Inclusion of Pore Pressure Effects in Discrete Element Modelling of Rock Cutting

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ABSTRACT

Many rock excavation processes occur in a marine or submerged environment, like in drilling for oil/gas, dredging, trenching and deep sea mining. The presence of a fluid in and surrounding the rock can have a significant influence on the cutting process, through differences in the ambient (confining) and pore pressure. The cutting motion deforms the rock matrix, and as a result, local fluid pressure differences will occur. The magnitude of these pressure differences, and thus its effect on the cutting process, increases with larger water depths and/or higher cutting velocities. The apparent strength of the rock matrix increases with higher ambient pressures, resulting in a higher cutting force. However, an increase in cutting velocity might also lead to lower cutting forces, dependent on the ambient pressure [1].

Various researchers have used the Discrete Element Method (DEM) to analyze the rock cutting process [2-4]. Thus far, most research has been limited to the cutting of dry rock. Several attempts have been done to mimic the effect of a fluid pressure, mostly by applying a confining pressure on the rock surface [5]. Further improvement of the rock cutting process can be achieved by including the fluid pressure effect in the rock.

In this paper, the DEM has been extended with a fully coupled fluid pressure model. This is done by solving a pore pressure diffusion equation with a Smoothed Particle (SP) method. By using the SP, it is possible to convert the discontinuum properties of the DEM to a continuum, in which the fluid pressure is modeled and applied as an additional force in the DEM.

Qualitative results show that the model is able to capture the confinement-strengthening and drainage-weakening phenomena as found in experiments [1]. The newly developed technique gives more insight in the physical processes that occur during cutting and it helps to improve the use and the design of the rock cutting equipment and processes.

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