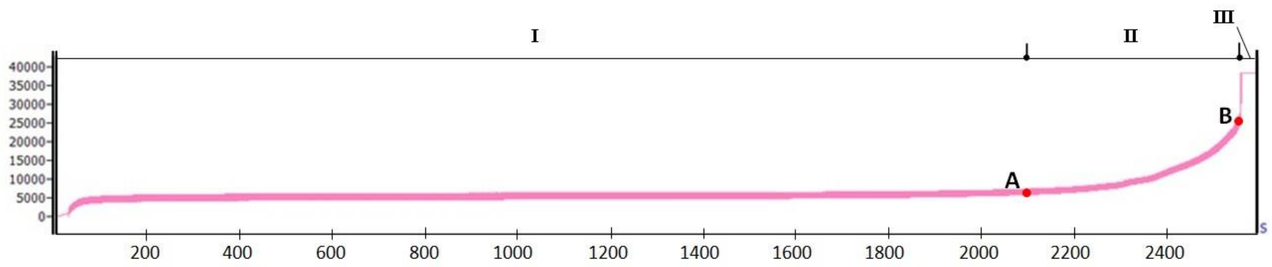

Fig. 7. Hoop strain evolution process.

We can mount the strain gauges on the barrel outside surface and monitor the strain from the first round. Strain of each fired round are stored and analyzed. When the strain is observed to decrease fast it is time for us to stop firing.

Conclusions

Gun barrel health can be evaluated by monitoring the outside surface strain and when the strain changes rapidly the continued firing of gun must be stopped in order to prevent fatigue fracture.