A Model of a Pneumatic Jackhammer System

By

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Summary

A complete model of a pneumatic jackhammer system has been developed. Application of this model requires that two preliminary experiments be performed. The first experiment produces the relationship between piston impact velocity and the pressures acting on the top and bottom surfaces of the piston, while the second determines the force-indentation behavior for the bit/target system. The model analysis leads to the prediction of the jackhammer efficiency and target response, including target penetration and crack propagation. This model is not dependent on the jackhammer type or size, and may be applied to any such system.

A jackhammer system, consisting of an Ingersoll Digger, a 30° conical bit tip, and a Sierra granite target, was used to validate the model. The efficiency, target penetration, and crack extension were measured for this system and found to be in good agreement with predicted results.

1. Introduction

Percussive drilling is one of the most important methods employed in the mechanical processing of rocks. The jackhammer operation encompasses very complicated phenomena that must be defined and quantitatively described in order to develop an effective analytical model. The resulting model can improve rock mechanics technology through the development of better tooling, more precise drilling procedures, and a closer control of target response.

A pneumatic jackhammer system typically consists of a trigger valve, chamber, piston, bit, target, and air reservoir; a schematic of the system is shown in Fig. 1. Several aspects of the operation of such a system have been studied by Clark (1979). The objective of this investigation is to predict the resulting target penetration (i. e., penetration of the bit into the
target) and target failure following impact as well as the jackhammer efficiency. Efficiency is defined here as the ratio of the work done on the rock to the energy transferred from the piston to the bit. These results can be determined for a given air reservoir pressure, jackhammer type, bit geometry, and target material properties.

![Schematic of a jackhammer system](from Pang and Goldsmith, 1989)

In the present study, a model is proposed which describes a pneumatic jackhammer system. The first part of this model consists of an analytical force-indentation relation for a chosen bit/target system, as well as of an empirical relation between the piston velocity and pressure on the piston for a given reservoir pressure. The output of the first part is then used in the second part to simulate the wave propagation in the bit, and the resulting penetration into the target material. Target penetration can be measured experimentally and compared with predicted model results. The model also allows one to predict two other results, the efficiency of the system and the crack propagation within the target; the latter can also be compared with experimental data.

The complete development of the jackhammer system requires that the following components of the model be developed.

### 1.1 Piston Velocity and Pressure Exerted on the Piston

Operation of a pneumatic jackhammer system consists of a series of momentum and energy transfers that extend from the reservoir through the bit to the target. Upon engagement of the trigger valve, air enters the chamber and impinges on the piston, which, in turn, strikes the bit. These momentum and energy transfers depend on the pressure exerted on the top and bottom surfaces of the piston and the resulting piston impact velocity.