Tool wear monitoring in rock drilling applications using vibration signals

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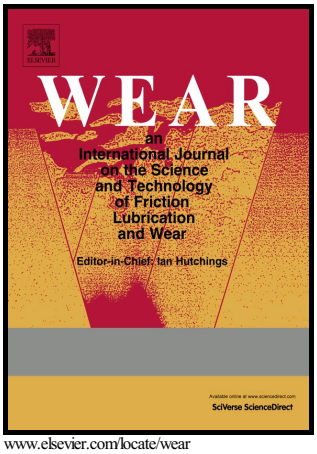

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Abstract

Tool wear highly influences the safety, productivity, and overall performance of rock drilling operations. Since rock is a brittle, non-homogeneous, and anisotropic material whose physico-mechanical properties usually vary substantially in the cutting zone, tool wear monitoring could potentially be a very difficult task. Nevertheless, the need for wear monitoring in a fully automated drilling environment is essential. Its function is not only to monitor and diagnose the cutting process but also to provide precise information that enables real-time adjustment of machining parameters. Therefore, a preliminary experimental study of the rock drilling process was performed on limestone and marble in order to determine whether vibration signals can usefully classify the level of drill wear. Accordingly, signals were measured on all three orthogonal axes and tool wear features were extracted from the frequency spectrum in the form of energies related to different bandwidths. Feature extraction and selection was performed using a new proposed methodology. Selected features were finally processed using an artificial neural network classifier. Results confirm the potential usefulness of signal analysis and the proposed methodology to classify tool wear levels during rock drilling.

Keywords

Tool wear; Rock drilling; Process monitoring; Vibration signals.

1. Introduction

Rock is one of the oldest and the most utilised materials throughout human history. Although it has been replaced today with other types of materials in many applications, market demands are still high and rising [1]. Rock is a typically non-homogeneous and anisotropic material characterised by its chemical composition, structure, and texture. These parameters have a strong influence on its physico-mechanical properties, which directly influence workpiece machinability. Considering the fact that physico-mechanical properties can vary substantially among various types of rock, rock machining can be a very demanding process [2]. Frequent variations of rock properties in the cutting zone, especially hardness, together with constant machining parameters (cutting speed and feed) will result in variations in the cutting forces the amplitude of which can lead to tool and/or workpiece breakage.

In addition to the material characteristics, the stability and overall quality of the machining