Abstract

Armor steel with a martensitic structure is commonly used because it can absorb a lot of energy when subjected to high-speed impacts. In real-life situations like crashes, explosions, ballistic impacts, and metal forming, factors such as strain (ε), strain rate ($\dot{\varepsilon}$), and temperature (T) change significantly. The material also undergoes major deformation, which is important for designing safe and strong structures. To accurately describe this deformation, a large displacements and large strain approach is used, considering the effects of high strain rates and increased temperature.

This study examines two types of martensitic steel—a typical Rolled Homogeneous Armour (RHA) and PHS1500—under different loading conditions, from slow to intermediate strain rates. Three models were used to predict how these steels behave: the Johnson-Cook model (a commonly used approach), the Rusinek-Klepaczko (R-K) model (a semi-physical model), and a new model based on the Johnson-Cook formulation. Finite element simulations were conducted using ABAQUS CAE Standard/Explicit software, and the results were verified by comparing them with real tensile test data. The research combined extensive experiments with simulations, and the material model was also validated using Charpy V-notch impact tests. Finally, ballistic impact tests were simulated using the three material models. The study closely analyzed how fracture toughness affects the performance of armour plates and showed how the fracture toughness parameter (K_{ID} or K_{IC} (t)) influences ballistic performance. The findings provide crucial insights into the mechanical behaviour and impact resistance of armour steel.