Numerical Study on Failure Process of Aluminium Plate Subjected to Normal Impact by Hemispherical Projectiles

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Abstract. In this paper a study is presented on the numerical analysis of the failure process of aluminium armour plate subjected to normal impact by hemispherical projectiles. The perforation process has been simulated by the application of 3D analysis using IMPACT dynamic FE program suite. The comparison on the elements size of meshing towards failure mode was observed and evaluated. The material behaviour of the target plate was approximated by an appropriate constitutive relation. The study covered different size of meshing element on target plate as well as different level of impact velocities. Different failure modes for each case were found. For low speed impact condition a petalling was observed, whereas for high speed impact a radial neck along with a holes enlargement was observed with better and uniform perforation mode. The deformation and failure mode of the impacted target plate will be given special attention in this investigation.

Introduction

The response of materials under dynamic loading has a considerable interest especially involving the perforation and penetration resulting from the impact of non-deformable projectiles and metallic plate. A relevant amount of publications can be found in the international literature dealing with high strain rate behaviour of metallic materials related with different engineering applications [1,2,3]. The failure mode seems to be strongly dependent on the impact velocity. The influence of the impact velocity on the failure mode during Taylor tests performed with Weldox 460 E steel cylinders have been implemented by Teng et al. [4]. At relatively low impact velocity no external cracks appeared in the specimen impacted. On the contrary, for high initial impact velocity it was observed the formation of several radial cracks. They were rapidly propagated causing formation of petals. The study about the perforation of steel and aluminium plates impacted by various shape of projectile has been performed by many researchers [5,6,7]. The numerical results show good correlation with the experimental results and able to emulate failure characteristics of the steel and aluminium plates.

In this investigation, the analysis of process requires the following assumptions: (a) The amount of energy absorbed by the projectile is neglected, (b) The projectile move with the same velocity after the initiation of perforation, (c) The plastic deformation is taken into account in the target plate while elastic deformation is neglected. The current paper presents the results of numerical investigation undertaken to study the perforation process of different size of meshing elements of target plate and projectile impact at different velocity. The perforation capabilities of hemispherical projectile against constraints plates were explored for an efficient damage of failure modes numerically.

Simulation Modelling

Finite element model

The proposed finite element model of projectiles and target plates are shown in Fig. 1. The projectile has the diameter of 10 mm while target plate has the dimension of 100 mm x 100 mm x 2 mm. Both projectiles and target plate is modelled using finite element pre-processor GiD with IMPACT interface module. The plate is constrained at the edges and subjected to impact by hemispherical nose shape of projectile at different velocities. The projectile is modelled as contact