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Air Pollution Control Equipment in Steam Boiler for Husk as a burning fuel using Bag Filter Housing

Parthiban A , [1] Sriram. R[2] ,Vasanth Kumar .S3

Asst.Professor, Department of Civil engineering Panimalar Engineering College Chennai, India [1].
Student scholar Department of Civil engineering Panimalar Engineering College Chennai, India [2]
Student scholar Department of Civil engineering Panimalar Engineering College Chennai, India [3]

ABSTRACT- *A new technology was recently developed for municipal solid waste incineration (MSWI) fly ash stabilization, based on the employment of all waste and byproduct materials. In particular, the proposed method is based on the use of amorphous silica contained in rice husk ash (RHA), an agricultural byproduct material (COSMOS-RICE project). The obtained final inert can be applied in several applications to produce "green composites". In this work, for the first time, a process for pre-treatment of rice husk, before its use in the stabilization of heavy metals, based on the employment of Instant Pressure Drop technology (DIC) was tested. The aim of this work is to verify the influence of the pre-treatment on the efficiency on heavy metals stabilization in the COSMOS-RICE technology. DIC technique is based on a thermomechanical effect induced by an abrupt transition from high steam pressure to a vacuum, to produce changes in the material. Two different DIC pre-treatments were selected and thermal annealing at different temperatures were performed on rice husk. The resulting RHAs were employed to obtain COSMOS-RICE samples, and the stabilization procedure was tested on the MSWI fly ash. In the frame of this work, some thermal treatments were also realized in O2-limiting conditions, to test the effect of charcoal obtained from RHA on the stabilization procedure. The results of this work show that the application of DIC technology into existing treatment cycles of some waste materials should be investigated in more details to offer the possibility to stabilize and reuse waste.*

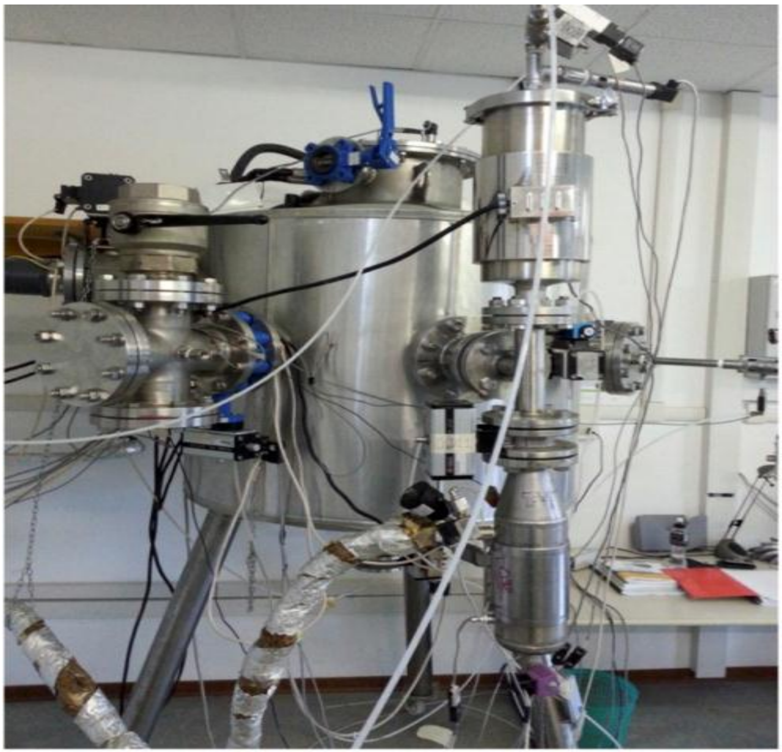
Keywords: fly ash; rice husk ash; DIC; heavy metals stabilization; COSMOS-RICE

1. Introduction

Because of poor combustion efficiency and the lack of air pollution control systems, from its early beginning in the 1870s, waste incineration was considered a very large source of pollution [1]. From 1950, the first efforts to limit the pollution of incinerators were imposed by law [2]. However these first limitations did not consider dust emissions, until 1970, when an aggravation of dust emission standards occurred. As a consequence, in the next years, the development of the air pollution control systems started [1]. Today, while modern waste incineration represents a consolidate technology for volume and mass reduction of the waste, combined with efficient energy recovery and systems to reduce andtreat emissions, some concerns regarding the production of toxic waste still exist. In particular, fly ash generated by the air pollution control systems are hazardous waste materials for which landfilling is still considered the most appropriate management strategy. Indeed, this ash contains leachable toxic metals, as for example Pb and Zn [3]. Great efforts of researchers are now devoted to developing sustainable stabilization technologies able to reuse this toxic ash, also in view of the European need of new solutions for raw materials substitution that are employed in several applications. In recent works, we proposed the use of silica extracted from rice husk ash (RHA) for heavy metals stabilization of municipal solid waste incineration (MSWI) fly ash [4]. The new proposed technology was named COSMOS-RICE. The idea to use this agricultural byproduct is due to its high availability. World rice production in 2011–2012 exceeded 480 million tons [5]. Rice husk constitutes about 20 wt%of the paddy production and it is an abundantly available biomass, commonly employed as a fuel. Its combustion product, rice husk ash (RHA), usually contains more than 60% silica ($SiO2$), and 10%–40% carbon and other minor mineral components. Due to the lower density of RHA, and consequently its bulky form, its disposal can become a problem. In some areas, a large amount of RHA is treated as a waste and landfilled, leading to air and water pollution. Airborne RHA particles have been linked to respiratory disease in humans [6]. Because rice husk is abundantly available and it can be converted into RHA after being subjected to an almost zero-cost thermal valorization process, more and more researchers have become interested in how to use this waste as a resource [7]. The stabilization mechanism involved in the COSMOS-RICE technology was extensively discussed [8]: it is attributed to two different reactions, due to the amorphous silica and carbonation. Indeed, the stabilization mechanism is mainly due to the capability of amorphous silica to entrap heavy metals, but this does not only occur during laboratory treatment, it also proceeds over time thanks to carbonation. The proposed method was very recently improved by the direct use of RHA without passing through silica extraction [8]. Since the organic part of rice husk (RH) can easily be removed by thermal decomposition, thermal treatment of RH is an approach to obtain, not only energy, but also silica from rice husk. Production of biochar from rice husk has also attracted many researchers' attention. This is a versatile material with good adsorption properties. Biochar has a relatively structured carbon matrix with a high degree of porosity and an extensive surface area. It may act as an adsorbent, which is similar in some aspects to activated carbon and it can play an important role in controlling contaminants in the environment [9]. Chemical impregnation with KOH or NaOH of RHA, followed by activation at 650–850 C, generates a material with extremely high surface area [10]. Even though biochar from rice husk has already been employed for removing heavy metals [11], it was never considered in the COSMOS-RICE technology. To also obtain biochar from RHA, pyrolysis of rice husk was realized at 500 C in O2-limiting conditions. To evaluate the effect on heavy metals stabilization by a pre-treatment of rice husk, the employment of Instant Pressure Drop (DIC) technology [12] was proposed for the first time. The DIC technology is based on a thermo-mechanical process that requires some moisture level in the material to be treated. A rapid pressure drop occurs during the material heating, producing bursts of moisture evaporation inside the bulk of material, with the occurrence of a structural damage. It was reported that DIC pre-treatment is able to make a material porous and expanded within short treatment time [13]. This process is based on the use of vacuum and temperature. Moreover, material properties are fundamental for obtaining different final characteristics of the product. Several research papers have been published in recent years exploring the use of DIC technology, in particular for food treatment [14]. Some applications that have been investigated include material sterilization, removal of certain inhibitors in legumes, structural expansion of fruit and vegetables, drying process acceleration, enhancement of extraction of essential oils, coffee extraction, andextraction, and preservation of food materials [15–17]. DIC technology was also applied on rice preservation [18]. However, it was never employed as a pre- treatment of rice husk. This paper reports the first work about the application of DIC as a possible new pre- treatment technology for the waste material. The aim of this project is to obtain a safe filler that can be applied in several application, to produce "green composites". This pioneering work explores the viability of applying DIC technology to pre- treat other waste types.

2. Materials and Method

Rice husk was provided by an Italian factory (Lombardy region). DIC technology is extensively described in several papers (see the Introduction Section). In the present work, we employed an experimental reactor designed and realized by Contento Trade srl. The laboratory DIC plant is composed of a 5 L stainless steel reactor, a refrigerated stainless steel vacuum chamber with 500 L of capacity, a vacuum pump, a steam generator and a steam overheater, and is completely controlled by software developed with Labview. It is able to carry out simple or cyclic DIC tests upto a maximum temperature and pressure of 180°C and 16bar ,respectively



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3. Results and Discussion

Figure 2 shows X-ray diffraction analysis of TQ rice husk ash treated at different temperatures and oven conditions (see Table 1). The XRD patterns of samples T1 and T2 (DIC pre-treated samples), thermally treated in the same conditions are very similar to corresponding reported TQ samples, hence, for the purposes of clarity, they were not shown in the Figure. From XRD patterns shown in Figure 2, it appears that all samples are amorphous, with one peak, due to the presence of a crystalline phase. the complete stabilization of heavy metals does not occur. This is necessary to compare the results obtained by using different RHA pre- treatment conditions and to select the best pre- treatment. After chemical stabilization of heavy metals, the solid inertized material can be washed out to recover almost pure soluble salts [19]. In the present case, salts recovery was not realized. Leaching tests were performed when samples resulted completely dried (30 days after the stabilization treatment). Leaching tests were carried out according to the CEN normative [20], in order to quantify the leachability of heavy metals in water. Tests were performed mixing the dried and homogenized sample with MilliQ water at a liquid to solid kg. The particle size was below 4 mm (with size reduction) and a temperature in compliance with the Directive (about 20 °C). The contact time of materials and aqueous solution was 2 h. This time was considered sufficient to establish equilibrium in subsequent experiments with MSWI fly ash [21]. Chemical analysis of the leachate solution was done by means of Total Reflection X- Ray Fluorescence technique (TXRF) by the Bruker TXRF system S2 Picofox (University of Brescia, Brescia, Italy) (air cooled, Mo tube, Silicon- Drift Detector), with operating values of 50 kV and 750 μA using an acquisition time of 600 s. TXRF quantitative analysis of the suspended samples was performed by the internal standard procedure. A proper amount of gallium, used as an internal standard element, was added [22]. Every analysis has been replicated three times.

Conclusion

Figure 2 shows X- ray diffraction analysis of TQ rice husk ash treated at different temperaturesand oven conditions (see Table 1). The XRD patterns of samples T1 and T2 (DIC pre- treatedsamples), thermally treated in the same conditions are very similar to corresponding reported TQsamples, hence, for the purposes of clarity, they were not shown in the Figure. From XRD patternsshown in Figure 2, it appears that all samples are amorphous, with one peak, due to the presence ofa crystalline phase.

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BIOGRAPHY

Sriram .R , Final year in Civil Engineering, Panimalar Engineering College

Vasanth Kumar .S, Final year in Civil Engineering, Panimalar Engineering College