Pendulum Technique to Measure Land Mine Blast Loading

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Introduction

An English mathematician and engineer named Benjamin Robins invented the ballistic pendulum, consisting of a wooden block suspended in front of a gun, in the mid 1700's. When a bullet is fired, its momentum is transferred to the bob and the velocity of the bullet at impact can be determined accurately from conservation of momentum and energy principles. The physics of this problem are explained in classic textbooks[1]. It is interesting to note that the momentum is applicable immediately before and after the impact; however, during the impact, applying the conservation of energy principle shows that most (often > 99%) of the initial kinetic energy of the bullet is dissipated in the form of heat and deformation.

The vertical ballistic pendulum was also used to measure effective blast loading[2][3]. In this application, an explosive charge is detonated some distance from the strike face of the pendulum and the response is determined by the total impulse, J, which is defined as:

$$J = \int_{t_0}^{t_f} F(t)dt \qquad\qquad \text{Equation (1)}$$

where F(t) is the average force applied to the strike face as a function of time, which includes the spatial integration of pressure over the face as well as momentum transfer from any solid particles ejected from the explosive device. The time limits on the integral should be sufficiently long to cover the full interaction time for the explosive event.