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(54) **METHOD OF HARDENING A FLUID MASS**

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(57) **ABSTRACT**

A method of hardening a fluid mass in contact with a wall, in a desirable shape. According to the invention, the fluid mass is a magneto-rheological fluid mixture that in addition to at least one hardening component comprises a particulate magnetic component, with minimally 80% of said particles having a particle size of at least 0.0005 mm, and a magnetic field is applied for a length of time that suffices to achieve the desired strength by hardening in the absence of a magnetic field.

METHOD OF HARDENING A FLUID MASS

[0001] The present invention relates to a method of hardening a fluid mass in contact with a wall.

[0002] Such a method is generally known, for example, for setting concrete. With some applications a force is exerted during setting, which results in the fluid mass setting in an undesirable shape. With some applications it is further desirable for the fluid mass to be able to bear a force as soon as possible after its delivery to the chosen place. An example of such an application is the introduction of a pipe structure in bore holes. Such a pipe structure is needed to prevent the collapse of the bore hole. A cylindrical metal pipe is lowered into the bore hole to the desired depth, after which cement is pumped via the bore hole through the lowered pipe. Via the bottom end of the pipe the cement flows upward around the outer wall of the pipe. This provides a seal around the pipe. In a soil stratum comprising high-pressure gas the gas may penetrate into the not yet set cement, thereby weakening it. This phenomenon is called gas migration. Due to the weakening it becomes possible for gas to escape from the bore hole in an uncontrolled manner.

[0003] It is the object of the present invention to provide a method allowing a force to be applied to the mass even while the fluid mass is setting, without causing it to set in an undesirable shape. It is a further object to provide a method by which, after the delivery of the fluid mass in the chosen place, the delivered mass is able to bear a force.

[0004] To this end the method according to the present invention is characterised in that the fluid mass is a magnetorheological fluid mixture that in addition to at least one hardening component comprises a particulate magnetic component, with minimally 80% of those particles having a particle size of at least 0.0005 mm,

[0005] the fluid mixture is brought into a desired shape, and

[0006] a magnetic field is applied for a sufficient length of time to achieve the desired strength by setting in the absence of a magnetic field.

[0007] By applying a magnetic field it is possible to prevent the fluid mass from acquiring an undesirable shape before setting, while achieving that it is able to bear a force immediately after application.

[0008] According to a first embodiment, the hardening component comprises a fluid cement or fluid concrete.

[0009] Such a method is useful for the problems of gas migration described above. The wall is formed by a part of the casing of the bore hole, and possibly also by the rock surrounding it. When speaking of a desired shape in the present invention, it is not necessary for the entire shape of the set fluid to be known beforehand, rather it suffices if at least a part has a desired shape, as in this case determined by the wall of the casing. In addition, the method is useful for civil engineering constructions such as buildings and tunnels. The method is believed to be especially advantageous if these are made by means of slide forming. The method is also useful for forming concrete construction elements such as floor and wall components and piles. The resulting elements can be taken from the place of manufacture to another site sooner, for example to a site where they are allowed to finish setting.

[0010] U.S. Pat. No. 4,802,534 describes a method in which a cement-comprising fluid is used to provide a bored well with cement. The cementitious fluid is a ferrofluid comprising particles up to 4000 Å. A ferrofluid is a fluid that can move under the influence of a (alternating) magnetic field. In contrast with the composition described in U.S. Pat. No. 4,802,534, the method according to the invention makes it possible to prevent gas migration and the ensuing weakening. Experiments have shown that by applying a magnetic field according to the invention, the viscosity of the mixture was increased by a factor of >25.

[0011] According to an alternative embodiment the hardening component is molten plastic, and hardening occurs as a result of the molten plastic cooling down.

[0012] This method makes it possible among other things to manufacture large thermoplastic objects that may be removed from the mould quickly.

[0013] For the manufacture of plastic products the hardening component may comprise a polymerisable compound, which is cured by means of polymerisation. Instead of that, or in addition, the curing component may comprise a cross-linkable polymer, and curing occurs by cross-linking of the polymer.

[0014] The magnetic component may be any magnetic component, e.g. a paramagnetic component, and preferably a ferro-magnetic component. It will be clear to the person not skilled in the art that the amount of magnetic component may vary widely, depending on the requirements with regard to mouldability during curing. Furthermore, if the content of magnetic component is low, a stronger magnetic field may be applied, and vice versa. The fluid mixture suitably comprises 2 to 50% vol./vol., and preferably 10 to 45% vol./vol. of a magnetic component chosen from iron, cobalt and/or vanadium.

[0015] According to common practice in the art, the percentage relates to the weight of the particles. The size of at least 80% of the particles of the particulate component is between 0.0005 and 5 mm, preferably between 0.005 and 0.5 mm.

[0016] It is essential that the particles exhibit sufficient interaction (cohesion/adhesion) with the surrounding curable fluid to influence the flow behaviour. The viscosity must be increased at least ten-fold, at the chosen field intensity. The particles may optionally be provided with a coating, or included in a larger object such as a sphere. Optionally, a coating may be provided to protect the particles from oxidation. In this way a limited amount of the actual magnetic component may still have a considerable effect on the fluid mass, and this may be cost-effective.

[0017] During hardening, the applied magnetic field usually has an intensity of at least 0.01 Tesla, and preferably at least 0.05, for example 0.05 to 0.5 Tesla.

[0018] Obviously, a suitable magnetic field depends on the fluid mass in question. Simple experiments will enable the ordinary person skilled in the art to determine a suitable magnetic field intensity. Lower contents of magnetic particles will generally require higher magnetic field intensities.

[0019] If the magnetic field is generated electrically, it is possible to save electricity by initially applying a stronger magnetic field, and reducing the intensity once the fluid

mass is set to some extent. With slide forming techniques a permanent magnet may be used, which will gradually become further removed from fluid mass applied earlier, and which is thus in a more advanced stage of hardening.

[0020] According to one particular embodiment the fluid mixture is supplied via a nozzle that is screened from a magnetic field.

[0021] This makes it possible to have a permanent magnetic field without impeding the supply of fluid mixture. A suitable screening material is mu-metal.

[0022] The invention also relates to the use of a magneto-rheological fluid mixture that, in addition to at least one hardening component, comprises a particulate magnetic component to prevent gas migration in cement during the application and/or setting of cement around a pipe for the formation of a cylindrical wall part of a bored well.

[0023] Finally, the invention relates to a magneto-rheological composition capable of hardening.

What is claimed is:

1. A method of hardening a fluid mass in contact with a wall, wherein the fluid mass is a magneto-rheological fluid mixture that in addition to at least one hardening component comprises a particulate magnetic component, with minimally 80% of those particles having a particle size of at least 0.0005 mm, and wherein:

- the fluid mixture is brought into a desired shape, and
- a magnetic field is applied for a sufficient length of time to achieve a desired strength by hardening in the absence of a magnetic field.

2. A method according to claim 1, wherein the hardening component comprises a fluid cement or fluid concrete.

3. A method according to claim 1, wherein the hardening component is molten plastic, and hardening occurs as a result of the molten plastic cooling down.

4. A method according to claim 1, wherein the hardening component comprises a polymerisable compound, which is cured by means of polymerization.

5. A method according to claim 1, wherein the hardening component comprises a cross-linkable polymer, and curing occurs by cross-linking of the polymer.

6. A method according to claim 1, wherein the fluid mixture comprises 10% to 45% vol./vol. of a magnetic component chosen from the group consisting of iron, cobalt and vanadium.

7. A method according to claim 1, wherein minimally 80% of the particles of the particulate component have a particle size between 0.005 to 0.5 mm.

8. A method according to claim 1, wherein during hardening, the applied magnetic field has an intensity of at least 0.05 Tesla.

9. A method according to claim 1, wherein the applied magnetic field is initially stronger, and its intensity is reduced once the fluid mass is set to some extent.

10. A method according to claim 1, wherein the fluid mixture is supplied via a nozzle that is screened from a magnetic field.

11. The use of a magneto-rheological fluid mixture that, in addition to at least one hardening component, comprises a particulate magnetic component to prevent gas migration in cement during the application and/or setting of cement around a pipe for the formation of a cylindrical wall part of a bored well.

12. A magneto-rheological composition capable of hardening.

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