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Evaluation of stress wave propagation in particle-reinforced metal matrix composites

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Abstract: This study presents an experimental evaluation of stress wave propagation induced by high strain-rate compression in particle-reinforced MMCs (Metal Matrix Composites) with different ceramic volume fractions. Composite specimens that are produced by powder metallurgy technique are utilized in the experiments. The high strain-rate compression tests are carried out using a SHPB (Split-Hopkinson Pressure Bar) setup at various strain-rates to evaluate the stress wave propagation in the composite specimens. Additionally, a quasi-static compression test for each specimen is conducted using a universal testing machine to understand the strain-rate sensitivity of the composites. The quasi-static and dynamic compression test results are examined in terms of stress-strain response and strain-rate sensitivity of the composite specimens, and the effect of ceramic volume fraction is also investigated. The compressive yield strength of the composites is found to be strain-rate sensitive, and it increases with increasing strain-rate and increasing ceramic volume fraction.

Keywords: metal matrix composites, particle reinforcement, stress wave propagation, dynamic compression

1. Introduction

Metal matrix composites (MMCs) draw a great attention in engineering applications with their desirable properties over monolithic metal alloys such as higher specific strength and stiffness, higher wear, fatigue, creep, and corrosion resistance and over polymer matrix composites such as higher strength, stiffness, service temperature, electrical and thermal conductivity, radiation resistance, and minor or no moisture absorption [1]. Therefore, MMCs have been employed in several engineering fields such as automotive, aerospace, and military industries. Especially, utilizing lightweight matrix material such as an aluminium alloy makes these composites a strong candidate for these industries due to high strength to weight ratio. In these application fields, they can be exposed to impulsive loadings during their service life. Thus, it is important to understand the dynamic mechanical response of MMCs for design of structural components.

In the literature, the high strain-rate compression behaviour of MMCs is studied for various matrix and reinforcement materials and different volume fractions of reinforcement, generally low or intermediate fractions [2-5]. In this study, the dynamic compressive behaviour of a ceramic particle-reinforced MMC with an aluminium alloy matrix is investigated for both low and high ceramic volume fractions at various strain-rates. The effects of strain-rate and ceramic volume fraction are discussed on the compressive behaviour of the composites. Different ceramic fractions are considered to understand the effect of ceramic content on the plastic deformation capability of the composites.

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