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DEVITRIFICATION OF CAST STONES

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The present invention relates to a method of devitrification of cast stone, and more particularly it relates to the devitrification of cast stone made from natural stone.

During the cooling of technically molten natural stone such as diabase, melaphyre, basalt, porphyry and the like, a vitreous layer usually having a thickness of several millimeters is formed on the surface of such cast stone. By X-ray analysis it has been found that this vitreous outer layer nearly in all cases is of uniform glass-like structure and does not contain any crystals, crystallites or crystal nuclei. Also, when viewing a thin section of the cast stone under highest possible magnification, a vitreous outer zone is found.

This glass layer or vitreous zone on the surface of the cast stone greatly reduces the usefulness thereof. Consequently many attempts have been made to prevent formation of the vitreous outer layer or to remove the same during the smelting process. For instance it has been attempted to obtain a crystalline surface layer by the addition of easily volatilizable components such as borates or fluorides. However such attempts were not successful, particularly not when undertaken on a large scale industrial operation. Other additions as well as normal tempering also did not lead to satisfactory results.

It is therefore an object of the present invention to devise a method whereby cast stone having a crystalline structure throughout can be produced.

It is another object of the present invention to provide a method for changing the vitreous outer layer into a crystalline structure in a simple and economical manner.

It is yet another object of the present invention to provide a method for the production of cast stone characterized by great hardness of the outer layer thereof.

Other objects and advantages of the present invention will become apparent from a further reading of the description and the appended claims.

With the above and other objects in view, the present invention mainly comprises in a process of forming a devitrified cast stone, the step of maintaining the cast stone at the recrystallization temperature of the dominant mineral phase thereof until substantially all of the dominant mineral phase has been recrystallized.

According to a preferred embodiment, the present invention also contemplates in a process of forming a cast stone from a natural stone including a dominant mineral phase and also including at least one additional mineral phase having a recrystallization temperature lower than the recrystallization temperature of said dominant mineral phase, the steps of casting the stone, cooling the cast stone below the recrystallization temperatures of the mineral phases, heating the stone to the recrystallization temperature of the dominant mineral phase, maintaining the stone at the recrystallization temperature of the dominant mineral phase until substantially all of the dominant mineral phase has been recrystallized, cooling the stone below the recrystallization temperature of the additional mineral phase, heating the stone to the recrystallization temperature of the additional mineral phase, and main-

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taining the stone at the recrystallization temperature of the additional mineral phase until substantially all of the additional mineral phase has been recrystallized, whereby a devitrified cast body is formed of the natural stone.

Thus, the present invention deals with the problem to develop a method which will prevent the formation of a vitreous layer or zone on the surface of the molten stone during solidification thereof, or to transform any such vitreous layer which might have been formed during cooling of the molten zone, into a crystalline structure. Accordingly, it may be said that the process of the present invention attempts to accomplish exactly the opposite of what is attempted in the glass and enamel manufacture. While in the glass and enamel manufacture crystallization is to be retarded, the present invention provides for heating up and enhancing the crystallization of the material, particularly the outer layer of the previously molten stone.

According to the present invention, the devitrification of technically molten stone is accomplished by reheating of the melt after a short time cooling such as for instance takes place during pouring into molds, to the recrystallization temperature of the dominant mineral phase or component of the specific stone, and by maintaining the cast stone at such recrystallization temperature for a sufficiently long period to allow for recrystallization of the major portion of the dominant mineral phase.

The method of the present invention, while not being limited to specific raw materials, has been found particularly advantageous for the treatment of cast stone made of natural plutonic rocks, i.e., igneous rocks which have solidified at great depth, such as pyroxenite, peridotite, hornblende, and of natural stones belonging to the group of volcanic rocks, i.e., igneous rocks that have been poured out or ejected at or near the earth's surface, such as stones belonging to the basalt-family, diabase, melaphyre, palagonite, trap, and feldspathoid-basalts.

In this connection, reference is made to some of the texts which describe natural rocks of the types contemplated herein, such as "Igneous Minerals and Rocks," by Wahlstrom (John Wiley and Sons, 1947); "A Descriptive Petrography of the Igneous Rocks," by Johannsen (The University of Chicago Press, 1937); "Eruptive Rocks," by Shand (John Wiley and Sons, 1947); "Theoretical Igneous Petrology," by Wahlstrom (John Wiley and Sons, 1950); "Theoretical Petrology," by Barth; and "Igneous Rocks," by Iddings (John Wiley and Sons, 1909).

The dominant mineral phases for the individual natural stone are well known, generally the dominant mineral phases belong to the group of either ferromagnesium-aluminum-silicates, particularly in the case of pyroxene, and amphibole minerals. To a lesser degree also alkali-earth alkali-aluminum-silicates form the dominant mineral phase.

The smelting temperature ranges of the various natural stones as well as the recrystallization temperature for the different mineral phases are well known, the smelting range for diabase for instance being approximately between 1,120° C. and 1,140° C. and the smelting range for pyroxenite being between about 1,230° C. and 1,265° C.

According to the method of the present invention which as stated above can be carried out in connection with a great variety of different stone types, it is possible to achieve perfect results, i.e., to completely transform the vitreous outer layer of the cast stone into a crystalline structure. This surprising result of the present invention can easily be determined by X-ray analysis. The temperature to which the preliminarily cooled cast stone has to be heated and the period of time for which the stone has to be maintained at such raised temperature de-

pendes obviously on the specific composition of the stone. In such cases where the stone contains in addition to the dominant mineral phase also a second mineral phase or several subordinate mineral phases of different recrystallization temperatures and where the recrystallization temperatures of the subordinate mineral stones are below the recrystallization temperature of the dominant mineral zones, it is preferred according to the method of the present invention, to cool the cast stone after recrystallization of the dominant mineral phase thereof to a temperature below the recrystallization temperature of the subordinate mineral phase and subsequently to reheat the cast stone to the recrystallization temperature of the subordinate mineral phase in order to achieve in addition to recrystallization of the dominant mineral phase also recrystallization of the subordinate mineral phase. Whether recrystallization of one or more subordinate mineral phases is necessary at all or to what degree it has to be completed depends on the specific composition of the stone, particularly on the quantitative relationship between the dominant and subordinate mineral phases.

The following examples are given as illustrative of the method of the present invention only, the present invention however not being limited to any specific details of the examples.

Example 1

A diabase-melt is poured into a mold. Thereby the melt is cooled and a glassy layer or vitreous zone is formed on the surface thereof. After the thus-formed cast stone has cooled to about 450° C., the same is reheated in two steps to the recrystallization temperature of the dominant mineral phase, in the present case to the recrystallization temperature of pyroxene, i.e. to a temperature of between about 910 and 960° C., preferably to a temperature of between 920 and 950° C. The entire cast stone is maintained at this temperature range for a period of about one hour. During this time, all of the glassy outer layer will be transformed into crystals which predominantly consist of pyroxene, as can easily be shown after the subsequent complete cooling of the cast stone.

Example 2

A diabase including including the mineral phases of labradorite, pyroxene, olivine, and magnetite and in which pyroxene constitutes the dominant mineral phase, is molten and poured into a mold. Immediately after pouring, the diabase is air-cooled to a temperature of between 500 and 600° C. and is retained at such relatively low temperature for a period of between 3 and 5 minutes. Thereafter the thus-formed cast stone is heated to about 920° C. and retained at this temperature for about one hour. The stone is then again cooled to a temperature of about 720° C. and maintained at this relatively low temperature for a period of between 2 and 3 minutes. Subsequently thereto, the stone is heated again to a temperature of about 850° C. In this manner, all of the mineral phases such as pyroxene, olivine and labradorite are completely recrystallized and in this manner, a completely crystalline structure of high tenacity is obtained. Due to the spherulitic configuration which is obtained in this manner and in which the tips of the crystals always extend in outward direction, an extremely high degree of hardness and strength is achieved, due to the fact that the hardness and strength of the crystal tips are usually higher than the average hardness and strength of the entire crystals.

Example 3

A diabase containing augite, labradorite, olivine, and magnetite is used as starting material. The content of the stone of volatile components such as carbonates, water, sulphur, etc. is such that the melting range of the same is between 1120° C. and 1128° C.

The diabase is crushed and then melted at the above temperature. The molten stone is then kept within a temperature range of 1184° C., plus-minus 10° C., for a period of two hours. Thereby all mineral components of the stone with the exception of the magnetite are completely liquefied, while the latter or at least the greater part thereof is split and disintegrated by convection streams and crystallization differentials. Simultaneously, the volatile components are driven off to the desired extent.

Thereafter, the thus molten stone is poured into molds, and subsequently cooled with air to about between 500° and 600° C. surface temperature. The thus cast stone is removed from the mold and placed into a furnace for devitrification in two temperature stages as described further above.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. In a process of making a cast body from natural diabase including pyroxene as dominant mineral phase and also including mineral phases of labradorite, olivine and magnetite, the steps of casting said diabase; cooling said cast diabase to a temperature below about 600° C.; maintaining said cast diabase at below about 600° C. for a period of at least 3 minutes; thereafter heating the same to a temperature of about 920° C.; maintaining said cast diabase at said temperature of about 920° C. for a period of about one hour; thereafter cooling the same to a temperature below about 720° C.; maintaining said cast diabase at said temperature of below about 720° C. for a period of at least about two minutes; thereafter re-heating said cast diabase to about 850° C.; and maintaining the same at said latter temperature until substantially all of said mineral phases have been recrystallized, whereby a devitrified cast diabase body is formed.

2. In a process of forming a cast stone from a natural stone having a composition substantially similar to that of a stone selected from the group consisting of diabase, melaphyre, basalt and porphyry, including a dominant mineral phase and also including at least one additional mineral phase having a recrystallization temperature lower than the recrystallization temperature of said dominant mineral phase, the steps of casting said stone; cooling said cast stone below the recrystallization temperatures of said mineral phases; heating said stone to the recrystallization temperature of said dominant mineral phase; maintaining said stone at said recrystallization temperature of said dominant mineral phase until substantially all of said dominant mineral phase has been recrystallized; cooling said stone below the recrystallization temperature of said additional mineral phase; heating said stone to the recrystallization temperature of said additional mineral phase; and maintaining said stone at said recrystallization temperature of said additional mineral phase until substantially all of said additional mineral phase has been recrystallized, whereby a devitrified cast body is formed of said natural stone.

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