Reaction-bonded boron carbide armour material: An investigation of the optimized dynamic performance

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Abstract

In the endless search for armours weight and cost reduction, boron carbide (B4C) has been found to be a relevant candidate when densified via the reactive infiltration of a liquid metallic phase, such as molten silicon. The resulting ceramic-metal composite is commonly called Reaction-Bonded Boron Carbide (RBBC). During the infiltration process, chemical reactions lead the consolidation of the constitutive ceramic particles by the formation of new phases, therefore shaping a dense material (2.5-2.8 g/cm3). The microstructural parameters possibly driving the material performance are the different phase proportions (B4C, SiC and residual silicon) and the particles size distribution. However, on such material, it is difficult to identify the direct influence of a single microstructural feature on the ballistic performance, as all these parameters are interdependent. Because of the complexity of RBBC microstructure, so far, the damage mechanisms occurring under impact are still not well understood. For this reason, in the industry, a "make-and-shot" iterative approach is the common way to develop this type of materials. These tests have demonstrated the noteworthy performance of RBBC materials for lightweight ballistic protection.

Under impact, dynamic tensile stresses spread in ceramic plate due to the propagation of numerous oriented cracks, leading to its fragmentation. This dynamic fragmentation is supposed to be highly related to the ceramic ballistic performance. Therefore, the main motivation for this study is to understand the fragmentation process occurring in RBBC ceramics under impact loading, in order to identify the link between microstructural parameters and ballistic performance.

For this purpose, two RBBC microstructures were selected, according to their ballistic limit velocity, to be further studied under dynamic solicitations. Specific experiments, such as edge-on-impact and normal impact tests, were performed on these two microstructures. Thanks to the damage growth observation, via ultra-high speed camera, and post-mortem analysis a better understanding of the failure modes induced in RBBC ceramics under impact is provided.

Based on these academic results, new RBBC microstructures (B4C/SiC/Si composite) were developed with the target to optimize both performance and manufacturing cost.

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