Egyptian Journal of Petroleum xxx (2017) xxx–xxx

HOSTED BY

Contents lists available at ScienceDirect

Egyptian Journal of Petroleum

journal homepage: www.sciencedirect.com

Full Length Article

The impact of cooling water types on the cement clinker properties

Ahmed M. Shafeek [a,*], Hamdy Salah [b], Nabila Shehata [b], A.B. Saddek [c]

[a] Minia White Cement Plant, Heidelberg Cement Group, Minia, Egypt
[b] Department of Environmental Science, Industrial Development, Faculty of Postgraduates for Advanced Sciences, Beni-Suef University, Egypt
[c] Civil Engineering Department, Faculty of Engineering, Beni-Suef University, Egypt

ARTICLE INFO

Article history:
Received 16 January 2017
Revised 16 March 2017
Accepted 3 April 2017
Available online xxxx

Keywords:
Cement
Nile River
Groundwater
Clinker
Compressive strength

ABSTRACT

This paper studied the influence of the different water types on clinker properties. It concern with cement plants which are using the water for cooling the clinker (El-Minia white cement plant). The water types are Nile, ground and deionized water. The cooling was mad suddenly for clinker by three water types at the same time. The paper discusses the physical and chemical analysis and algal detection of all water types. It also discusses the chemical and physical analysis for kiln feed, clinker. The analysis of water showed that the concentration of dissolved salts in groundwater is higher than Nile water. The concentration of algae gave opposite direction; the algae concentration in Nile water is higher than groundwater. While the deionized is completely free from dissolved salts and algae. The cement tests for clinker which treated by the different water types showed that the cement strength was reducing when used the Nile water with high algae count. From another side, the high concentration of dissolved salts in groundwater does not affect on strength. The water contained the algae prevent the complete crystallization of calcium silicate for clinker. The results also showed that the best type of water, which improved cement compressive strength ranged according to algae count by the sequence deionized water > groundwater > Nile water.

1. Introduction

River Nile is always an important fresh water resource, for Egypt. It is a natural potential source of irrigation, drinking and industry [1]. Groundwater will be an important source of future water supply. The concentrations of anions and cations in the surface Nile water are fit with the standards limits, while they are above the permissible levels in groundwater and are not suitable for drinking and domestic purposes [1,2]. Cement considers the second most consumed substance on the earth after water; each person uses around three tons per year from the concrete. Cement is very important for construction activities, so it is tightly related to the global economy [3]. Cement is a binder, a substance that sets and hardens independently, and can bind other materials together [4].

Portland cement (OPC, Ordinary Portland Cement) is the most common type of cement. It is a basic ingredient of concrete, mortar, stucco and most non-specialty grout. The raw materials for cement production are the mixture (as fine powder in the 'Dry process') of minerals containing calcium oxide, aluminum oxide, silicon oxide, ferric oxide, and magnesium oxide [5]. Clinker is a multiphase mixture and, so far, more than 30 constituent phases have been identified [6]. After high temperature calcinations in a cement rotary kiln, cement clinkers are cooled, the cooling was made by water or air [7]. Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates ($3CaO{\cdot}SiO_2$ and $2CaO{\cdot}SiO_2$), the remainder consisting of aluminum and iron-containing clinker phases and other compounds [5]. Consider

$C2S = Ca_2SiO_4$

$C3S = Ca_3SiO_5$

$C3A = Ca_3Al_2O_6$

$C4AF = Ca_4Al_2Fe_2O_{10}$

White cement is special cements differ from conventional Portland cements in their phase composition and chemical as well as in their properties. Their properties can be achieved by using a modified raw mix, a grinding admixture or by adjusting the grinding

Peer review under responsibility of Egyptian Petroleum Research Institute.
* Corresponding author.
E-mail addresses: A.shafik@suezcem.com (A.M. Shafeek), nabila@psas.bsu.edu.eg (N. Shehata).

http://dx.doi.org/10.1016/j.ejpe.2017.04.003
1110-0621/

Please cite this article in press as: A.M. Shafeek et al., The impact of cooling water types on the cement clinker properties, Egypt. J. Petrol. (2017), http://dx.doi.org/10.1016/j.ejpe.2017.04.003

fineness of the cement. The whiteness is understandably one of the most important properties of white cement. In view of its low iron content the raw material melts at higher temperatures, at 1420–1450 °C [8]. Concrete is one of the major building materials use in modern day construction. It is a composite construction material composed of cement and other cementitious materials such as fly ash and slag cement. Concrete's compressive strength is generally used as a measure of overall concrete quality [9–11]. Water added during cement industry in three stages which are cooling clinker, grinding and during mixing water for making concrete. Most previous studies concerned only with mixing water. Almost the water used as mixing for making concrete should be pure as natural water that is drinkable and has no odor or pronounced taste. High concentration of impurities in mixing water not only effect on concrete strength and setting time, but also may cause corrosion of reinforcement, staining, volume instability, efflorescence, and reduced durability. Therefore, certain optional limits should be set on these impurities especially sulfates, chlorides [12]. Water containing impurities with less than 2000 parts per million (ppm) of total dissolved solids can generally be used without problem for making concrete. The impurities such as alkali carbonate and bicarbonate, chloride, iron salts, tin, manganese, copper, zinc, lead, sulfate, calcium and magnesium carbonates and industrial waste water [12–16]. When pH values are less than 3.0 for acid waters this may create handling problems so should be avoided if possible. Organic acids, for example, Tannic acid, with higher concentration can cause a significant effect on strength [17]. The algae have a high effect on strength where it reduces the strength so the water containing algae is unsuited for making concrete.

The study is aiming to improve the physical properties of cement. By introducing a proposal for using an alternative source for Nile water.

2. Material and methods

2.1. The experimental area

The area under study is El-Minia white cement plant which locates at Bani Khaled, Samalout, El-Minia Governorate. The plant includes industrial processes related to the production of white cement. It is using Nile water at different processes such as cooling clinker in the rotary cooler and at grinding cement through a ball mill. The plant has industrial water treatment unit which is a sand filter.

2.2. Sample collection

The water samples were manually collected during January 2016 (drought period for the Nile) from three different areas which are a – Nile water before and after treating for plant under study b – Groundwater before and after treating from nearby well owned for another cement plant far from the Nile c – deionized water produced from water distillation unit, double distillation (GFL Water-distilling Apparatus 2108).

The water samples were collected in plastic bottles (3.0 L) for chemical analysis. While the samples for algal detection were collected in sterile brown bottles (1 L), fitted with Iodine. The chemical analysis was measured at the laboratory of National Research Centre, water pollution control department. The algal detection were measured at El-Minia laboratory of The Holding Company for Potable Water and Sanitary Drainage.

Clinker samples were manually collected by nontraditional method before rotary cooler as shown in Fig. 1. Every clinker sample divided into three identical samples in order to standardize the samples and to avoid any changes. The three samples will be cooled suddenly at the same time by three different water types separately. The amount of water which used for clinker cooling are equal amounts for all samples, it around 600 ml of water for each kg from clinker. The sampling repeated three times every time clinker treated with the different water types.

2.3. Analysis

2.3.1. Water analysis

2.3.1.1. In situ measurements. The temperature (°C) was measured by using an ordinary dry mercury thermometer.

2.3.1.2. Laboratory measurements.

2.3.1.2.1. The algal detection. Enumeration of phytoplankton concentration was measured by Microscope, (Model Leica CM-E). The analysis was carried out according to APHA [18].

2.3.1.2.2. Physico-chemical analysis and heavy metals. The hydrogen ion concentration (pH) was measured by using pH meter, (Model Jenway 3510). Total solids (TS), volatile suspended solids (VSS), total dissolved solids (TDS), total suspended solids (TSS) and oil & grease were measured by gravimetric methods. Conductivity (EC) was measured by using Conductivity meter, (Model Jenway 3110). Turbidity was measured by using turbidity meter, (Model Turbo Direct). The color was measured by using UV–VIS

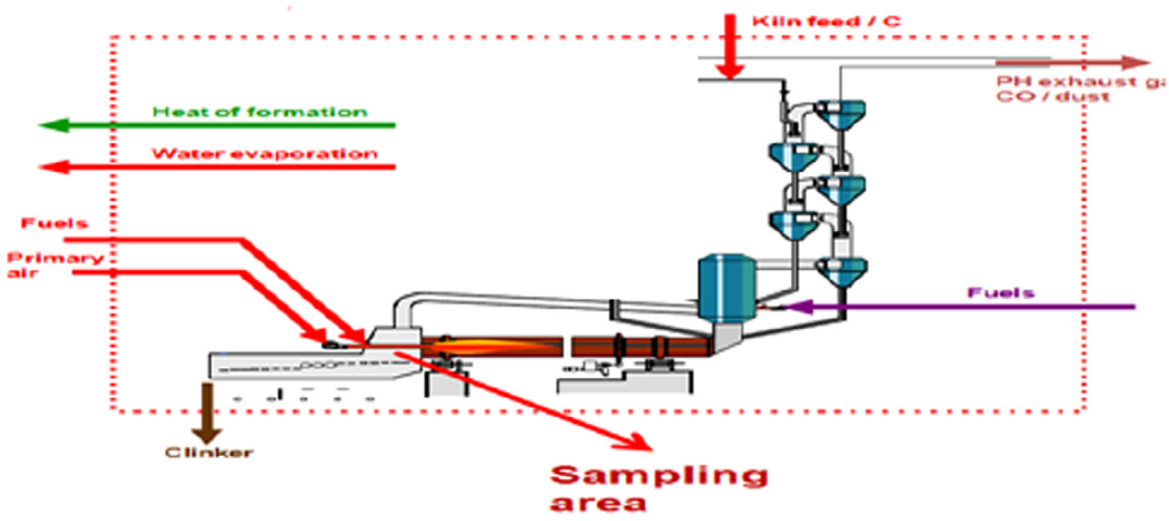

Fig. 1. Nontraditional methods for clinker sampling.

Please cite this article in press as: A.M. Shafeek et al., The impact of cooling water types on the cement clinker properties, Egypt. J. Petrol. (2017), http://dx.doi.org/10.1016/j.ejpe.2017.04.003