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Case study

Feasibility of producing nano cement in a traditional cement factory in Iraq

Sada Abdalkhaliq Hasan Alyasri[a], Iyad Salim Alkroosh[a,*], Prabir Kumar Sarker[b]

[a] Department of Civil Engineering, College of Engineering, University of Al-Qadisiyah, Iraq
[b] Department of Civil Engineering, School of Civil and Mechanical Engineering, Curtin University, WA, Australia

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ABSTRACT

This study investigates the economic feasibility of producing nano cement through the establishment of a production line within an existing cement factory. Creating a nano cement production line within the Alkufa Cement factory in Iraq is selected as a case study. Evaluation measures including internal rate of return (IRR), net present value (NPV) and breakeven point (BEP) are used to evaluate the possible gain that can be achieved from this option. The results demonstrated a positive NPV. The IRR is found to be 26.8% and BEP is reached within 3 years after the establishment of the line. This indicates that producing nano cement in the existing cement factory is economically feasible and can be more advantageous than the ordinary cement.

1. Introduction

It is estimated that a total of 4.3 billion tonnes of cement is produced worldwide annually with a rapid increase in demand [1]. The production of such a huge quantity of cement is associated with enormous energy consumption, significant cost and greenhouse gas emissions to the environment. It is therefore necessary to develop alternative binders which are cost effective and more environment friendly. Introducing a new technology to cement manufacturing methods that are consistent with the principles of sustainability can be a proper response to this necessity. Using nanotechnology for producing nano cement may be considered as a potential approach in this regard.

This technology of manufacturing can be achieved by increasing the specific surface area of cement by producing cement particles of nano scale i.e. the particle of size less than 100 nano meter. Increasing the surface area increases the chemical reactivity and nucleation effect, thus improving strength and durability of concrete with less quantity of cement [2–7].

The grains of nano cement are covered by solid shells in the process of grinding (mechanical activation). The shell is a capsule with thickness of several tens of nanometers of modified polymer compound, which imparts a radically new quality to Portland cement and concretes [8,9].

Nanotechnology can help to overcome major environmental challenges by reducing CO_2 emissions and produce cement of better quality. With the use of this technology, the amount of carbon dioxide emitted from cement factories is reduced significantly through reduction of the quantities of produced cement [10–15]. The technology has also been used for producing cement of better properties as a result of incorporating various nanomaterials such as Silicon Dioxide nanoparticles (SiO_2), nano-$CaCO_3$, Carbon nanotubes composite fibers, and Aluminum Oxide nanoparticles (Al_2O_3). The nanomaterials are mainly used to enhance various mechanical properties of the cementations materials: crack resistance, corrosion resistance, tensile strength and compressive strength [16–24].

* Corresponding author.
E-mail addresses: iyad.alkroosh@curtin.edu.au, iyad.alkroosh@qu.edu.iq (I.S. Alkroosh).

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Since 2001, an increased number of researches have been conducted indicating that nanotechnology is a potential alternative to the traditional cement production methods [25–29]. Thus, there is a technical possibility of adopting nanotechnology in cement production. However, in addition to the ongoing scientific research, it is also necessary to study the economic aspects of this alternative in order to evaluate its cost effectiveness. This paper presents a study evaluating the suitability of introducing nanotechnology through the establishment of nano cement production line within a traditional cement factory. The economic feasibility of establishing a production line of nano cement within the Alkufa cement factory of Iraq, using the silica sand, has been studied.

2. Background

In 2012, certification of six types of nano cements was made by Rusnano Ltd verified a full compliance of produced nano cements with general purpose nano cement technical conditions (TU – 5733-067-66331738-2012). At the end of 2014, the national pre-standard 19-2014 (Nanomodified Portland Cement Technical Conditions) was approved by the Russian Federation, and the international nano cements patenting was begun [28]. Sabdonoa et al. [23] found that the nano cement content has significant effect on the compressive strength of mortar. Mistry [30] studied the effect of nano materials on various properties of concrete in comparison with conventional cementations materials. It was shown that the increased surface area of nano materials improved compressive and flexural strengths at early ages, reduced porosity and reduced water absorption.

Bickbau and Shykun [31] showed that the characteristics of ultra-high strength concrete using nano cement was significantly improved. The use of nano cement reduced shrinkage, increased strength, reduced permeability and thus increased the long term durability of concrete.

Bickbau [32] discussed the implementation of the low-clinker nano cements technology and showed that there is a real opportunity to reduce cost per tonne of cement by 40–60 kg unit fuel, improve the cement quality and increase the production in any cement plant without constructing clinker burning steps. This will decrease emissions of the operating cement plants per tonne of nanocement by 30 to 40%. Ikhlef [33,36] provided results of different tests investigated mechanical and physical characteristics of mortars and concretes consisting nano cements. The results showed improvement in water absorption of mortar and concrete. The 28-day compressive strength of concrete increased by 10–65%.

Selvaraj et al. [34] have recently carried out a study of reactivity of nano cement in concrete. They found that 30% replacement of OPC by nano cement led to excellent strength characteristic. Thus, nano cement proved to be an outstanding construction material for many applications in the building industry. Sarsam et al. [35] concluded that the addition of nano coal fly ash or limestone dust in the range of 2–6% as partial replacement of cement shows significant reduction in the water absorption properties of concrete.

The above research works in literature shows the benefits of nano cement in terms of strength and durability of concrete. Thus, a case study has been conducted to investigate the feasibility of the addition of a nano cement product line in an existing conventional cement factory.

2.1. Nano cement manufacturing process

The production of nano cement from sand & clinker is performed by mixing mineral supplement additions such as fly ash and slag or silica sand with crushed and grinded clinker or cement [33,36]. Before processing into the mill which is shown in Fig. 1, the moisture content of the mixture must not exceed 3%. This is achieved by making the mixture passing through a drying unit attached to the production unit. The mixture is grinded for 30 to 40 min in the mill [9]. Finally, nano cement is produced as the output of chemical reaction of clinker particles with a modifier.

As shown in Fig. 2, the production process of nano cement begins with adding a tonne of grinded Portland cement or clinker to a tonne of materials comprising sand or silica sand and polymeric modifier such as sodium naphthalene (FDN – 05) in dry form (polymeric modifier of 0.6%–2.0% and silica sand additive). Then, mineral supplements are added in a form of nuggets (300 mm in diameter) and gypsum of 5% to 6% moisture content (0.3%–6.0% gypsum rock). The output of the process is two tonnes of nano

Fig. 1. Turbine ball mill; (Source: http://www.hxjq-crusher.com/products/chinaware-ball-mill.html).