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(54) USE OF AN ADDITIVE COMPOSTION FOR CEMENTING BORE WELLS

(71) Applicant: MEGA-TECH HOLDING B.V.

(72) Inventor: Robin de La Roij, Zwijndrecht (NL)

(73) Assignee: MEGA-tech Holding B.V.

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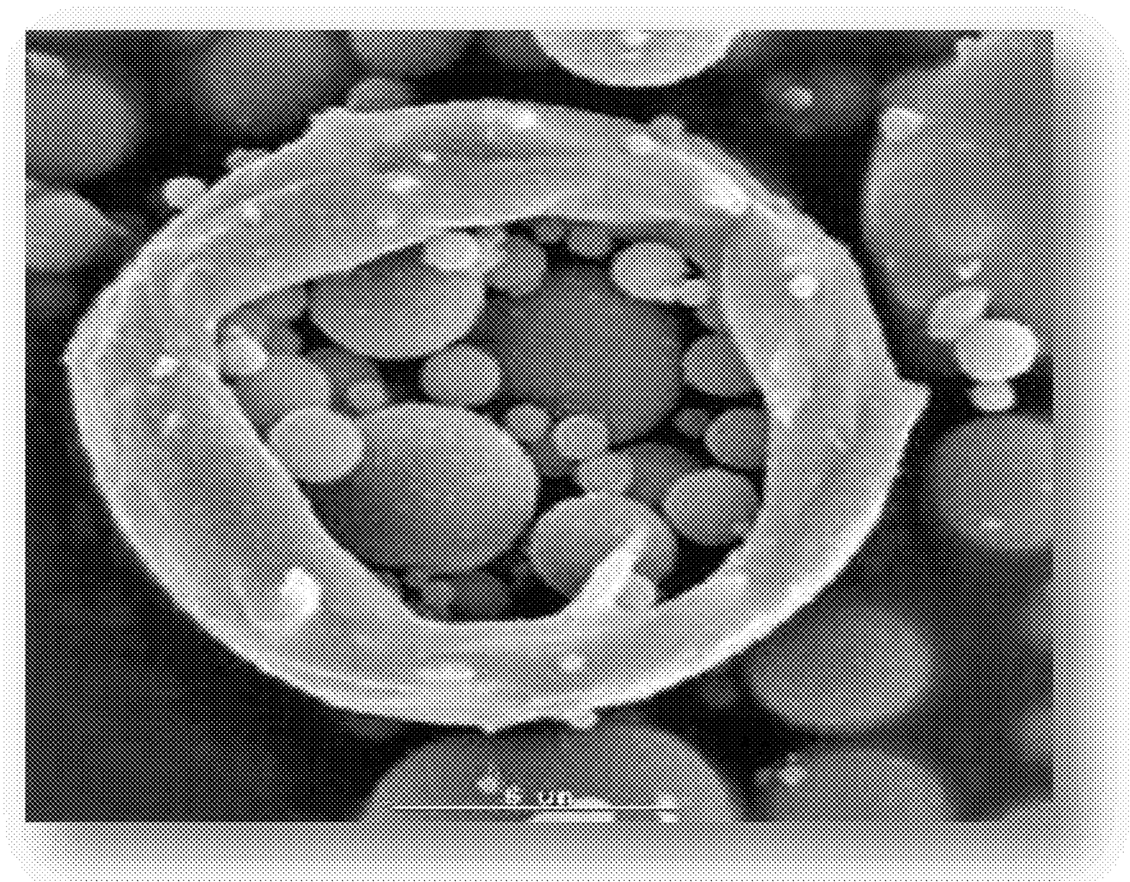
(57) ABSTRACT

The present invention relates to the use of a composition for reinforcing cement, which comprises one or more compounds selected from group: a) sodium chloride, potassium chloride, magnesium chloride, calcium chloride, strontium chloride, barium chloride and ammonium chloride; b) aluminum chloride; and comprises one or more compounds selected from c) silica, zeolite, and apatite for cementing a wellbore. Moreover, the present invention relates to a cement slurry for cementing a wellbore, comprising I): cement; II) water; and III) a composition for reinforcing cement. In addition, the present invention relates to a method of cementing a wellbore.



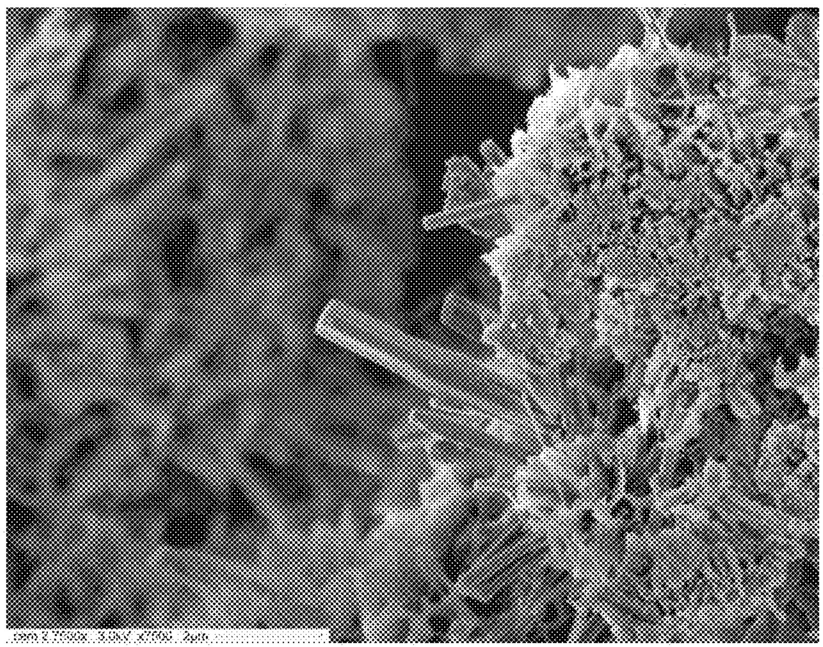


FIG. 1

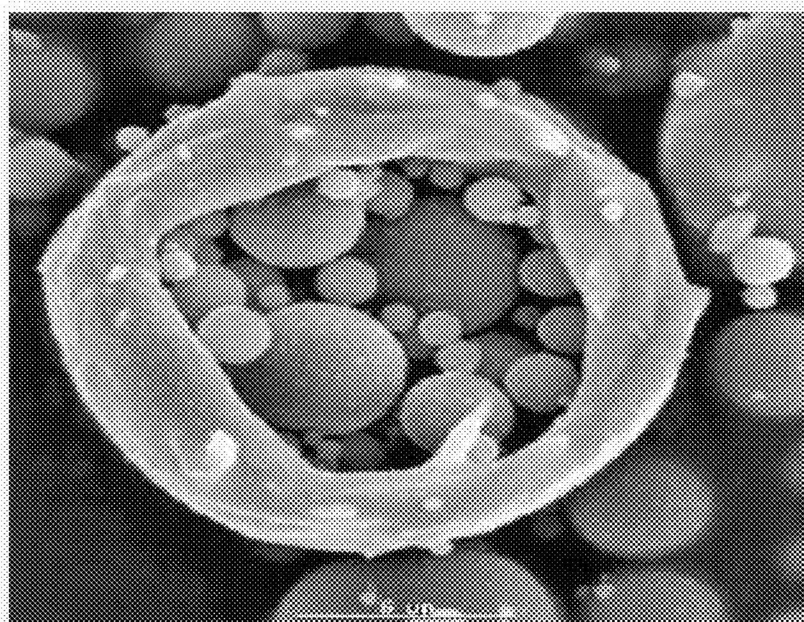


FIG. 2

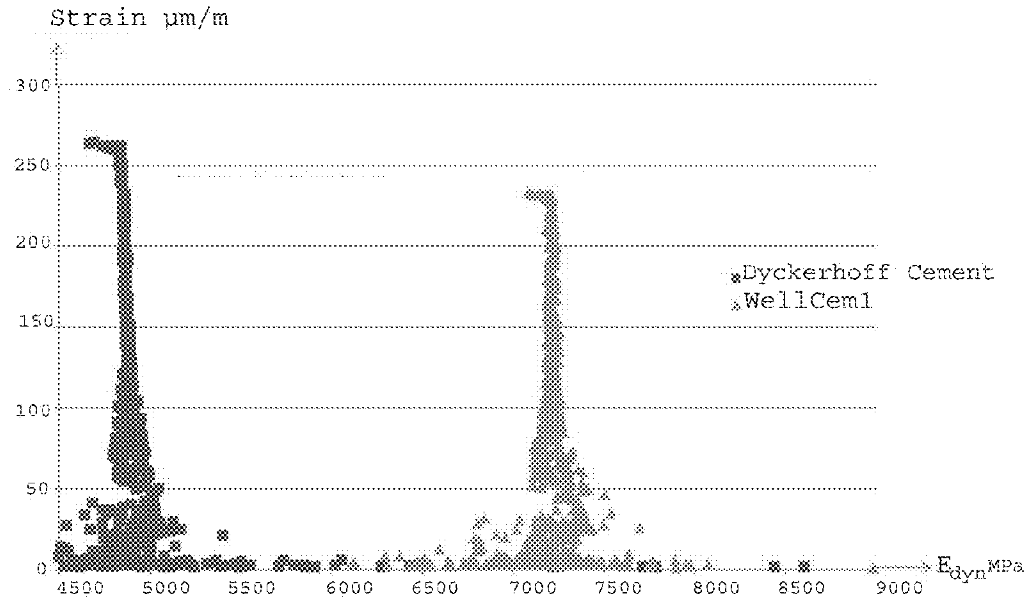

Strain µm/m
300
250
200
150
100
50
0
4500
5000
5500
6000
6500
7000
7500
8000
8500
9000
E_{dyn} MPa
Dyckerhoff Cement
WellCem1

FIG. 3

USE OF AN ADDITIVE COMPOSTION FOR CEMENTING BORE WELLS

RELATED APPLICATION

[0001] This application is a continuation-in-part of U.S. application Ser. No. 13/540,181, filed Jul. 2, 2012. The entire teaching of the above application is incorporated herein by reference.

BACKGROUND OF THE INVENTION

[0002] Patent EP 1 349 819 (corresponding to U.S. Pat. No. 7,316,744) of the present inventor discloses a composition for reinforcing cement, which contains: a) sodium chloride, potassium chloride, magnesium chloride, calcium chloride, strontium chloride, barium chloride and/or ammonium chloride; b) aluminum chloride; and c) silica and/or zeolite and/or apatite. This reference is incorporated herein in its entirety.

[0003] The composition for reinforcing cement according to EP 1 349 819 is commercially available from PowerCem Technologies B.V. under the registered trade names of PowerCem and RoadCem. In a preferred embodiment of EP 1 349 819 the additive composition comprises a combination of sodium chloride, potassium chloride, ammonium chloride, magnesium chloride, calcium chloride, aluminum chloride, silica, magnesium oxide, magnesium hydrogen phosphate, magnesium sulphate, sodium carbonate and cement.

[0004] The composition for reinforcing cement, according to EP 1 349 819, shows excellent performances in, for example, the field of road construction, soil consolidations (i.e. before drilling into the soil) and concrete for flyovers.

SUMMARY OF THE INVENTION

[0005] The present inventor has discovered a new cementing composition and a new use for the cited additive composition.

[0006] The present invention relates to the use of an additive composition for cementing wellbores. Moreover, the present invention relates to a cement slurry for cementing a wellbore, comprising: I) cement; II) water; and III) a composition for reinforcing cement. In addition, the present invention relates to a method of cementing a wellbore.

[0007] The present invention is related to the use of a composition for reinforcing cement, which comprises: a) one or more compounds selected from sodium chloride, potassium chloride, magnesium chloride, calcium chloride, strontium chloride, barium chloride and ammonium chloride; b) aluminum chloride; and c) one or more compounds selected from silica, zeolite, and apatite; for cementing a wellbore.

[0008] In an embodiment of the present invention, the composition comprises at least sodium chloride and calcium chloride from group a).

[0009] In an embodiment of the present invention, the composition contains silica and/or zeolite.

[0010] In an embodiment of the present invention, the composition comprises 45 to 90% by weight of the compound or compounds from group a); 1 to 10% by weight of the compound from group b); and 1 to 10% by weight of the compound or compounds from group c); based on the total weight of groups a+b+c.

[0011] In an embodiment of the present invention, the composition comprises 45 to 90% by weight of the compound or compounds from group a); 1 to 10% by weight of the compound from group b); and 1 to 10% by weight of the compound or compounds from group c); based on the total weight of the composition.

[0012] In an embodiment of the present invention, the composition also comprises magnesium oxide and/or calcium oxide.

[0013] In an embodiment of the present invention, the composition comprises sodium chloride, potassium chloride, magnesium chloride, calcium chloride, ammonium chloride, aluminium chloride, magnesium oxide, and silica and/or zeolite.

[0014] In an embodiment of the present invention, group c) consists of silica.

[0015] In an embodiment of the present invention, the composition further comprises magnesium hydrogen phosphate, magnesium sulphate and/or sodium carbonate.

[0016] Moreover, the present invention relates to a cement slurry for cementing a wellbore, comprising: I) cement; II) water; and III) a composition for reinforcing cement, which comprises: a) one or more compounds selected from sodium chloride, potassium chloride, magnesium chloride, calcium chloride, strontium chloride, barium chloride and ammonium chloride; b) aluminum chloride; and c) one or more compounds selected from silica, zeolite, and apatite; for cementing a wellbore.

[0017] A cement slurry is wet cement obtained by mixing dry cement and water and optionally one or more additives.

[0018] All embodiments described above for the use also apply to the cement slurry and method for cementing a wellbore and vice versa.

[0019] In an embodiment of the cement slurry, said slurry comprises between 50 and 85 wt %, preferably between 65 and 75 wt % of: I) cement, and between 20 and 40 wt %, preferably between 25 and 30wt % of; II) water, and between 0.1 and 10 wt %, preferably between 1 and 3 wt %, more preferably between 1.5 and 2.5 wt % of composition III).

[0020] In addition, the present invention relates to a method of cementing a wellbore, comprising the steps of: i) drilling a wellbore; ii) introducing a casing string into the wellbore; iii) preparing a cement slurry based on a combination of cement and the composition for reinforcing cement, which comprises: a) one or more compounds selected from sodium chloride, potassium chloride, magnesium chloride, calcium chloride, strontium chloride, barium chloride and ammonium chloride; b) aluminum chloride; and c) one or more compounds selected from silica, zeolite, and apatite, for cementing a wellbore; iv) pumping said cement slurry into the wellbore; and v) allowing said cement slurry to set.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021] FIG. **1** shows a Scanning Electron Microscopic photograph of hardened cement slurry according to the present invention showing nanoscopic crystalline structure.

[0022] FIG. **2** shows a Scanning Electron Microscopic photograph of hardened cement slurry according to the prior art without the presences of the additive.

[0023] FIG. **3** shows a graph of the strain (in micrometers per meter) on the ordinate (y-axis) and the dynamic modulus of elasticity or E_{dyn} (in Mega Pascal) on the abscissa (x-axis) for a sample according to the present invention and a reference sample.

DETAILED DESCRIPTION OF THE INVENTION

[0024] One important use of concrete or cement in the oil and gas field is so-called "well cementing" or the cementing of the drilling or oil well. For this use deep bores are drilled into the ground or soil. The inside of these bores are covered by a metallic layer or pipe that is used to guide the oil from the oil field up to the surface. These metallic layers should adhere to surrounding environment (i.e. soil or rock). In order to obtain this adhesion between the metallic layer (casing or casing string) and the surroundings cement is often used.

[0025] Wellbores are protected and sealed by cementing, i.e. for shutting off water penetration into the well, to seal the annulus after a casing string (viz. a long section of connected oilfield pipe) has been introduced down the wellbore, or to plug a wellbore to abandon it.

[0026] Cementing is carried out using a cement slurry that is pumped into the well. In this method, usually the drilling fluids that are present inside the well are replaced by cement. The cement slurry fills the space between the casing and the actual wellbore, and hardens to create a seal. This prevents external materials entering the well flow. This cementing also positions the casing string into place permanently.

[0027] The term cement is understood to refer to a salt hydrate consisting of a fine-ground material which, after mixing with water, forms a more or less plastic mass, which hardens both under water and in the outside air and which is capable of bonding materials suitable for that purpose to form a mass that is stable also in water. The cement standards according to European standard NEN-EN-197-1 are as follows: CEM I is Portland cement; CEM II is composite Portland cement; CEM III is blast furnace slag cement; CEM IV is pozzolan cement and CEM V is composite cement.

[0028] The wet cement (viz. cement slurry) is obtained by the use of mixers (e.g. hydraulic jet mixers, re-circulating mixers or batch mixers) from water and dry cement and one or more additives.

[0029] For wellbore cementing Portland cement is most frequently used (calibrated with additives to 8 different API classes). Examples of additives are accelerators, which shorten the setting time required for the cement, as well as retarders, which do the opposite and make the cement setting time longer. In order to decrease or increase the density of the cement, lightweight and heavyweight additives are added. Additives can be added to transform the compressive strength of the cement, as well as flow properties and dehydration rates. Extenders can be used to expand the cement in an effort to reduce the cost of cementing, and antifoam additives can be added to prevent foaming within the well. In order to plug lost circulation zones, bridging materials are added, as well.

[0030] The present invention provides a very special additive for cement to be used for wellbores.

[0031] A method for well cementing is known in the art. After the casing string has been run into the well, a cementing head is attached to the top of the wellhead to receive the slurry from the pumps. A so-called bottom plug and top plug are present inside the casing and prevent mixing of the drilling fluids from the cement slurry. First, the bottom plug is introduced into the well, and cement slurry is pumped into the well behind it, viz. within the casing and not yet between the casing and its surroundings. Then the pressure on the cement being pumped into the well is increased until a diaphragm is broken within the bottom plug, permitting the cement slurry to flow through it and up the outside of the casing string, viz. outside of the casing and hence between the casing and its surroundings. After the proper volume of cement is pumped into the well, a top plug is pumped into the casing pushing the remaining slurry through the bottom plug. Once the top plug reaches the bottom plug, the pumps are turned off, and the cement is allowed to set.

[0032] Since wellbores are very deep, setting or hardening at deep depths and under conditions of high temperature and/or high pressure, and optionally corrosive environments, there are stringent requirements for the cement.

[0033] A few of the challenges today with respect to well cementing are discussed below.

[0034] Despite recent technological advances with elastomers, polymers, fibres and reactive components that self-heal micro fissures, the cement sheath between the casing string and the surrounding rock and/or soil is not always able to deliver an acceptable long-term solution for today's demanding drilling environment. Changes in down hole conditions with pressure and temperature fluctuations impose stresses on the cement sheath. Consequently, shrinking and de-bonding of the cement sheath creates very small micro cracks allowing fluid migration which is undesirable. Besides these external forces that cause cement sheath damage an evaluation of conventional oil well cement sheath on the nanoscopic scale from 1-100 nm reveals that the chemical bond between components within the cement itself is relatively brittle.

[0035] Examples of the challenges are: i) micro cracks occurring because of fluctuations in pressure and/or temperature inside the well; ii) undesired gas migration due to shrinkage or expansion of the cement; iii) corrosion of the protective casing, which costs hundreds of millions and which reduces longevity.

[0036] There are several demands required in the field of well cementing, viz. with respect to density, permeability, shrinkage, bonding, chemical resistance, setting time, viscosity, flexibility, and durability. Moreover, downhole temperature can exceed 200° C.

[0037] An example of preferred product criteria for cement for wells are the following:

- **[0038]** Density: value <1300 kg/m^3
- **[0039]** Permeability: material has to be impermeable
- **[0040]** Shrinkage: material may not shrink, expansion is preferred
- **[0041]** Bonding: good bond required with steel
- **[0042]** Chemical resistance: high chemical resistance required
- **[0043]** Thickening time: materials needs to be workable up to 6 hours
- **[0044]** Viscosity: preferably 300 CP
- **[0045]** Flexibility: stretch of 2% without fracturing

[0046] Known Portland cement consists of five major compounds and a few minor compounds. The composition of a typical Portland cement is as follows: 50 wt % of tricalcium silicate (Ca_3SiO_5 or $3CaO.SiO_2$); 25 wt % of dicalcium silicate (Ca_2SiO_4 or $2CaO.SiO_2$); 10 wt % of tricalcium aluminate ($Ca_3Al_4O_6$ or $3CaO.Al_2O_3$); 10 wt % of tetracalcium aluminoferrite ($Ca_4Al_2Fe_2O_{10}$ or $4CaO.Al_2O_3.Fe_2O_3$); 5 wt % of gypsum ($CaSO_4.2H_2O$).

[0047] Without wishing to be tied to any specific theory, experimental results indicate that the components which are present in the composition for reinforcing cement used in the present application form crystalline structures when added to cement material which crystalline structures are well bonded together and are homogeneously distributed, in between the cement particles, and thereby bind the cement particles. This is clearly visible in FIG. **1**. FIG. **1** shows a Scanning Electron Microscopic photograph of hardened cement slurry according to the present invention showing nanoscopic crystalline structure. A cement mixture has been prepares and allowed to set. Samples of this hardened cement were prepared and measured using SEM by the Nanolab of the Radboud University Nijmegen.

[0048] Hardened cement which is prepared without this binder or with known binders has a relatively open structure when viewed on a microscopic scale, with crystalline agglomerations which are not homogeneously distributed. This is clearly visible in FIG. **2**. Consequently, the interaction between the crystalline agglomerations and also between the cement particles and the crystalline agglomerations is poor.

[0049] The crystalline compounds which are formed by this additive (and which are shown in FIG. **1**) are surprisingly homogeneously distributed and may be in the form of acicular (viz. needle-like) structures. The homogeneous distribution of the crystalline structures results in an optimum strength and stability. The water in the cement is bound in, and to, the crystalline structures. Consequently, there are no local concentrations of water, and therefore the formation of potential weak spots is avoided. The crystalline structures comprise, inter alia, zeolite and/or apatite compounds. Zeolites are a widespread group of silicate crystals of, inter alia, hydrated alkali metal and alkaline earth metal aluminosilicates. Apatites belong to the group of strontium, barium or calcium halophosphates, the halogen ion usually being a chloride or fluoride, but which may also be substituted by a hydroxyl group. The formation of these structures is one of the reasons why silicon, aluminum and/or phosphate compounds are added to the composition.

[0050] Without wishing to be bound to a theory, the following is observed. When water is added to cement, each of the compounds undergoes hydration and contributes to the final product. Only the calcium silicates contribute to strength. Tricalcium silicate is responsible for most of the early strength during first 7 days. Dicalcium silicate, which reacts more slowly, contributes only to the strength at later times. Upon the addition of water, tricalcium silicate rapidly reacts to release calcium ions, hydroxide ions, and a large amount of heat. The pH quickly rises over 12 because of the release of alkaline hydroxide (OH^-) ions. This initial hydrolysis slows down quickly with a corresponding decrease in heat.

[0051] The reaction slowly continues producing calcium and hydroxide ions until the system becomes saturated. Once this occurs, the calcium hydroxide starts to crystallize. Simultaneously, calcium silicate hydrate begins to form. Ions precipitate out of solution accelerating the reaction of tricalcium silicate to calcium and hydroxide ions, also called Le Chatelier's principle. The evolution of heat is then dramatically increased again.

[0052] The formation of the calcium hydroxide and calcium silicate hydrate crystals provide "seeds" upon which more calcium silicate hydrate can form. The calcium silicate hydrate crystals grow thicker which makes it more difficult for water molecules to reach the anhydrate tricalcium silicate. The speed of the reaction is controlled by the rate at which water molecules diffuse through the calcium silicate hydrate coating. This coating thickens over time causing the production of calcium silicate hydrate to become slower and slower. The majority of space is filled with calcium silicate hydrate, what is not filled with the hardened hydrate is primarily calcium hydroxide solution. The hydration will continue as long as water is present and there are still anhydrate compounds in the cement paste.

[0053] Dicalcium silicate also affects the strength of concrete through its hydration. Dicalcium silicate reacts with water in a similar manner as tricalcium silicate, but much more slowly. The heat released is less than that by the hydration of tricalcium silicate because the dicalcium silicate is much less reactive. The other major components of Portland cement, tricalcium aluminate and tetracalcium aluminoferrite also react with water. Heat is evolved with cement hydration. This is due to the breaking and making of chemical bonds during hydration.

[0054] The strength of cement bound products is very much dependent upon the hydration reaction just discussed. Water plays a critical role, particularly the amount used. The strength of the product increases, when a lower amount of water is used. The hydration reaction itself consumes a specific amount of water. The empty space (porosity) is determined by the water to cement ratio. The water to cement ratio is also called the water to cement factor (abbreviated by wcf) which is the ratio of the weight of water to the weight of cement used in the slurry. The wcf has an important influence on the quality of the cement produced.

[0055] Low water to cement ratio leads to high strength but low workability. High water to cement ratio leads to low strength, but good workability. Time is also an important factor in determining product strength. The product hardens as time passes. The hydration reactions get slower and slower as the tricalcium silicate hydrate forms. It takes a great deal of time up to several years for all of the bonds to form, which eventually determines the product's strength for the life of the well.

[0056] When the composition according to the present invention is used as additive, moisture remains necessary for hydration and hardening. The five major compounds of the hydration process of cement still remain the most important hydration products but the minor products of hydration probably change. Furthermore, the rate at which important hydration reactions occur and the relative distribution of hydration products changes as a result of the addition of the present inventive composition. In addition, the crystallization of calcium hydroxide accordingly occurs at different rates and the reduction of heat generation from the hydration reactions occurs. There are more crystals formed during the reactions and the relevant crystalline matrix is much more extensive.

[0057] When adding the present composition, the water changes chemically in sphere, electrical load, surface tension and reaches a chemical/physical equilibrium in the matrix. This complex process depends of the type and mass of materials involved in the cement slurry. Similar to the chemical processes physical aspects are part of the equilibrium process in the matrix when the amount of water, trapped as free water is reduced and the crystals grow into the empty void space. This makes the product less permeable to water and more resistant to all types of attack that are either water dependant or water influenced. A bigger fraction of the water is converted to crystalline water than is the case with the reactions in the absence of the present inventive composition. The reduced porosity and increased crystalline structural matrix increases compressive, flexural and breaking strength of the product and change the relative ratio between these strengths.

[0058] As before, the strength of the product increases when less water is used to make a product. The hydration reaction itself now tends to consume a different amount of water. When the present inventive composition is mixed with oil well cement it is also possible to use salt water and achieve a good end result.

[0059] The empty space (porosity) is still determined by the water to cement ratio but is affected to a lesser extent as a result of the increased rate and extent of the crystallization process.

[0060] The extended crystallization process changes significantly with the present inventive composition. The present inventive composition causes a physio-chemical equilibrium in the oil well cement slurry based on synergy between water percentage and API Class G oil well cement. This is followed by changes in the chemical and physical properties of the cement slurry, first from hydrophilic then into hydrophobic. As a result, strong hydrogen bonds form which make a significant contribution to the bonding forces. The binding mechanism changes from "glue" to "wrapping" and the cement slurry exhibits a crystalline structure that is able to partially block capillary pores. Because of this fiber-like structure, it becomes flexible and prevents micro cracking from occurring.

[0061] Further research indicated that only part of the present composition is involved in the chemical reaction. The remaining part is buffered in the pore structure and remains active, even after 90 days, still able to actively react within the silicate-containing matrix. During this period the remaining active composition of the invention subsequently participates in the continued formation of a crystalline structure, improving durability.

[0062] Tests from independent laboratories have indicated special properties that could not be attributed to conventional cement. The special properties are improved fatigue values, higher compressive strength, chemical durability and even fire resistance. The process continues for up to 180 days, further improving the physical properties until the matrix is fully saturated with the durable crystalline structure (FIG. **1**) (Picture taken by Nanolab, Radboud University of Nijmegen).

[0063] The compressive strength of set cement is an indication of the cement's resistance to failure in compression. Cement must be strong enough to support the casing in the hole, withstand the shocks of drilling and perforating, and support high hydraulic pressure without fracturing. The compressive strength test determines the strength of set cement under downhole conditions. This property is measured in pounds per square inch (psi). The compression strength of conventional cement decreases in time with an increase in permeability. This is not observed with a cement obtained by the cement slurry of the present invention.

[0064] A low density cement is particularly preferred to be able to pump cement slurry, especially at higher temperatures. The additive composition lowers the density of cement slurry, which is an advantage. Moreover, the present composition improves the bonding with water, which is an advantage over traditional oil well cement. The crystallization process actually results in an expansion of the cement since it obtains a higher volume with same mass.

[0065] With respect to the permeability, it can be observed that the cement slurry when mixed with the present composition obtains, after curing, a higher density due to crystallization of water. Based on the fact that the water content in the slurry bonds much better in the modified crystal matrix that is obtained due to the presence of the present composition. Over time the remaining part of the present composition is buffered in the pore structure and is even after months still able to actively react within the matrix. This results in a reduction in capillary forces while the crystalline structure keeps growing. The presence of the nanostructures (i.e. modified crystal matrix) by use of the present composition also has been observed to lead to higher chemical resistance values (i.e. that chemicals in the soils are not damaging the cement), and to a reduced shrinkage during the expansion process.

[0066] The crystallization process of the cement sheath at a scale of 1-100 nanometers shows that elements cross-link and create long needle crystalline structures that interlock, block the capillary pores, and enhance dynamics and chemistry of the cement hydration process. As a result, the molecular structure changes with hydrogen bridges in a stable, locked position. It is important to recognize that the mechanical properties of a cement bound material are determined during the first hours of the binding and during the first 48 hours of the hardening stage. Consequently, if a modification of the cement hydration process is required to enhance the structural, mechanical and chemical resistance behaviour of the cement sheath, it has to take place within 72 hours.

[0067] The above is in sharp contrast with conventional oil well cement slurries which still depend on the calcium silicate hydrate (C-S-H) matrix and cement hydration process where only a few chemical reactions take place.

[0068] To prevent excessive shrinkage of cement, it is important to design a cement slurry that is able to absorb pull and tensile forces. The inventor has succeeded in this by using the present composition.

[0069] As discussed above a good bonding is required to steel. The present inventor has proven increased binding to a steel casing using the composition according to the present invention. Without wanting to be bound to a theory, it is proposed that this is due to the effect that crystals are allowed to grow under normal circumstances of e.g. temperature in the formation (due to the available moisture in formation).

[0070] An additional advantage of the composition used in the present invention is that it is easy to handle and can be provided in ready-to-mix bags.

[0071] An additional advantage of the present composition is that it allows more moisture to be mixed in the cement slurry than with traditional cement which ensures a higher viscosity. The present composition affects the viscosity of the cement bound material. Normal cement shows a lower viscosity and therefore has more character. With the present composition a higher viscosity will be achieved which results in a higher flexural behaviour.

[0072] When the composition of the present invention is used in well cement, it is possible to add fine cohesive material to the cement slurry. The use of the present composition can increase the flexibility up to for example 2000 mm/m compared to normal cement having a value of only 150 mm/m. A person skilled in the art can custom engineer the slurry in order to optimize the flexibility and stiffness.

[0073] The present applicant has carried out the following tests in a laboratory: energy absorption, flexibility, tensile strength, and compressive strength. The results are provided below.

[0074] FIG. **3** shows the flexibility after 24 hours of hardening. FIG. **3** shows a graph of the strain (in micrometers per meter) on the ordinate (y-axis) and the dynamic modulus of elasticity or E_{dyn} (in Mega Pascal) on the abscissa (x-axis) for a sample according to the present invention and a reference sample. A reference sample comprising only cement and water (Dyckerhoff cement) is shown in dark grey color and a sample according to the present invention comprising cement, water and the present composition (Wellceml)

[0075] (PowerCem of Powercem Technologies B.V.) is shown in light grey color. It is clearly visible that the ratio of dynamic modulus of elasticity to strain (E_{dyn}*strain) is much higher for the slurry according to the present invention (viz. 1.74×10^6) than that for the reference slurry (1.3×10^6).

[0076] Table 1 below shows the makeup of the reference cement and the slurry according to the present invention.

TABLE 1

Material	Reference cement (in kg)	Slurry according to the invention (in kg)
Cement (API Class G by Dyckerhoff)	12.5	12.5
Additive composition	—	0.375
Water	4.75	4.75

[0077] The components of the additive composition are set forth in Table 2:

Component	Quantity (% by weight of total additive composition)
NaCl (techn. pure)	32.4
NH_4Cl (techn. pure)	1.1
$AlCl_3$•$6H_2O$ (extra pure)	3.2
KCl (techn. pure)	17.3
$CaCl_2$•$2H_2O$ (techn. pure)	16.2
$MgCl_2$•$6H_2O$ (techn. pure)	17.3
MgO (pure)	2.2
$MgHPO_4$•$3H_2O$ (techn. pure)	3.2
$MgSO_4$•$7H_2O$ (techn. pure)	2.7
Na_2CO_3 (techn. pure)	3.2
Amorphous SiO_2 (5-40 m)	1.1

[0078] The wcf (water cement factor or water cement ratio) for the slurry according to the present invention is 0.38. This wcf is the ratio of the weight of water to the weight of cement used in the slurry and has an important influence on the quality of the cement produced. The test results after 24 hours are provided below in Table 3.

TABLE 3

Test	Reference cement	Slurry according to the invention	Difference ( ))
Bending force	3.1 N/mm^2	4.5 N/mm^2	+45%
Compressive strength	13.4 N/mm^2	20.9 N/mm^2	+56%
Average density	1947 kg/m^3	1917 kg/m^3	−1.5%

The result of this comparative research shows major differences between the samples of API Class G and nano-engineered API Class G cement (viz. the slurry according to the invention). Test data show higher bending forces from the nano enhanced oil well cement as well as significantly stronger values for compressive strength.

[0079] It can be concluded that the addition of the present composition to a cement slurry for well cementing provides a higher Dynamic Elastic modulus (E_{dyn}) (measured according to ASTM E1875-08) and a higher flexibility (E_{dyn}/Breaking strain). Thus, there is less chance of the formation of cracks on both short and long term. Moreover, the compression strength and the breaking strength are increased with the use of the present composition as well as the chemical resistance, viscosity, and permeability after hardening.

[0080] Mechanical properties tests of the newly created oil well cement show a fundamental change in the molecular structure. The creation of a dense crystalline mineral fibre structure tightly knits the materials together. Resulting into the introduction of significant ductility and tensile strength increase, thus greatly reducing cracking and blocking the capillary pores of the cement sheath. The present invention is further explained in the appended claims.

[0081] While this invention has been particularly shown and described with references to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the scope of the invention encompassed by the appended claims.

1. Use of a composition for reinforcing cement, which comprises:

one or more compounds selected from group: a) sodium chloride, potassium chloride, magnesium chloride, calcium chloride, strontium chloride, barium chloride and ammonium chloride; b) aluminum chloride; and comprises one or more compounds selected from c) silica, zeolite, and apatite for cementing a wellbore.

2. Use of a composition according to claim **1**, in which composition the compounds from group a) contains at least sodium chloride and calcium chloride.

3. Use of a composition according to claim **1**, said composition comprising 45 to 90% by weight of group; a) 1 to 10% by weight of group b) and 1 to 10% by weight of the components from group c), based on the total weight of groups a+b+c.

4. Use of a composition according to claim **1**, which composition also contains magnesium oxide and/or calcium oxide.

5. Use of a composition according to claim **1**, said composition containing sodium chloride, potassium chloride, magnesium chloride, calcium chloride, ammonium chloride, aluminium chloride, magnesium oxide and silica and/or zeolite.

6. Use of a composition according to claim **1**, wherein group c) consists of silica.

7. Use of a composition according to claim **1**, which composition comprises magnesium hydrogen phosphate, magnesium sulphate and/or sodium carbonate.

8. Cement slurry for cementing a wellbore, said cement slurry comprising:

I) cement; II) water; and III) a composition for reinforcing cement, which comprises one or more compounds selected from group: a) sodium chloride, potassium chloride, magnesium chloride, calcium chloride, strontium chloride, barium chloride and ammonium chloride; b) aluminum chloride; and comprises one or more compounds selected from; c) silica, zeolite, and apatite.

9. Cement slurry for cementing a wellbore according to claim **8**, comprising between 50 and 85 wt %, preferably between 65 and 75 wt % of I) cement, and between 20 and 40 wt %, preferably between 25 and 30 wt % of II) water, and between 0.1 and 10 wt %, preferably between 1 and 3 wt %, more preferably between 1.5 and 2.5 wt % of composition III).

10. A method of cementing a wellbore, comprising the steps of: i) drilling a wellbore; ii) introducing a casing string into the wellbore; iii) preparing a cement slurry based on a combination of cement and the composition for reinforcing cement, which comprises one or more compounds selected from group: a) sodium chloride, potassium chloride, magnesium chloride, calcium chloride, strontium chloride, barium chloride and ammonium chloride; b) aluminum chloride; and comprises one or more compounds selected from c) silica, zeolite and apatite; iv) pumping said cement slurry into the wellbore; and v) allowing said cement slurry to set.

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