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Effect of minimum quantity lubrication (MQL) on fine and ultrafine particle emission and distribution during polishing of granite

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ABSTRACT

Granite polishing generates aerosols containing fine and ultrafine particles that can be detrimental to occupational health and safety. As the occupational safety regulations are becoming more and more stringer, it is important to find ways of limiting the workers exposure to these particles. Different methods have been proposed to reduce the dust emission at the source during polishing of granite. They include using ventilation to capture or redirect the dust and using of wet polishing process to help settling down quicker the generated particles. Traditionally, the wet machining processes are conducted using flood lube but given the costs associated with this lubricating condition, in most machining sectors, the use of minimum quantity lubrication or cooling, also known as MQL machining is being tried. MQL polishing could be a cost effective way of reducing the dust generation at the source when polishing granites. Knowledge on the distribution and behavior of semi-wet particle could also help in designing other methods and apparatus for capturing or taking the dust away of the working environment.

This paper investigates fine and ultrafine particle emissions during polishing tests under minimum quantity lubrication (MQL) conditions as compared to dry polishing. The MQL polishing is done using water at different flow rates and their effects on the working environment air quality investigated. It is found that the effectiveness of water MQL in particle reduction depends on size of particles considered.

1. Introduction

During grinding and polishing of granites, there is a high emission of fine and ultrafine dust containing silica. Silica has been found to cause respiratory diseases among granite grinding workers [15,31,17,30,23,8,20]. Crystalline silica is a common but variable component of granite. Ahmad et al. [1] studied the nanotoxity of dust during a granite manufacturing process. Lung problems including cancer and kidney malfunction have also been reported by Jayawardana et al. [14].

On March 2016 the USA department of Labor's, occupational Safety and Health Administration (OSHA) has reduced the exposure limit for inhalable crystalline silica dust by half and has given one to five years to industries according to their sector to comply. The new exposure limit is now 50 $\mu g/m^3$ for an 8 h working shift [18]. The problem is very serious as in USA only, it is estimated that more than two millions people are exposed to silica when working [27,18]. To quickly comply with these new regulations, engineers and researchers must help industries developing strategies to limit workers risk of exposition to the silica.

Some researchers as Zemzemi et al. [34], Balout et al. [3], Songmene et al. [24] and Kouam et al. [12] have identified the friction at the tool-workpiece interface as a contributor to the total particle emission occurring during machining. Khettabi et al. [10] have studied the particle emission when machining metallic workpieces in dry condition. Khettabi et al. [9] have also studied the effect of MQL on particle emission but their studies have been done on metallic workpiece.

Few research articles focus on the dust during the polishing of granite. Kouam et al. [13] and Saidi et al. [22] have studied these dust emissions. Their investigations showed that the kind of granite and the machining parameters have an impact on the dust emission; however, their works were done in dry conditions only. Saidi et al. [22] have shown during polishing of granite that fine particle dispersion depends more on spindle speed used rather than on the sizes of the particles. High concentrations of fine particles with diameters size lower than 2.5 μm ($PM_{2.5}$) were found away of the polishing zone (source of emission). This suggested that any worker close to the machining area but away of the particle emission source could be exposed to these

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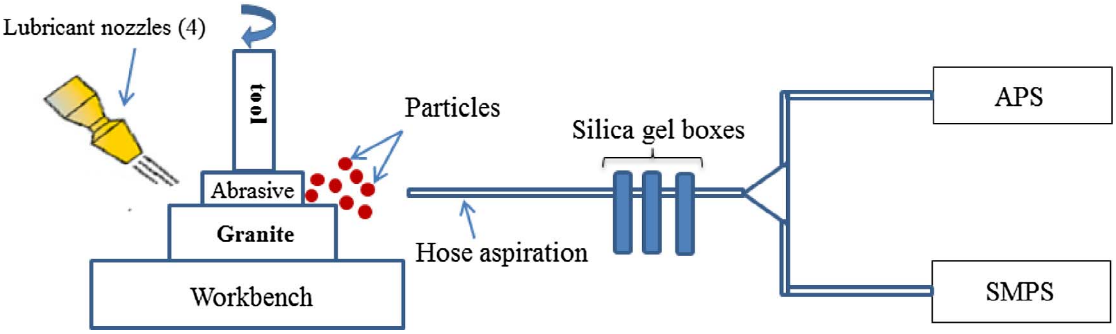
a) Lubricating system

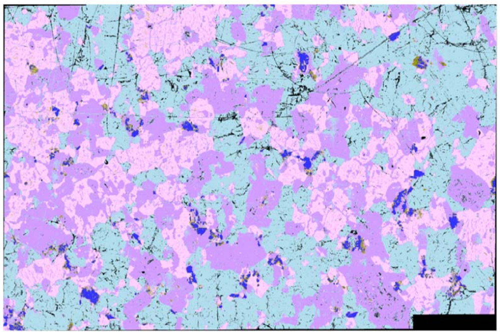
b) Tool & abrasive

c) Silica gel boxes and data acquisition systems (APS, SMPS)



d) Schematic representation of machining and dust sampling systems

Fig. 1. Experimental setup.

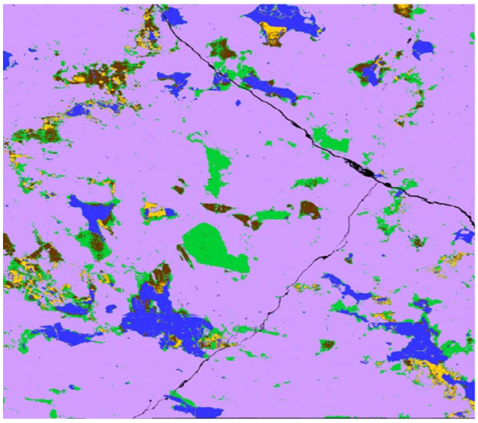


Composition of White Granite

Colours	Minerals	Proportions (%)
🟦	Quartz	41.38
🟪	Plagioclase	32.39
⬜	**K-feldspar**	23.14
🟨	Biotite	1.14
🟦	Oxydes/biotite	1.95

uncertainty : ± 2 %

a) White granite



Composition of black Granite

Colours	Minerals	Proportions (%)
🟪	Plagioclase	83.61
🟨	Olivine	1.51
🟫	Biotite	2.83
🟦	Oxydes/sulfures	5.20
🟩	Orthopyroxene	6.85

uncertainty : ± 2 %

b) Black granite

Fig. 2. Compositions of (a) white granite and (b) black granite tested.