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Short Communication

High temperature fracture behavior of tungsten fiber reinforced copper matrix composites under dynamic compression

Z. Wu [a,*], G.H. Wu [a,b], P.C. Kang [a], Q. Gou [a], G.Q. Chen [a], L.T. Jiang [a]

[a] School of Materials Science and Engineering, Harbin Institute of Technology, Harbin 150080, PR China
[b] State Key Laboratory of Advanced Welding Production Technology, Harbin Institute of Technology, Harbin 150001, PR China

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ABSTRACT

$W_f/Cu_{82}Al_{10}Fe_4Ni_4$ composite was fabricated by flow casting method. Dynamic compression tests with strain rate of 1600 s^{-1} at 20 °C, 200 °C, 400 °C and 600 °C were finished by means of Split Hopkinson Pressure Bar (SHPB). The results showed that the composites possessed obvious high temperature softening behaviors. The damages of $W_f/Cu_{82}Al_{10}Fe_4Ni_4$ composites all occurred within the tungsten fibers when compressed at 20 °C, 200 °C and 400 °C, indicating that the interface strength of the composites was high. While the damages of the composites occurred either in the tungsten fibers or in the matrix at 600 °C, in addition, the melt of matrix alloy also occurred. Microstructure of the composites after dynamic compressing at 600 °C was analyzed by transmission electron microscope (TEM), observation revealed that there were a lot of high-density dislocations, stacking faults and twins existing in the matrix. It was also found that the precipitated phase in the matrix played the role of the second phase strengthening.
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1. Introduction

With the development of armor-piercing projectile to high speed, high strength and high density, the demand to mechanical properties of materials used for armor-piercing projectile increased higher and higher [1–3]. Composites are composed of two or more kinds of materials reasonably, so they often possess better performance than a single material. Therefore, many countries start to do research in composites' armor-piercing projectile in recent years [4–6]. Tungsten fibers, which possess the advantage of high density and high melting point (3410 °C), were formed by drawing the massive tungsten at high temperature [7–9]. During the process of drawing, the internal microstructure of the tungsten fibers were turned into fibrous structure so that the tungsten fibers could obtain high mechanical properties [10,11]. Due to the above advantages, tungsten fibers are selected as reinforcement for the new generation of composites used in armor-piercing projectile [10]. As copper alloy has high density and high strength, and tungsten–copper composites have been successfully used in electronics, military and aerospace fields, so copper alloy is chosen as the matrix of the composites in our experiment [12–15]. In order to increase the interface bonding strength, ferrum, nickel and aluminum elements were added in the copper, then $W_f/Cu_{82}Al_{10}Fe_4Ni_4$ composites were prepared by means of flow casting method [16,17].

Temperature of armor-piercing projectile will increase sharply when flying and impacting, so the research of dynamic mechanical properties and fracture characteristics of the armor-piercing projectile under the condition of high temperature is necessary. In this paper, the dynamic mechanical properties of $W_f/Cu_{82}Al_{10}Fe_4Ni_4$ composites under the condition of high temperature were tested, meanwhile the fracture behavior and microstructure of the composites were investigated also.

2. Materials and experimental methods

$Cu_{82}Al_{10}Fe_4Ni_4$ alloy was chosen as the matrix, and 0.25 mm diameter straightening tungsten fibers were chosen as the reinforcement in $W_f/Cu_{82}Al_{10}Fe_4Ni_4$ composites. Tungsten fibers were cut into 100 mm long and immersed in 40% HF liquor to remove the surface oxide film, then they were cleaned by ultrasonic in acetone and alcohol respectively to get pure surface. The prepared tungsten fibers were put straightly into the clean quartz tube, and the master alloy was set above the tungsten fibers, then $W_f/Cu_{82}Al_{10}Fe_4Ni_4$ composites was fabricated by flow casting method. The volume fraction of the tungsten fibers in the prepared composites is 80%. Impacting samples with the dimension of $\varnothing$ 4 mm × 4 mm, in which tungsten fibers arranged vertically, were prepared by means of wire cutting machine. Split Hopkinson Pressure Bar (SHPB) was selected as the test equipment, and a controllable heating device was installed on SHPB to control the test temperature. Strain rate of 1600 s^{-1} and temperature of 20 °C, 200 °C, 400 °C and 600 °C were chosen in this experiment. Each test will be finished at least three times to ensure the reliability of the test data. Microstructure and

* Corresponding author. Tel.: +86 451 86402373; fax: +86 451 86412164.
E-mail addresses: wuzhepersonal@126.com (Z. Wu), wugh@hit.edu.cn (G.H. Wu).

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