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Influence of high-energy milling on structure and microstructure of asbestos-cement materials

Józef Iwaszko*, Anna Zawada, Małgorzata Lubas

Czestochowa University of Technology, Institute of Materials Engineering, 19 Armii Krajowej St., 42-200 Czestochowa, Poland

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ABSTRACT

Asbestos-Containing Waste (ACW) in the form of a fragment from an asbestos-cement board was subjected to high-energy milling in a planetary mill at a constant rotational speed of 650 rpm and for variable milling times: 1, 2, and 3 h. The initial and the milled materials were subjected to infrared spectroscopic examination to identify the asbestos variety and to evaluate changes in the structure caused by high-energy milling. FT-IR (Fourier Transform Infrared Spectroscopy) examinations followed optical microscopy and SEM (Scanning Electron Microscopy) studies as well as X-ray analysis of the phase composition. It was found that the asbestos fibres present in the asbestos-cement board were respirable fibres with pathogenic properties. Identifying asbestos using the spectroscopic method showed that chrysotile asbestos was present in the as-received ACW while no characteristics of absorption bands from crocidolite or amosite were found. The results of the spectroscopic examinations were confirmed by the X-ray phase analysis. During SEM investigations of the milled ACW, complete loss of the fibrous structure of chrysotile was observed. The FT-IR examinations of the milled material showed that with an increased milling time, the characteristic absorption bands characteristic for chrysotile diminished and already after 2 h of milling their almost complete decay was observed. Thereby, it was confirmed that high-energy milling results in destruction of the crystalline structure of the asbestos phase. The conducted studies have shown that the treatment of asbestos-cement materials using high-energy milling is an effective method for asbestos disposal, capable of competing with other technologies and solutions. Moreover, FT-IR spectroscopy was found to be useful to identify asbestos phases and to assess changes caused by high-energy milling.

1. Introduction

Asbestos is an inorganic fibrous mineral that is a hydrated magnesium, iron, calcium or sodium silicate. Mineralogically, asbestos is divided into serpentine and amphibole. The only representative of the serpentine group is chrysotile, i.e. hydrated magnesium silicate with the chemical formula $Mg_3Si_2O_5(OH)_4$ (CAS No. 12001-29-5). Of all the asbestos varieties only chrysotile (white asbestos), and to a lesser extent crocidolite (blue asbestos) and amosite (brown asbestos) have found practical use, whereby chrysotile asbestos accounts for nearly 90–95% of total asbestos usage [1–3]. The asbestos application potential is a consequence of its high mechanical strength and thermal insulation, as well as resistance to high temperature, abrasion and chemical and biological factors [4,5]. These properties, in particular heat resistance and high thermal insulation, formed the main application area of asbestos. Asbestos was intensively used in Poland in the 1960s and 1970s, especially in the construction industry, including the manufacture of asbestos-cement boards. Such boards, called eternite, contained between 11 and 18% of asbestos fibers and were primarily used to make facade cladding and roofing. It is estimated that currently almost 15.5 million tons of asbestos fiber products require disposal, of which the vast majority are asbestos-cement boards, and the rest, nearly 600,000 tonnes of asbestos fibers, are asbestos-cement pipes and other asbestos-cement products [6]. The asbestos removal process is a difficult and costly project and can be implemented either by disposal or by depositing in hazardous waste landfills. This second solution is far simpler and cheaper to implement because it only comes down to storage of asbestos-containing materials in special landfills or in inactive mines without interfering with asbestos properties and structure. A solution that is more expensive and more technologically complex,

* Corresponding author.
E-mail address: iwaszko@wip.pcz.pl (J. Iwaszko).

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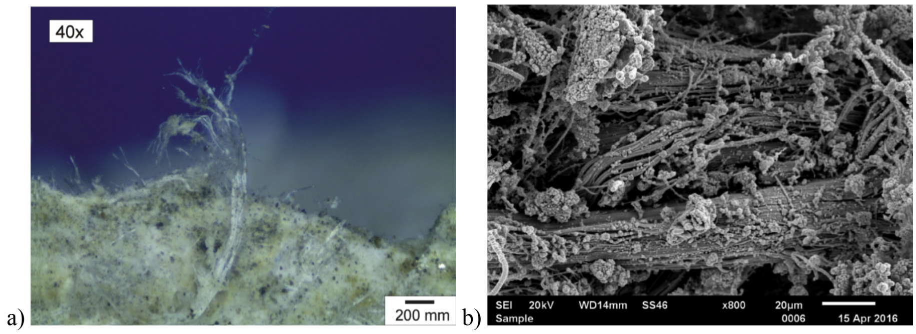

Fig. 1. Microstructure of asbestos-cement board (a) board surface, (b) fracture. Light microscopy (a), SEM (b).

but which makes it possible to completely neutralize asbestos and convert it into a reusable material, is disposal. One of the most common methods of asbestos disposal is the thermal method. The influence of temperatures of 700 °C and higher leads to gradual destruction of fibrous asbestos and significant structural and phase changes [7–9]. Numerous authors have demonstrated that the thermal treatment allows the effective recycling of asbestos fibers and transforms them into newly formed crystalline phases which are totally non-toxic [8,10]. For example, Witek et al. [10] reported that due to the melting of asbestos-containing waste, the fibrous structure of asbestos can be completely “destroyed”. It was also demonstrated that adjusting the chemical composition of ACW properly and choosing appropriate cooling conditions for the so obtained melt, it is possible to obtain a material in which the predominant phases are calcium silicates. Equally effective is utilization with microwaves [11–14] or thermochemical treatment [15]. C. Leonelli et al. [11] used a microwave source to dispose of asbestos fibers and showed that inertised asbestos no longer contained the

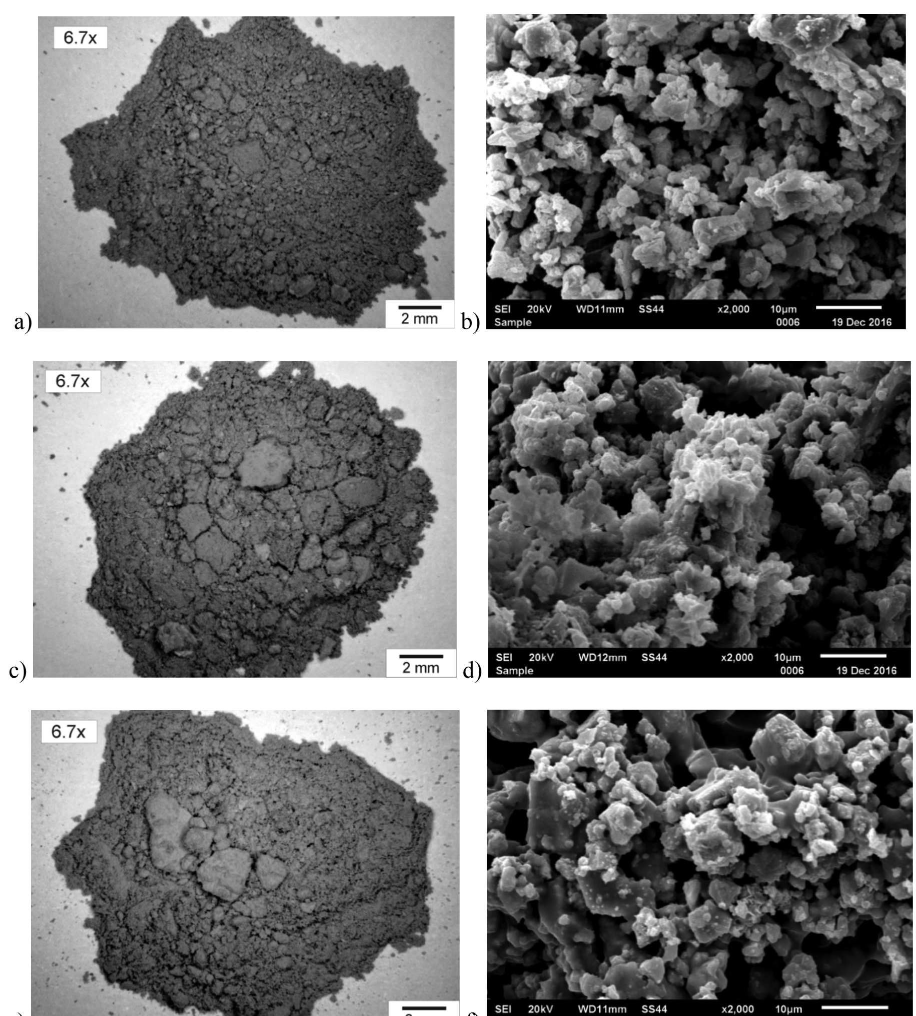

Fig. 2. High-energy grinding effect for 1 h (a, b), 2 h (c, d), 3 h (e, f). Light microscopy (a, c, e), SEM (b, d, f).