Dean&Francis
ISSN 2959-6157

Research on heat treatment of waste asbestos

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Abstract:

The use of asbestos materials in the industry is widespread today. Due to its exceptional high-temperature resistance, affordability, and chemical resistance, asbestos has become a preferred material. If people are exposed to asbestos dust in living environment for an extended period, or if humans experience prolonged exposure to it in the workplace, there is a risk of inhaling asbestos fibers into the lungs, leading to long-term lung damage. Additionally, this exposure can also cause harm to the bronchial tubes and other respiratory system components. Heating asbestos fibers at high temperatures to dissolve them is not a benign method, and the advantages and disadvantages of this approach are thoroughly examined in this article. Regarding asbestos heat treatment, the current feasibility of this method, its advantages and disadvantages are discussed. The advantages and disadvantages of various existing asbestos treatment methods are compared with heat treatment methods. Although there are defects in asbestos heat treatment, through investigation, it is found methods to improve the shortcomings of asbestos heat treatment. Data comparison is conducted to demonstrate the feasibility of asbestos heat treatment methods.

Keywords: heat treatment, advantages, and disadvantages, improve.

1. Introduction

The use of asbestos materials in industry is very common nowadays. Due to its unique high-temperature resistance, affordable price, and chemical resistance, asbestos has become a favored material by people. At the same time, asbestos material also has excellent flexibility, which makes it easy to plasticize. Asbestos materials have various industrial applications, including common use as insulation materials. It is often used to make common products in daily life such as water pipes and firewalls. Furthermore, asbestos is also widely used as a building material, with its presence on roofs, floors, and even walls, thanks to its unique thermal insulation properties. Although asbestos has been proven to cause serious harm to the human body, people have now discovered a reasonable way to use it to keeping people from being exposed to asbestos. Therefore, the focus of this article is not on how to safely use asbestos, but on how to safely handle asbestos after use. This

ISSN 2959-6157

is because the most common asbestos treatment method currently available is landfill, which involves burying and sealing asbestos underground. However, such methods must have their drawbacks, which are the probability of leakage or asbestos infiltration into the soil over time. If asbestos infiltrates into the land, it will remain in the soil for a long time, polluting the land and groundwater, and even disrupting ecological balance. Meanwhile, if it leaks into the air due to air circulation, it will have a huge impact on people's health.

Although there are many methods for dealing with asbestos now, they all have some very serious drawbacks. If asbestos is sealed in a container, people must regularly inspect and maintain the device, which can result in high costs and prevent large-scale implementation. If waste asbestos is recycled, some health risks may arise. If asbestos is dissolved or treated chemically, the cost of chemical agents is very expensive and cannot guarantee the complete safety of the treatment process. In this article, a new asbestos treatment method, namely the heat treatment of asbestos will be investigated. Heating asbestos fibers at high temperatures to dissolve them is not a harmless method, and the advantages and disadvantages of this method are discussed in depth. Finally, a more feasible composite method will be derived [1]. That is, adding oxalic acid when heating asbestos to reduce the temperature required to dissolve asbestos fibers and improve efficiency. If the heat treatment method is used reasonably and its disadvantages are actively improved, energy consumption and other disadvantages can be efficiently solved. It can bring us safer and more efficient methods for disposing of waste asbestos. And the asbestos heat treatment method can better save space, and the space required for the residue after high-temperature heating will be significantly reduced, which will be discussed in this paper.

2. Mechanism of heat treatment of waste asbestos

The mechanism of heat treatment method is very simple. Waste asbestos is rendered harmless by heating it to break down asbestos fibers and organic matter. At high temperatures, asbestos fibers break down into harmless silicon oxides and other chemicals. For the gases generated during the heat treatment process, evolutionary treatment is carried out, and N95 material is usually used to directly block asbestos fibers and help the discharge of gases. According to the data, asbestos will first show an exothermic peak at 410-420 degrees Celsius, then a sharp endothermic peak with weight loss at 895-910 degrees Celsius, and finally a small exothermic peak at 920-960 degrees Celsius, furtherly, a dihydroxylation and crystallization have been discovered at the second and the last peak, respectively [2]. After the dihydroxylation and crystallization, the overall size of the asbestos fiber will disappear, which means the asbestos becomes harmless and can be treated easily. There are a series of testing methods to ensure that asbestos is successfully purified. The density and fiber size of the treated asbestos can be observed under a microscope to ensure the successful treatment of asbestos. It is feasible to determine by testing the content of organic matter, nitrogen oxides, and sulfur dioxide in the treated gas or testing the fiber content in the treated asbestos debris. By comparing the asbestos fibers before and after treatment, we can intuitively observe that the size and morphology of the asbestos fibers have changed after high-temperature heating, from the original fibrous form to a powder form, which demonstrates the effectiveness of the heat treatment method. According to the data, the temperature at which asbestos fibers begin to decompose and dehydrate varies depending on the type of asbestos, but when the temperature is high enough to reach over 1000 degrees, the decomposition of asbestos fibers becomes very thorough. At the same time, experiments have shown that under heating at 700 degrees, the treated waste asbestos material can be recycled once and used as a material for making clinker ceramics, which further improves the feasibility of asbestos heat treatment methods and reducing costs by decreasing the space we need to store the asbestos after heating them [3]. The cost of asbestos heat treatment is influenced by many factors, but overall, the cost of asbestos heat treatment is relatively high compared to other treatment methods. Due to the better dissolution effect of asbestos fibers at temperatures above 800 degrees, the required temperature for asbestos treatment is high, which leads to higher energy consumption and increased costs, approximately $300-500 per ton. At the same time, asbestos heat treatment requires the use of high-temperature furnaces, which have relatively high construction costs. According to data, the cost is approximately $1000-2000 per ton [4]. In addition to equipment and energy consumption, there is also a need for personnel and space costs, as the placement and transportation costs of waste asbestos need to be taken into account. According to data released by the Environmental Protection Agency, the cost of heat treatment for waste asbestos is approximately $1500-3000 per ton and may increase or decrease due to external factors. The relatively high cost is one of the disadvantages of this method, but there are already good solutions to this defect, which will be discussed in detail later.

3. Pro & con of heat treatment

The advantages of the asbestos heat treatment method are very significant. The first and most advantageous advantage is that after the asbestos heat treatment method, the asbestos fibers will be completely removed. This also means that after processing, asbestos will transform into completely harmless substances such as silicon and glass, which can eliminate the danger of asbestos as a hazardous material [5]. At the same time, this will also make subsequent asbestos processing more convenient. Due to the harmless nature of asbestos, post-processing can save a lot of costs such as protective clothing and the additional cost of building closed containers for storing hazardous asbestos. At the same time, heat treatment greatly reduces the danger of asbestos industry to the natural environment and humans. Since asbestos is converted into a non-hazardous substance after heat treatment, there is no risk of environmental harm. Under normal processing conditions, asbestos fibers have the potential to leak into water bodies, land, and even the air, posing a threat to the environment and flora and fauna [6]. However, the asbestos heat treatment method cleverly solves this problem. Simultaneous heat treatment is a more environmentally friendly treatment method, as the treated glass and silicon insomnia residues can be recycled and reused, greatly reducing the cost of asbestos post-processing and cleverly utilizing the debris [7]. The glassy insomnia residue can be used as building materials or in the porcelain firing industry [8]. Asbestos heat treatment solves the problem of hoarding asbestos waste in landfills and other safe enclosed facilities, and cleverly recycles it, making it a more efficient and environmentally friendly method. Almost $50-200 per ton of asbestos landfill costs can be saved.

The main drawback of asbestos heat treatment lies in energy consumption. Due to the unique insulation properties of asbestos, a high temperature of over 800 degrees Celsius is required to dissolve asbestos fibers and make them pollution-free. Asbestos fibers will experience dehydration and dissolution at 800 degrees Celsius, with the best dissolution effect occurring at around 1000-1500 degrees Celsius. The dissolution effect may vary depending on the type of asbestos, but the difference in dissolution effect between 1000-1500 degrees Celsius is not significant [9]. This means that if you want to effectively treat asbestos, temperatures above 1000 degrees Celsius are the most suitable. However, heating the furnace to 1000 degrees Celsius can be quite energy consuming, and after investigation, it has been found that each ton of asbestos heat treatment consumes 2-4 megawatt hours. The maintenance and repair costs of the comprehensive heating container, as well as the electricity cost, will result in a cost of over $500 per ton of asbestos material, according to the Energy Bureau. Simultaneously subjecting asbestos to heat treatment may have some indirect negative impacts on the environment, as heating asbestos may produce greenhouse gases, which can lead to global climate change and other issues. And due to the complexity of the program, the technical requirements for operators will be higher. And any errors in the processing program may lead to serious consequences, such as improper handling of asbestos that leaks into the air and affects human health, or insufficient heating temperature that fails to completely harmless asbestos. Due to the limited use of this technology, it remains to be studied whether the by-products of dissolved asbestos pose long-term harm to the environment and human health.

The advantages and disadvantages of comprehensive heat treatment are that heat treatment methods have better effects, are more environmentally friendly after treatment, and save land resources and some expenses. However, there are also disadvantages such as high energy consumption, potential safety hazards that may not be discovered, and indirect impacts on climate change. Therefore, if we want to better use this method, we need a further solution to address the shortcomings of the method while retaining its advantages. After investigation, it has been found that this can be achieved by using a hybrid method, which will be further discussed in detail later, to address the main drawback of high energy consumption.

4. Treatment costs and performance

4.1 Costs

The cost of asbestos heat treatment is relatively high, and there are several reasons for the high cost. Firstly, the dissolution of asbestos fibers requires high temperatures, which not only consumes energy to heat asbestos, but also requires the construction of high-temperature resistant asbestos treatment containers or reaction devices [10]. And due to the risks involved in the processing steps, the heat treatment of asbestos requires operators to have good behavior norms and skills, which also leads to the need for some funds to train operators. The sum of these expenses will result in higher costs, but the main expense still comes from heating asbestos.

4.2 Performance

The performance of the asbestos heat treatment method is good, and the dehydration state, dissolution, and transformation of asbestos fibers into other substances at high temperatures demonstrate the effectiveness of the asbestos

ISSN 2959-6157

heat treatment method. According to the data, asbestos heating has three stages, namely the peak heat release at 410 ° C to 420 ° C, the peak heat absorption at 895-910 ° C, and the small peak heat release at 920 ° C to 960 ° C. In the latter two stages, asbestos fibers exhibit effective decomposition. Fig. 1 shows the changes in asbestos fibers after heat treatment.

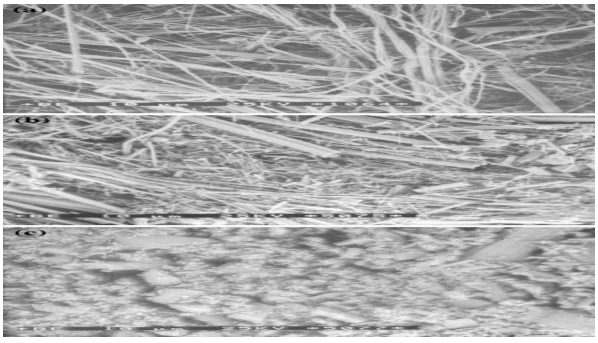

Fig. 1 Changes in asbestos fibers after heat treatment [1]

5. Comparison of different method

There are many existing asbestos treatment methods, but the most commonly used ones include the most mature landfill treatment method, the emerging microbial treatment method, acid dissolution method, and asbestos grinding treatment method. In this section, I will briefly introduce landfill treatment method, grinding treatment method, and acid dissolution method, and compare the treatment efficiency, performance, and other factors of these methods with heat treatment method. Firstly, the landfill treatment method involves placing waste asbestos in a closed container and burying it in the soil. The acid dissolution method uses a large amount of sulfuric acid and oxalic acid to dissolve asbestos into harmless substances, while the grinding treatment method involves repeatedly grinding waste asbestos materials to become harmless. This method is low-cost, but the treatment effect, processing capacity, and speed are lacking compared to other methods, so it is basically used as an auxiliary method. The landfill method is also the most cost-effective treatment method and is known for its mature technology. However, this method is ultimately not a long-term solution, as the landfill method does not completely render asbestos harmless but rather seals it up for burial, which leads to the problem of asbestos leakage still existing. Once asbestos leaks, it will bring serious disasters and hazards [1]. Acid dissolution is known for its powerful dissolution ability, which results in harmless asbestos after treatment. However, the problem with the acid dissolution method is its dangerous handling method. Storing a large amount of strong acid in a large container is very dangerous and produces by-products after dissolution [6]. Small amounts of by-products are easy to handle, but once the acid treatment method is used to process a large quantity of waste asbestos, excessive by-products will become a burden. In contrast, although it has the disadvantage of high cost, the asbestos heat treatment method has a safer treatment process compared to the acid treatment method, higher efficiency and treatment capacity compared to the grinding treatment method, and lower environmental safety hazards compared to the landfill method.

6. Futher trends

The heat treatment method has the disadvantage of high processing costs. If this disadvantage cannot be improved, the heat treatment method is difficult to be widely used. However if mixed methods are used to improve the drawbacks of heat treatment methods, it can achieve the effect of reducing treatment costs [1]. By adding oxalic acid to the heat treatment container and heating it together with waste asbestos material, the dissolution temperature of asbestos fibers can be reduced from 1000 degrees Celsius to around 250 degrees Celsius, thereby achieving energy-saving effects and reducing costs. According to the data, at an acidity of 1.0M and a temperature of 250 degrees, asbestos exhibits good solubility when heated for 1-3 hours. This represents a significant reduction in energy consumption and cost due to high temperatures, making the heat treatment method easier to use.

7. Conclusion

This paper mainly discusses the treatment mechanism, advantages and disadvantages, feasibility, and other aspects of waste asbestos heat treatment methods, and compares the heat treatment methods with existing methods to demonstrate the advantages of heat treatment methods. When comparing, the relatively feasible heat treatment methods were mainly demonstrated from various aspects such as environmental hazards, potential hazards, treatment efficiency, treatment effectiveness, and cost. In terms of advantages and disadvantages, asbestos heat treatment is a double-edged sword. Although it has excellent advantages such as high treatment efficiency and good results, it also has disadvantages such as high treatment costs and environmental side effects. Therefore, when using heat treatment methods, it is necessary to consider multiple factors before making a decision. After research and discussion, in order to make asbestos heat treatment a more usable treatment method in the future, a mixed treatment method has been proposed. By combining chemical

substances such as oxalic acid with the heat treatment method, the treatment temperature can be significantly reduced, thereby reducing energy consumption and costs. Although some existing methods are relatively mature, heat treatment methods, as a relatively new and short-lived approach, still have broad prospects.

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