
A Method and Apparatus for Processing Water Treatment Residuals

Description

FIELD OF THE INVENTION

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This invention relates to a method and apparatus for processing water treatment residuals or other amorphous aluminium oxide or aluminium hydroxide rich waste residuals to provide raw materials for use in the manufacture of hydraulic binders for construction and related applications, in particular calcium aluminate

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containing hydraulic binders.

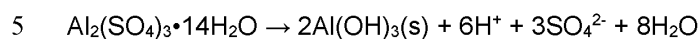
BACKGROUND OF THE INVENTION

Water treatment residuals (hereinafter referred to as WTR or residuals) is a

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waste material from the industrial purification of drinking water by coagulation

using a flocculant, typically comprising aluminium compounds such as aluminium sulphate ($\text{Al}_2(\text{SO}_4)_3 \cdot 14\text{H}_2\text{O}$), commonly referred to as Alum, or ferric aluminium sulphate (ferrum). Coagulation removes particles suspended in natural, untreated water. The chemical reaction involved comprises:



The coagulated solids are separated from the treated water to form an aluminium rich waste slurry, referred to as WTR. WTR consist of water, organic material, remnant flocculant and other minor components. There are currently few viable recyclable options for this material,
10 much of which ends up in landfill. This type of waste is generated worldwide and the ability to recycle it would have global appeal. However, WTR is a good source of amorphous aluminium oxide and/or amorphous aluminium hydroxide.

Therefore, it is an object of the present invention to provide a method for processing water
15 treatment residuals and an apparatus for processing water treatment residuals that do not have these drawbacks or at least partially do not have these drawbacks.

SUMMARY OF THE INVENTION

20 This object is solved by the patent claims. Therefore, this object is solved by a method for processing water treatment residuals with the features of independent claim 1 and an apparatus for processing water treatment residuals with the features of independent claim 20. Further details of the invention unfold from the dependent claims as well as the description and the drawings. According to the invention, features and details which are
25 described in connection with the method for processing water treatment residuals also apply in connection with the respective apparatus for processing water treatment residuals according to the invention and vice versa, such that according to the disclosure of the single aspects of the invention it can always be reciprocally related to.

30 As previously mentioned, the term "water treatment residuals" can be understood in particular as drinking water treatment residuals, which can be purified much more easily than other residuals, such as waste water treatment residuals or the like, in particular because

they are less contaminated. Because of the different ingredients of drinking water and wastewater, these (drinking water / wastewater) are not directly comparable.

5 The term "amorphous" can be understood and explained in particular with respect to the degree of crystallisation. The degree of crystallization can thereby serve as a measure of the amorphous character of a material, the properties being anti-proportional to one another. In particular amorphous aluminium oxide or aluminium hydroxide rich waste residuals according to the invention have a degree of crystallisation of less than 25 wt.%, preferably less than 20 wt.%, in particular less than 15 wt.%. The degree of crystallization can be
10 measured, for example, by spectroscopic methods, DSC measurements or X-ray diffraction experiments.

According to a first aspect of the present invention there is provided a method for processing water treatment residuals or other amorphous aluminium oxide or aluminium hydroxide rich
15 waste residuals for use in the manufacture of hydraulic binders, said method comprising heating the residuals to remove water and oxidise organic material contained therein, comprising controlling the temperature of the residuals such that they are heated to a temperature no higher than 800°C.

20 Preferably the method comprises controlling the temperature of the residuals such that they are heated to a temperature no higher than 700°C, more preferably no higher than 650°C.

Preferably the method comprises controlling the temperature of the residuals such that they are heated to a temperature between 350°C and 650°C, more preferably to a temperature
25 between 400°C and 500°C.

By controlling the temperature of the residuals, any aluminium oxide or aluminium hydroxide in the residuals remains in its amorphous and therefore reactive state and therefore remains useful in the manufacture of hydraulic binders.

30 Optionally the residuals may be heated in a heating chamber, the temperature of the residuals being controlled by the addition of air and/or water to the chamber and/or by

controlling the heat supplied to the heating chamber by a heating means by a temperature control means.

5 Preferably air is added to the heating chamber at a rate adapted to ensure that substantially all organic material in the residuals are oxidised.

10 The residuals within the heating chamber may be heated indirectly by heating an exterior of the heating chamber and/or the exterior of the heating chamber is heated by means of burners acting directly on the exterior of the heating chamber.

15 Preferably the heating chamber is located within a heating jacket receiving hot gases from a burner.

20 Preferably the residuals are at least partially dewatered prior to heating. The residuals may be dewatered via a mechanical process, such as a belt dryer and/or rotary dryer. Preferably the residuals are dewatered to have a water content of between 20% and 40%.

25 Preferably, the residuals may be milled and/or ground after heating to a particle size of 40 microns or approximately 40 microns.

30 Further advantages can be achieved, when the residuals may be hydrated after heating to convert amorphous aluminium oxide to amorphous aluminium hydroxide.

In addition, it is advantageous, when the residuals, in particular after heating, may be mixed with a source of calcium ions and a source of sulphate ions in the presence of water to form ettringite. For example, the residuals, in particular after heating, may be mixed with Portland cement, hydrated lime and calcium sulphate in the presence of water.

Moreover, it is advantageous, if the residuals, in particular after heating, may be mixed with a source of calcium ions in the presence of water to form calcium aluminates.

Further it is advantageous, when the residuals may be mixed with a source of calcium ions and a source of sulphate ions in the presence of water to form calcium aluminates and calcium sulphoaluminates.

- 5 According to a further aspect of the present invention there is provided an apparatus for processing water treatment residuals or other amorphous aluminium oxide or aluminium hydroxide rich waste residuals for use in the manufacture of hydraulic binders, comprising a heating chamber within which the residuals can be heated, means for heating the heating chamber and means for controlling the temperature therein.

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Additionally it is advantageous, that the apparatus is configured to perform the method according to the first aspect. Thus, an apparatus in accordance with the invention has the same advantages as described in detail above regarding the inventive method. An apparatus designed in this way is particularly advantageous because it allows for the use of water
15 treatment residuals in the manufacture of hydraulic binders for construction and related applications, in particular calcium aluminate containing hydraulic binders.

- Furthermore, it is advantageous, when the heating chamber may be heated by burners acting against an outer wall of the heating chamber and/or the heating chamber may be
20 heated by ducting hot gases from a combustion chamber into a heating jacket surrounding the heating chamber.

- Preferably means are provided for adding air to the heating chamber. Preferably combustion gases from the heating means may be used to pre-heat the air added to the heating
25 chamber.

Moreover, it is advantageous, when the heating chamber may be adapted to be rotated during heating.

- 30 Alternatively or additionally it is advantageous, when the heating chamber comprises a tubular drum mounted for rotation about a longitudinal axis and having an inlet at one end and an outlet and an opposite end.

It can further be possible that the apparatus may further comprise a dewatering means upstream of the heating chamber for reducing the water content of the residuals.

5 It can also be possible, if the apparatus may further comprise a milling and/or grinding means downstream of the heating chamber for reducing the particle size of the residuals after heating.

Preferably the temperature control means is adapted to limit the temperature of the residuals to no more than 700°C, more preferably to no more than 650°C.

10 In addition, it is advantageous, if the temperature control means may be adapted to control the temperature of the residuals in the heating chamber to between 350°C and 650°C, more preferably to between 400°C and 500°C.

15 BRIEF DESCRIPTION OF THE DRAWINGS

Further advantages, features and details of the invention unfold from the following description, in which by reference to drawings working examples of the present invention are described in detail. An inventive method and apparatus for processing water treatment
20 residuals or other amorphous aluminium oxide or aluminium hydroxide rich waste or water treatment residuals (hereinafter referred to as "residuals") in accordance with embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which :-

25 Figure 1 is a schematic view of an apparatus for processing residuals in accordance with the present invention; and

Figure 2 is a transverse sectional view through the apparatus of Figure 1.

30 DETAILED DESCRIPTION OF THE DRAWINGS

A method for processing residuals in accordance with an embodiment of the present invention will now be described, by way of example. The method comprises the steps of :-

1. Moisture Removal: residuals from a water treatment process or other amorphous aluminium oxide or aluminium hydroxide rich waste residuals may be initially filter pressed in filter beds, typically at the water treatment plant, whereby the moisture content of the residuals may be reduced to 60-80%. Further moisture is preferably removed by mechanical drying, for example using a belt dryer or rotary dryer, or drying using solar energy under poly tunnels, to produce residuals having a water content of between 20% and 30%.

2. Thermal Treatment: The partially dried residuals are then heated to between 350°C and 800°C to remove (burn off) organic carbon content without reaching a temperature high enough to convert amorphous Aluminium Oxide or Aluminium Hydroxide present in the residuals to its crystalline unreactive state. The equipment used for the thermal treatment step may comprise an indirect rotary calciner, as illustrated in the drawings (although other thermal treatment technologies are envisaged).

The optimum processing temperature is preferably no higher than 800°C, more preferably no higher than 650°C, to ensure that aluminium compounds in the residuals, in particular aluminium oxide and aluminium hydroxide, remain in an amorphous state. At temperatures greater than 800°C such amorphous aluminium compounds begin to convert to a crystalline unreactive form. Based on carbon removal efficiency balanced against cost the preferred thermal treatment temperature is between 400°C and 500°C.

As shown in the drawings, heating may be carried out in a drying chamber 2 of an indirect rotary calciner, wherein the products of combustion do not come into direct contact with the residuals being treated. Heat is transferred to the residuals by conduction and radiation through the wall of the drying chamber 2. The drying chamber 2 may be heated by burners 4 positioned in a heating jacket 6 around the outer wall of the drying chamber 2, as illustrated in Figure 1, or by the use of a separate combustion chamber from which hot gases are ducted to the heating jacket 6 mounted around the drying chamber 2. Additional process air A is preferably blown into the drying chamber to provide additional oxygen for complete combustion of organic material within the residuals. The added air may also be used to control the temperature within the chamber. The process air may be introduced to the drying chamber via an air sparge pipe 8. Each kg of carbon requires 2.67 Kg of O₂ for complete

combustion. Therefore a process air flow rate of 9m³ of air per hour per kg of carbon in the feed slurry is preferred.

It is envisaged that a heat exchanger may be used to recover heat from a combustion
5 exhaust to pre-heat the process air before it enters the drying chamber.

As illustrated in Figure 2, the drying chamber 6 may be rotated and may contain paddles 10 to break up and mix the residuals during heating.

10 3. Milling: After the thermal treatment the residuals, in the form of ash, are ground or milled, preferably to particle sizes of approximately 40 micron.

4. Hydration: The above process will form a product that contains amorphous aluminium oxide which can be successfully used as a component in cementitious binder. However, for
15 some applications amorphous aluminium hydroxide is required. In such cases the product may be hydrated much in the same way as powdered hydrated lime is produced from lime. Hydration may happen before or after the milling stage.

A source of calcium ions may be added to the residuals, preferably after heating or
20 alternatively before heating, to form calcium aluminates in the presence of water.

The residuals typically have a calorific value of around 7MJ/Kg and as a result may provide a source of fuel during combustion.

25 The removal of organic material from the residuals is important for almost all successful applications of the resulting product, in particular as a raw material for the manufacture of hydraulic binders.

As previously mentioned the product produced from the processed residuals consists
30 predominately of amorphous aluminium oxide and/or amorphous aluminium hydroxide (typically 75 to 80% amorphous aluminium oxide). The remaining components (primarily varying amounts of quartz, iron oxide and some residual carbon) are essentially inert fillers.

The amorphous aluminium oxides/hydroxides remaining in the treated residuals can react to form cementitious minerals.

Ettringite ($\text{Ca}_6[\text{Al}(\text{OH})_6]_2(\text{SO}_4)_3 \cdot 26\text{H}_2\text{O}$) may be formed when the treated residuals are mixed
5 with a source of calcium ions (e.g. Portland cement, hydrated lime) and a source of sulphate ions (e.g. calcium sulphate) in the presence of water.

Calcium aluminate hydrates may be formed when the treated residuals are mixed
10 with a source of calcium ions (e.g. Portland cement, hydrated lime) in the presence of water.

The exact formulations used to manufacture cementitious materials will depend on the chemical composition of the residuals and the specific industrial application.

It is envisaged that one application of the processed residuals may be used in the
15 manufacture of floor screed. It has been found that the processed residuals, particularly in the form of Ettringite, exhibit shrinkage compensating characteristics. As such, the product produced from the processed residuals can be a direct competitor to Portland cement or anhydrite based screeds.

20 Laboratory trials have indicated that the residuals could also be thermally treated in the presence of hydrated lime or calcium carbonate to form calcium aluminates, such as mayenite. The consequent calcium aluminates can also be utilised in the above mentioned applications.

25 The invention is not limited to the embodiments described herein but can be amended or modified without departing from the scope of the present invention as defined in the appended claims.

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