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(54) **METHOD FOR PRODUCING A CONCRETE, PLASTER OR GYPSUM MIX AND FOR BRINGING THE MIX TO ITS PLACE OF USE**

VERFAHREN ZUM HERSTELLEN VON ZEMENT-, PUTZ- ODER GIPSMISCHUNGEN UND
TRANSPORT DES GEMISCHES ZU SEINEM VERWENDUNGORT

PROCEDE CONCERNANT L'ELABORATION DE MELANGES DE CIMENT OU DE PLATRE ET
LEUR TRANSFERT SUR LE LIEU D'UTILISATION

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(56) References cited:
DE-A- 2 316 447 **DE-A- 3 436 215**
DK-C- 104 778 **SE-C- 32 663**
US-A- 3 530 555 **US-A- 3 606 277**
US-A- 3 779 519

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Description

[0001] This invention relates to a method for producing a concrete mix according to the preamble of appended claim 1.

[0002] Methods are previously known in which concrete mix is batch mixed from mineral aggregate sorted into a particle size suitable for the purpose, cement acting as binding agent, water required for the hydration and possible additives. Earlier, 60 - 90 seconds has been regarded as the minimum time for mixing, depending on the type of the mixer. DIN-standard 1045, Section 9.3.1 defines the mixing time to be at least 30 seconds when a mixer having a particularly good mixing ability is used.

[0003] After mixing, the mixer is emptied and after various transfers and transports the mix is brought into a mould. The mould is filled, vibrated and the mix is smoothed. After that, the concrete is allowed to harden. Time from the moment when the binder and water have come into contact with each other until the mix is in its final or nearly final form in the mould, is usually required at least several minutes, even hours. Because of this, the cement standards define so called minimum setting times for cements, generally 45 or 60 minutes. Finnish standard requirements are defined in standard SFS 3165.

[0004] Methods are also known (see, for example, US-A-3,606,277) in which the mixing of a concrete or plaster mix is continuous using for instance a mixing screw, but due to the size or the length in the mix flow direction of the mixer and the way of handling the mix, the mix does not reach its final location and form in the mould until several minutes or even more time has passed from the moment when the binder and water have come into contact with each other. The effectiveness of the mixing is also relatively modest. In these methods, too, the mineral aggregate used as aggregate material has to be sand, gravel and/or crushed stone sorted into its final particle size.

[0005] A drawback in prior art methods is the fact that the mix has time to somewhat stiffen until it is brought into a mould. In order to compact it in the mould, it still has to be vibrated.

[0006] SE patent publication 32663 discloses a method in which the three components of a casting mix, that is cement, sand and water, are sprayed or thrown onto a vertical surface or into a mould from separate containers. In this way cement comes into contact with water and begins to set only at its final location. A thin layer is formed on the counter surface, and the operation is repeated several times until a sufficient material thickness has been achieved. The method is slow and applicable only for spray cast type technics or plasters with a very small maximum dimension of the particles.

[0007] DE patent publication 545 319 discloses a method in which pressure is applied to a concrete mix immediately after mixing, before bringing it into a mould,

in order to remove air and excess water. This takes place by bringing the mix from the mixer into a cylindrical pressure container where the mix is pressed with a piston. The method is not continuous, the mixing takes place in batches. Because of the pressing step carried out after mixing, it takes several minutes until the mix is brought into a mould.

[0008] US patent publication 3 530 555 discloses injection of a slurry type concrete mix. The mixing occurs in 10 - 25 seconds, after which the slurry is injected into a mould. The method can be applied only in special cases because the mix is in slurry form.

[0009] In the method described in US patent publication 3 779 519, the solid components of the concrete, that is cement and mineral aggregate, are conveyed by means of an air stream into a mixer above the casting place. Water is fed to the solid components only immediately before the mixer. The mixer has a funnel-like, open lower end, and the mix rotates along its walls until it drops through the opening at the lower end into a mould below. When circulating on the walls of the mixer, the velocity of the mix is reduced to such extent that when the mix drops from the mixer, only gravitational force is applied to it. Rotating mixing paddles can be additionally used in the mixer. In order to sufficiently reduce the velocity, it is necessary that the mix rotates in the mixer for some time. In spite of that, mixes containing mineral aggregates of coarse particle size and having a low water content cannot be sufficiently mixed by means of a mixer of this kind. Considerable problems are also caused by the stone and cement dust contained in the air used for conveying. Because of these reasons among others, the method is not in use anywhere, as far is known.

[0010] Also various other devices are known which in principle could be used also for the mixing of fresh concrete. Some such devices are described in SU patent publications 1 304 870 and 1 445 780. These devices are intended for grinding material primarily in dry environment. Provided that the structure, wearing strength, power and speed as well as discharge mechanism of these devices were suitable for the purpose, the devices could be imagined to be used for efficient mixing of concrete and also for crushing of coarse aggregate fed into the device. This, however, has not been done before.

[0011] For instance pin mills, screw mixers, worm pumps and various hammer mill type or other rotating grinders or mixing devices can also be used for mixing concrete. One pin mill is described in DK patent publication 104 778. The grinder has pins mounted on circles rotating in opposite directions, and the material particles are hit against these pins and crushed.

[0012] When developing a highly efficient and fast continuously operating concrete mixer, we have noticed that immediately after adding water, the mix for a while is extremely fluid and workable, even when only small amounts of water are used.

[0013] A method according to the present invention is

characterized by the combination of features of the characterising portion of the appended claim 1.

[0014] Preferably the mix is not mixed and its structure is not disturbed after the early stiffening has begun which stiffening follows immediately after the early workability.

[0015] The said intensive mixing process can include simultaneous crushing of aggregate by adding power to reinforced mixing members.

[0016] By means of the invention, it is possible to utilize the early age workability of the mix during the first seconds following the moment of contact between solid materials and water. For instance in laboratory tests in which the mix has been mixed continuously in about five seconds from adding water, the difference when compared to the workability and fluidity of the same mix for instance even at the age of one minute is significant, even if the mix were mixed all the time. However, when continuously mixing the mix, the stiffening of the mix due to the actual hardening reaction begins to appear at a much later moment which is defined by the setting time of the cement.

[0017] Both the early workability and the early stiffening of fresh concrete are phenomena which have not been noticed before, and at least they have not been taken advantage of.

[0018] According to the present invention, after adding water the mix is discharged from the mixer before water, binder and aggregate have had time to significantly react with each other. When such fluid mix is brought into a mould at once, it fills the mould very tightly. Vibration and shocks are not even necessarily required for compacting and improving the cast surface. Due to this, robust moulds enduring vibration or dropping shocks, are not needed.

[0019] In the mixing equipment, the mix is mixed efficiently and rapidly so that the flow-through time is short. A precondition for the short flow-through time is also efficient discharging of the device. When the device is sufficiently fast, it gives time to utilize both the early workability and the early stiffness of the mix.

[0020] Sufficient mixing power can be achieved for instance by means of an impact mill of a pin mill type. The efficiency and power of the mixing can be adjusted by increasing the rotational speed of the device. The centrifugal force of the fast rotational movement also centrifuges the mix efficiently and completely off from the device. So the device is also self-cleaning.

[0021] The process according to the invention is continuous. When the efficient mixer is also self-cleaning, the composition of the mix can also be changed without interrupting the mixing. Nor is washing required at all. When necessary, the cleaning of the device can be made more effective by changing the rotational direction of the mixing members. By so acting, it is possible among other things to add pigments of different colours to desired points in the product to be cast, for instance to the surface of the cast element while the inner part

remains grey. When necessary, the amount of water to be fed can be changed if the moisture of the aggregate varies. Similarly, various additives can easily be added when desired.

[0022] Efficient mixing also secures that various agglomerates such as silica agglomerates or the ones in cement or pigment or stone dust are dispersed. In this way, a mix is achieved which is homogenous and dispersed at microlevel and in which agglomerates where particles adhering together have been dispersed and the particles are evenly distributed.

[0023] When desired, reinforcing fibres can be added to the mix. Because the mixing time is short, the fibres are not able to form balls. The reinforcing can be applied exactly at a desired location in the product to be cast. The adding of fibres can take place by cutting fibre pieces from a continuous rope when feeding them into the mixing chamber or by using precut fibres.

[0024] When necessary, cement used as binder can be substituted also by other binder systems, such as activated slag from blast furnace or by binders containing for instance fly ash, silica, stone dust or various additives.

[0025] When the mix is brought into a casting mould immediately after mixing, it is also possible to use cement qualities hardening more rapidly. Earlier, a minimum setting time of 45 minutes, before which setting does not start, has been required from even rapid cements. When using a method according to the invention, stiffening and subsequent hardening can begin nearly immediately. This results in that the flow-through time of the entire casting process, intermediate stocks and the number of moulds needed in the circulation are reduced.

[0026] If simultaneously with the rapid mixing of the mix, the conditions are arranged to be such that the aggregate fed in is crushed to an essential extent, increase in the potential strength of the mix is achieved, and this increase for instance in respect of compression strength may reach some dozen per cent, at its best. The increase in strength is mainly due to the freshly formed, clean, active fracture surfaces of the aggregate and to the breaking of weak zones. Besides, the form value of the aggregate improves when sharp edges and stone splinters are rounded off so that the packing becomes easier and a more compact packing than with chiplike crushed stone is achieved.

[0027] The device used for the mixing has to be continuously operating and extremely rapidly and efficiently mixing. In such aggressive mixing, particles are ground and hit against each other and the mixing members and the walls of the device. Then besides the crushing of aggregate particles, also dust and rust stuck to the surface of them are loosened and the agglomerated particles are dispersed.

[0028] Mixing combined with crushing makes it possible to take advantage of the *in statu nascendi* phenomenon which improves the bonds between the cement glue and the stone surfaces. The substances are also

made to react more rapidly. The strengthening of bonds and the accelerating of reactions results from the fact that the substances are able to come into contact with each other via the freshly formed surfaces onto which the molecules of the environment have not had time to adhere and to form a protective non-wanted contamination layer.

[0029] Due to the efficient mixing, also stone dust which usually is regarded problematic, can be utilized in a method according to the present invention so that the amount of cement can be reduced.

[0030] The mixing device can be used for mixing combined with crushing by designing the mixing members suitable for and enduring crushing, and by using higher power. The use of a crushing mixer makes it possible to feed aggregate without dividing it into separate fractions according to particle size. It is possible to use unsorted aggregate of indefinite size in which the largest pieces can have a diameter of 100 mm, for instance. In this way, the various screening steps, storing of several different fractions and accurate portioning of different fractions in order to achieve the correct particle size distribution for compacting the concrete are avoided. It is possible to utilize even waste aggregate of poorer quality and still obtain concrete of good quality, because in crushing, the weak links of the aggregate are broken and so these do not remain in the finished concrete. In this way, savings are obtained both in material, production and investment costs.

[0031] In laboratory tests carried out, it has further been noticed that the crushing way of mixing gives the aggregate a good particle size distribution in respect of compacting the concrete mix and the strength of the concrete. The distribution can easily be fine adjusted by varying the power of the device and/or the size or positioning of its mixing members.

[0032] Now it has surprisingly been noticed in addition that if the mix is mixed and it is brought into its mould by means of a method of the invention in less than 10 seconds, and the mix is then afterworked or compacted and settled or stabilized in its casting mould or other casting place to its final location and final compactness sufficiently rapidly, an extremely workable or fluid state is first created, which state remains for some seconds, at the most for some dozens of seconds. The compacting after the mixing has to be carried out preferably in less than 30 seconds, particularly preferably in less than 5 seconds, even in less than 1 second from the moment of bringing the mix into the mould.

[0033] This fluid state changes then in some seconds or in some dozens of seconds, and the mix stiffens exceeding the stiffness level of a mix of corresponding composition and batch mixed according to standard methods, and the stiffening continues further. The growth of the stiffening slows down somewhat from the change rate of the early minutes, but it continues even for some hours towards the actual strengthening level. The final strength level is at least the strength level of a

mix which has been mixed according to the standard.

[0034] Preferably the mixing power is raised so much that the mixing energy per unit to be mixed, in other words the product of the power and the mixing time is not essentially reduced from the mixing energy used in a method according to the standard. This is necessary particularly with mixes having a low water-binder ratio and proportioned for fairly high design strength and of fairly stiff character. Sufficient mixing power can be obtained by means of a continuous method so that the amount of material momentarily contained in the mixing chamber is relatively small.

[0035] So when a mix which has been rapidly mixed according to the invention is left undisturbed and its setting is not interfered with in the mould either, the internal structures formed in the initial phase of the stiffening of the mix are not broken, and the stiffness rapidly increases to a high value. The value of the early age stiffness can be increased in a few minutes manyfold or many tenfold when compared to the stiffness level measured at the same age of a mix which has been mixed with a method according to the standard or with other prior art methods.

[0036] The utilization of the early workability and the early stiffness in a method according to the invention makes it possible to cast the mix by using a smaller amount of compacting work than in prior art methods. Alternatively, a more compact casting result is obtained with an equal amount of compacting work. The upper surface of the casting can be partly loaded mechanically. Depending on the size and on the shape proportions of the concrete product to be cast, the casting mould can also be disassembled totally or partly at a very early age counted from the mixing moment of the mix. This again improves the mould circulation and reduces the number of moulds and mould costs.

[0037] The early workability of the first seconds is so good that when mixes representing the stiffness level of normal site concretes are cast into fairly small concrete product moulds, the moulds or the mix need not necessarily be vibrated at all. In several cases, the mix is compacted quite by itself, without any significant deterioration in the final compression strength.

[0038] The rapid stiffening also means that all the problems caused by the separation of components are reduced. Stones, for instance, will not have time to sink towards the bottom of the mould as tends to happen in prior art methods. In a method according to the invention, water does not tend to separate or bleed on the surface of the product either. In prior art methods, when producing thin plates, the water accumulated on the surface together with other separation phenomena caused the upper surfaces of the plates to shrink and so the plates to be curved.

[0039] When desired, the mix can also be heat treated so that the early stiffening speed increases, provided that the heat transfer is sufficiently efficient in order to get the effect of the temperature raise into the mix from

its first minutes.

[0040] Also CO₂ can be conducted into the mix, and it displaces air in the mix and in the known way reacts with Ca(OH)₂ forming CaCO₃ and so improves the hardening of the concrete and reduces the porosity.

[0041] By applying under-pressure to the mix or by conducting into it steam or hot air which is compressed when cooling, the compacting of the mix can also be improved.

[0042] The best levels of the early workability and the early stiffness are achieved if the solid components used are completely dry.

[0043] In a method according to the invention, aggregate, water and binder are fed into a mixer. The finished mixture leaves the mixing chamber through the discharge opening, and it is brought into a mould immediately. When using a drier and stiffer mix, the discharge end of the mixing device can be connected directly to the nozzle of a slide casting device, which nozzle tapers towards its point in order to compact the mix.

[0044] The mix can be brought into a mould in any manner differing from spraying, in which manner the mix is brought to the casting place in portions bigger than drops or in a continuous flow.

[0045] The invention and its details will be described in detail in the following, by means of examples and with reference to the accompanying drawings. Examples 1 and 2 relate to the measurement of the early workability, and in examples 3 and 4 also the early stiffness following the early workability has been measured.

[0046] The drawings illustrate graphically the stiffness of mixes made by means of prior art methods and methods according to the invention, as a function of time.

Fig. 1 shows schematically the stiffnesses of mixes made by means of a method according to the invention and a prior art method, respectively,

Fig. 2 shows measurement results obtained in laboratory tests from mixes made both by means of methods according to the invention and by means of prior art methods,

Figs. 3 and 4 show measurement results from mixes made by means of prior art methods,

Figs. 5 and 6 show measurement results from mixes made by means of methods according to the invention,

Fig. 7 shows measurement results from a mix made by means of a prior art method, and

Fig. 8 shows measurement results from a mix made by means of a method according to the invention.

[0047] The reduction of the workability can be followed by means of the following modified slump test. Mix is allowed to run freely by dropping it from a horizontal conveying screw with a screw diameter of 100 - 200 mm from a height of 0.5 m to a horizontal plane at a production rate corresponding to 2 m³/h of compacted concrete, for 10 seconds. This is done at the age corre-

sponding to the moment of bringing the mix into a mould and at the age of 5 minutes. The heaps so formed are compared with each other. The latter heap is at least 50 % higher than the heap formed at the age corresponding to the age of bringing the mix into a mould. If the difference is less than 50 %, the early workability is regarded to have been essentially reduced when running the first heap.

[0048] The following examples 1 and 2 from laboratory tests carried out illustrate the early workability achieved by means of a method according to the present invention.

Example 1

Procedure: combined crushing and mixing

[0049]

Compositon of the mix	kg/m ³
Crushed aggregate 11 - 16 mm	1850
Cement P40/7	440
Water	195
Plasticizers	8

[0050] The workability of a mix made according to the invention, at the age of about 5 seconds was measured by means of the above modified slump test, and the obtained dimensions of the spreading heap were: height 4 cm and diameter 58 cm.

[0051] The workability of a mix according to the same formula which was mixed for 3 minutes by means a prior art batch mixing method, when the aggregate was the same crushed aggregate which had been precrushed when dry to have a particle distribution corresponding identically to the one of the preceding, fine crushed aggregate wash screened from the concrete mix made by means of the method according to the present invention. The obtained dimensions of the spreading heap were: height 16 cm and diameter 25 cm.

[0052] The compression strength of the concrete which was crush mixed with the method of the present invention, measured from a 15 cm test cube at the age of 28 days was about 10 % higher than the compression strength of a test cube made from previously fine crushed aggregate and mixed by means of the prior art method.

Example 2

Procedure: mixing

[0053] In another test, a mix was made with a method of the present invention so that crushing of aggregate hardly occurs or occurs only to a very slight extent. The results are similar.

Composition of the mix	kg/m ³
Crushed aggregate 0 - 16 mm	1700
Cement P40/7	560
Silica	56
Water	190
Plasticizers	24

[0054] The workability of the mix was measured at the age of about 5 seconds by means of the modified slump test carried out from a height of 0.5 m to a horizontal level. The dimensions of the spreading heap were: height 5 cm and diameter 57 cm.

[0055] The dimensions of the spreading heap of the same mix at the age of 10 minutes were: height 20 cm and diameter 32 cm.

[0056] The same mix, mixed with a prior art batch mixing method for 3 minutes and at the total age of 5 minutes at the measurement moment, gave the workability or the dimensions of the spreading heap as: height 18 cm and diameter 31 cm.

[0057] The compression strength of the concretes made with the method of the present invention and the prior art method, respectively, measured from a 15 cm test cube at the age of 28 days, were the same.

[0058] When measuring the particle distributions of a concrete mix obtainable by means of a method of the present invention when mixing was combined with crushing, it was noticed that the particle distributions of the crushed aggregates were very close to the optimum values required for good compaction in precast concrete element technics. This was achieved from indefinite aggregate fractions by adjusting the device.

[0059] The early workability and the early stiffness phenomenons are further illustrated in the following.

[0060] The partially overlapping various stiffness grades of a mix are shown on the left-hand side of Fig. 1. Reference number 1 refers to the flowing state, number 2 to the stiffening, number 3 to the setting and number 4 to the hardening. In the figure, graph 5 illustrates the stiffness of a mix made with a method of the invention, and graph 6 illustrates the stiffness of a mix made with a traditional batch method. The figure is schematic.

[0061] The differences between the traditional and the new method at a very early age can be seen from Fig. 1. The mix which has been mixed according to the traditional method is stiffer at the casting moment and it does not begin to set until much later, depending on the setting time of the concrete. The concrete mixed with the new method has an essentially better early workability, and the mix is cast into a mould at this stage. Because of this, the mix can also be easily brought into its final shape. The mix made with this method also stiffens very rapidly, due to various early reactions. If the mixing and treating times become longer or if the mix is

remixed, preconditions for the phenomenons of the early workability and the early stiffness are lost, and the mix will behave as a mix which has been mixed in a traditional way. This can be seen from Fig. 2 which shows measurement results obtained in laboratory tests.

[0062] Fig. 2 shows measurement results obtained by measuring the stiffness of a concrete mix with a method described below. Graphs 7 and 8 show the stiffnesses of mixes made by means of a continuous method according to the invention. Graph 9 shows the stiffness measured from a mix which first was mixed very rapidly but the mixing was not stopped according to the invention. Fig. 10 shows the stiffness of a mix which has been mixed with a prior art batch mixing method.

[0063] Laboratory tests have shown that for instance a normal concrete according to standard DIN 1045, item 6, mixed with a method according to the standard, stiffens when brought into a mould, after about 1 minute from the ending of the mixing, when the filling of the mould and vibration compacting have been carried out in a few seconds. In the comparisons, a mix which has been mixed with a mixer according to standard DIN 459, part 1, the mixing time being according to standard DIN 1045, item 9.3.1, was used as a mix which has been mixed with the method according to the standard.

[0064] This kind of early stiffening of the fresh concrete can be observed numerically from the surface of a freshly cast concrete block, for instance by means of a device comprising a measuring press and a press needle, according to ASTM C 403-92.

[0065] The penetration resistances measured during the first minute by means of the pressing tip of the measuring device, having the cross area of 1 square inch, the resistances representing the stiffness of the mix, increase manyfold, and after that they remain completely the same for about 30 minutes. This kind of values are obtained when the cement type is for instance Finnish P40/3 and the mix is in room temperature (20 °C).

[0066] This stiffening occurring during the first minute, however, is not sufficient. When this kind of a fresh concrete is proportioned in respect of its workability to be such that it can be compacted rapidly by vibration, without simultaneous compression, its casting mould usually cannot without the risk of breaking the cast be disassembled until the concrete has sufficiently hardened as a result of chemical reactions. In room temperature, the hardening with this cement quality takes several hours.

[0067] In a method according to the invention, the momentaneous level of the growth of the early workability can in 10 seconds be measured for instance by means of a method according to ASTM C 403-92, with the exception that the mix is not screened. Besides, screening would in practice be impossible due to the rapid stiffness increase.

[0068] When the particle size exceeds 5 - 8 mm, the penetrometer measuring according to ASTM C 403-92 is inaccurate, due to the small needle size, unless more robust devices are used in which the needle diameter

remains equal to or greater than the greatest particle size of the aggregate of the mix. With the exception of more fluid mix types, compression strength measuring can be used instead of penetrometer measuring.

[0069] Examples of laboratory measuring results relating to the early stiffness according to the present invention are the following comparisons of such concrete mixes with identical compositions, one of which has been batch mixed with a method according to the standard, applying a total mixing time of 120 seconds, and the other of which has been mixed and afterworked according to the present invention by using a total mixing time of 3 seconds and an afterworking time of 4 seconds.

Example 3

[0070]

Composition of the mix		kg/m ³
Aggregate		
Natural sand	< 0.125 mm	115
	0 - 0.6 mm	100
	0.5 - 1 mm	265
	2 - 3 mm	265
	5 - 10 mm	280
	8 - 16 mm	220
Crushed aggregate	11 - 16 mm	640
Cement P40/3		375
Water		150
Plasticizer		9,2

[0071] Penetration resistances measured by a penetrometer from mixes which have been batch mixed with a method according to the standard are shown as a function of the age in Figs. 3 and 4. The total mixing time is 120 seconds, and the afterworking time or the time taken by the compacting and settling of the mix is 30 seconds. In Fig. 3, the time interval is 0 - 30 minutes, and in Fig. 4 the time interval is 0 - 300 minutes. The 0 moment corresponds to the moment of bringing the mix into a mould. In Fig. 4, the lower graph represents a mix from which all aggregate over 5 mm has been screened off according to ASTM C 403-92. The graphs of all the other figures represent measurement results obtained by means of the modified ASTM method where the coarse aggregate has not been screened off.

[0072] The resistances of mixes which have been mixed according to the present invention are shown in Figs. 5 and 6. Fig. 5 represents a mixing time of 3 seconds combined with an afterworking time of 30 seconds. Fig. 6 represents a total mixing time of 3 seconds combined with an afterworking time of 4 seconds. The time intervals are 0 - 30 minutes and 0 - 300 minutes, while the resistance scales are 0 - 1.6 MPa and 0 - 30 MPa, respectively, similarly to Figs. 3 and 4.

Example 4

[0073]

Composition of the mix		kg/m ³
Aggregate		
Natural sand	< 0.125 mm	115
	0 - 0.6 mm	100
	0.5 - 1 mm	265
	2 - 3 mm	265
	5 - 10 mm	280
	8 - 16 mm	220
Crushed aggregate	11 - 16 mm	640
Cement P40/3		375
Water		188

[0074] Penetration resistances measured by a penetrometer from a mix which has been mixed with the method according to the standard are shown as a function of time in Fig. 7. The total mixing time is 120 seconds, and the afterworking time is 30 seconds. The resistances of a mix which has been mixed according to the present invention are shown in Fig. 8. The total mixing time is 3 seconds, and the afterworking time 4 seconds.

[0075] By means of the penetrometer measurements according to standard ASTM C, item 403-92, it is also possible to define an accurate value for a settling time preferably used in a method according to the invention. The penetration resistance is measured from a mix maintained untouched from the moment of ending the afterworking both for a mix which has been mixed with a method according to the standard and for a mix made with a method according to the invention, both mixes having the same proportionings and afterworking times. The time corresponding to the penetration value of 3.5 MPa is the so called vibration limit (initial setting).

[0076] The penetration resistance of a mix made with a method according to the invention is measured at the age which is 1/10 of the age corresponding to the vibration limit of a mix made with the method according to the standard. When the penetration resistance measured in this way from a mix made with a method according to the invention is at least twice the resistance value measured at a corresponding time from a mix made with the method according to the standard, the afterworking time is sufficiently short according to the invention.

[0077] The invention is not restricted to the above embodiments, it can vary in many different ways within the scope of the claims.

[0078] In order to achieve sufficiently aggressive mixing in which the material particles hit against counter surfaces and after that change their direction, the mixing device must have, in addition to mixing members rotating or otherwise moving in one direction, also counter members protruding into the mixing chamber. These

can rotate or move in a direction opposite to the direction of the first moving members, or they can be stationary. In this way, impacts are applied to the aggregate particles breaking the weak zones in the particles and peeling off the weakly bonded surface layers of the particles.

[0079] In the mixing device, the mixing itself is continuously operating, but the discharging may occur either continuously or in pulses.

Claims

1. A method for producing a concrete mix by using water and binder hardening by the action of water, and mineral aggregate as well as possibly auxiliary and additive substances as components, and for bringing the mix into its place of use, in which method the components of the mix are brought into a mixing device in continuous flows and are rapidly and efficiently mixed and discharged, the mixing being done in such a way that impacts breaking agglomerates and peeling off the weakly bonded surface layers of possible aggregate particles are applied to material particles when they hit against each other and the mixing members and walls of the mixing device, whereby an essential early workability or fluidity of short duration and a subsequent early stiffening are created, **characterized in that** the mix is discharged by utilizing centrifugal forces and is brought directly into a casting mould or extrusion nozzle or onto a desired surface in less than 10 seconds from the point of contact between water and binder, by flowing, dropping, extruding, centrifuging, pumping or other mechanical, non-pneumatic means, and is brought into its final shape and compactness before said early stiffening begins.
2. A method according to claim 1, **characterized in that** the mix is caused to move from the point of contact between water and binder into the casting mould or nozzle or onto the desired surface in less than 3 seconds.
3. A method according to claim 1 or 2, **characterized in that** the mix is not mixed and its structure is not disturbed after the early stiffening immediately following the early workability has begun.
4. A method according to claim 3, **characterized in that** the mix is not mixed and its structure is not disturbed after 30 seconds following bringing the mix into the casting mould or nozzle or onto the desired surface.
5. A method according to any of claims 1 - 4, **characterized in that** the time the mix takes to move from the point of contact between water and binder into the casting mould or nozzle or onto the desired surface is so short that when the mix is allowed to run freely by dropping it from a horizontal conveying screw with a screw diameter of 100 - 200 mm from a height of 0.5 m into a first heap on a horizontal plane at a production rate corresponding to 2 m³/h of compacted concrete, for 10 seconds at the age corresponding to the moment of bringing the mix into the mould, nozzle or onto the desired surface; and at the age of 5 minutes after said moment onto a latter heap, the latter heap is at least 50 % higher than the first heap.
6. A method according to any of claims 1 - 5, **characterized in that** the value of the penetration resistance of the mix measured at an age which is counted from the moment of bringing the mix into the mould, and which age is 1/10 of the age corresponding to the vibration limit of 3.5 MPa according to standard ASTM C 403-92 of a compacted comparison mix which has been mixed with a method according to standard DIN 1045 and has identical proportioning, is at least twice the value of the penetration resistance of the comparison mix at a corresponding age, measured by a penetrometer.
7. A method according to any of claims 1 - 6, **characterized in that** the mix is heated or under-pressure is applied to it or carbon dioxide, steam and/or hot air is conducted into it.
8. A method according to any of claims 1 - 7, **characterized in that** the water/solid material ratio of the mix is suitable for slide casting by means of an extrusion machine.
9. A method according to any of claims 1 - 8, **characterized in that** binder the setting time of which is less than 30 minutes from adding water is used.
10. A method according to any of claims 1 - 9, **characterized in that** casting is carried out without vibrating the mould or nozzle.
11. A method according to any of claims 1 - 10, **characterized in that** the composition of the mix and the mixing proportions of the raw materials, including possible pigments, are changed without interrupting the continuous process.
12. A method according to any of claims 1 - 11, **characterized in that** aggregate fractions with different particle sizes are fed into the mixing chamber in such proportions that a desired particle size distribution is obtained.
13. A method according to any of claims 1 - 11, **characterized in that** aggregate particles are crushed in the mixing device.

14. A method according to claim 13, **characterized in that** only one aggregate fraction having an indefinite particle size is fed into the mixing chamber, and that aggregate is crushed in the mixing chamber in the presence of binder and water and possible additives and admixtures. 5
15. A method according to claim 14, **characterized in that** the desired particle size distribution is obtained in connection with the crushing occurring in the mixing chamber. 10
16. A method according to claim 15, **characterized in that** the particle size distribution is adjusted by changing the crushing power of the device. 15
17. A method according to any of claims 1 - 16, **characterized in that** fibres are added into the mix, either precut or so that the fibre pieces are cut from a continuous rope when feeding them, the fibres being evenly dispersed in the mix. 20
18. A method according to any of claims 1 - 17, **characterized in that** it produces microhomogenous mix in which cement, silica, pigment, stone dust or other agglomerates have been broken and the particles are evenly dispersed. 25
19. A method according to any of claims 1 - 18, **characterized in that** the mixing device discharges either continuously or in pulses. 30

Patentansprüche

1. Verfahren zur Herstellung eines Betongemisches durch die Verwendung von Wasser und Abbindehärtung durch die Wirkung des Wassers, und eines mineralischen Aggregats sowie auch möglichen Hilfs- und Zusatzstoffen als Komponenten, und zum Befördern des Gemisches an seinen Verwendungsort, wobei die Komponenten des Gemisches bei diesem Verfahren in kontinuierlichen Strömen in eine Mischvorrichtung gebracht und schnell und wirksam vermischt und abgegeben werden, wobei das Mischen so erfolgt, dass Schläge, durch die die Agglomerate zerbrechen und die schwach gebundenen Oberflächenschichten möglicher Aggregatteilchen ablättern, auf die Materialteilchen einwirken, wenn sie gegeneinander und die Mischelemente und Wände der Mischvorrichtung schlagen, wodurch es zu einer wesentlich frühen Verarbeitbarkeit oder kurzzeitigen Fluidität und einem anschließenden frühen Festwerden kommt, **dadurch gekennzeichnet, dass** das Gemisch unter Ausnutzung von Zentrifugalkräften in weniger als 10 Sekunden ab dem Zeitpunkt des Kontaktes zwischen dem Wasser und dem Bindemittel abgegeben und 35
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durch Fließen, Tropfen, Extrudieren, Zentrifugieren, Pumpen oder eine andere mechanische, nicht-pneumatische Maßnahme direkt in eine Gießform oder Extrusionsdüse oder auf die gewünschte Oberfläche befördert und zu seiner Endform und Kompaktheit gebracht wird, bevor das frühe Festwerden beginnt.

2. Verfahren nach Anspruch 1, **dadurch gekennzeichnet, dass** das Gemisch veranlasst wird, sich in weniger als 3 Sekunden vom Zeitpunkt des Kontaktes zwischen dem Wasser und dem Bindemittel in die Gießform oder Düse oder auf die gewünschte Oberfläche zu bewegen.
3. Verfahren nach Anspruch 1 oder 2, **dadurch gekennzeichnet, dass** das Gemisch nach dem frühen Festwerden, unmittelbar nach dem die frühe Verarbeitbarkeit begonnen hat, nicht gemischt und seine Struktur nicht gestört wird.
4. Verfahren nach Anspruch 3, **dadurch gekennzeichnet, dass** das Gemisch 30 Sekunden, nachdem das Gemisch in die Gießform oder Düse oder auf die gewünschte Oberfläche gebracht worden ist, nicht gemischt und seine Struktur nicht gestört wird.
5. Verfahren nach einem der Ansprüche 1 bis 4, **dadurch gekennzeichnet, dass** die Zeit, die das Gemisch benötigt, um sich vom Kontaktpunkt zwischen dem Wasser und dem Bindemittel in die Gießform oder Düse oder auf die gewünschte Oberfläche zu bewegen, so kurz ist, dass, wenn das Gemisch frei fließen kann, indem es 10 Sekunden mit einem Alter, das dem Zeitpunkt entspricht, zu dem das Gemisch in die Form, Düse oder auf die gewünschte Oberfläche gebracht wird, von einer waagerechten Förderschnecke mit einem Schnecken-durchmesser von 100 bis 200 mm aus einer Höhe von 0,5 m mit einer Fertigungsgeschwindigkeit, die 2 m³/h verdichtetem Beton entspricht, zu einem ersten Haufen auf einer waagerechten Ebene und mit einem Alter von 5 Minuten nach diesem Zeitpunkt zu einem späteren Haufen tropfen kann, der spätere Haufen mindestens 50 % höher als der erste Haufen ist.
6. Verfahren nach einem der Ansprüche 1 bis 5, **dadurch gekennzeichnet, dass** der Wert des Penetrationswiderstandes des Gemisches, der bei einem Alter gemessen wird, das vom Zeitpunkt des Einbringens des Gemisches in die Form gemessen wird und dieses Alter 1/10 des Alters beträgt, das dem Rüttelgrenzwert von 3,5 MPa gemäß dem Standard ASTM C 403-92 eines verdichteten Vergleichsgemisches entspricht, das mit einem Verfahren gemäß dem Standard DIN 1045 gemischt wor-

den ist und eine identische Dosierung hat, mindestens das doppelte des Wertes des Penetrationswiderstandes des Vergleichsgemisches bei einem entsprechenden Alter, gemessen mit einem Penetrationsmesser, beträgt.

7. Verfahren nach einem der Ansprüche 1 bis 6, **dadurch gekennzeichnet, dass** das Gemisch erhitzt wird oder Unterdruck darauf angewendet wird oder Kohlendioxid, Dampf und/oder Heißluft in dieses eingeführt wird. 10
8. Verfahren nach einem der Ansprüche 1 bis 7, **dadurch gekennzeichnet, dass** das Verhältnis von Wasser/festem Material des Gemisches für den Gleitguss mit einer Extrusionsvorrichtung geeignet ist. 15
9. Verfahren nach einem der Ansprüche 1 bis 8, **dadurch gekennzeichnet, dass** ein Bindemittel verwendet wird, dessen Abbindezeit weniger als 30 Minuten nach der Zugabe des Wassers beträgt. 20
10. Verfahren nach einem der Ansprüche 1 bis 9, **dadurch gekennzeichnet, dass** das Gießen ohne Rütteln der Form oder Düse durchgeführt wird. 25
11. Verfahren nach einem der Ansprüche 1 bis 10, **dadurch gekennzeichnet, dass** die Zusammensetzung des Gemisches und die Mischungsverhältnisse der Ausgangsmaterialien, einschließlich möglicher Pigmente, geändert werden, ohne dass das kontinuierliche Verfahren unterbrochen wird. 30
12. Verfahren nach einem der Ansprüche 1 bis 11, **dadurch gekennzeichnet, dass** Aggregatfraktionen mit unterschiedlichen Teilchengrößen in solchen Verhältnissen in die Mischkammer eingeführt werden, dass die gewünschte Teilchengrößenverteilung erreicht wird. 35 40
13. Verfahren nach einem der Ansprüche 1 bis 11, **dadurch gekennzeichnet, dass** die Aggregatteilchen in der Mischvorrichtung zerkleinert werden. 45
14. Verfahren nach Anspruch 13, **dadurch gekennzeichnet, dass** nur eine Aggregatfraktion mit einer unbestimmten Teilchengröße in die Mischkammer eingeführt wird und dass das Aggregat in der Mischkammer in Gegenwart von Bindemittel und Wasser und möglicher Zusätze und Beimengungen zerkleinert wird. 50
15. Verfahren nach Anspruch 14, **dadurch gekennzeichnet, dass** die gewünschte Teilchengrößenverteilung in Zusammenhang mit dem Zerkleinern erreicht wird, das in der Mischkammer erfolgt. 55

16. Verfahren nach Anspruch 15, **dadurch gekennzeichnet, dass** die Teilchengrößenverteilung geregelt wird, indem die Zerkleinerungswirkung der Vorrichtung verändert wird.

17. Verfahren nach einem der Ansprüche 1 bis 16, **dadurch gekennzeichnet, dass** Fasern, entweder vorgeschritten oder so, dass die Faserstücke von einem durchgängigen Seil abgeschnitten werden, wenn sie zugeführt werden, in das Gemisch gegeben werden, wobei die Fasern gleichmäßig im Gemisch dispergiert werden.

18. Verfahren nach einem der Ansprüche 1 bis 17, **dadurch gekennzeichnet, dass** es ein mikrohomogenes Gemisch erzeugt, in dem Zement, Sand, Pigment, Steinmehl oder andere Agglomerate zerbrochen worden sind und die Teilchen gleichmäßig dispergiert sind.

19. Verfahren nach einem der Ansprüche 1 bis 18, **dadurch gekennzeichnet, dass** die Mischvorrichtung entweder kontinuierlich oder in Impulsen abgibt.

Revendications

1. Procédé pour la production d'une pâte de béton en utilisant de l'eau et le durcissement d'un agglomérant sous l'action de l'eau, et un agrégat minéral, ainsi que des substances auxiliaires et additives, tels que des composants et pour le transport de la pâte à son emplacement d'utilisation, dans lequel procédé, les composants de la pâte sont amenés dans un dispositif de malaxage en flux continu et sont mélangés et évacués rapidement et efficacement, la pâte étant réalisée d'une telle manière que les impacts cassant les agglomérés et détachant les couches de surface liées faiblement des éventuelles particules d'agrégat, sont appliqués aux particules de matériau lorsqu'ils se heurtent les uns aux autres et les éléments de malaxage et les parois du dispositif de malaxage, dans lequel une maniabilité ou fluidité précoce essentielle et de courte durée et un raidissement précoce subséquent sont créés, **caractérisé en ce que** la pâte est évacuée en utilisant les forces centrifuges et est amenée directement dans un moule de fonte ou une buse d'extrusion ou sur une surface souhaitée en moins de 10 secondes depuis le point de contact entre l'eau et l'agglomérant, par écoulement, ramollissage, extrusion, centrifugation, pompage ou autres moyens mécaniques, non pneumatiques, et est amenée dans sa forme et sa compacité finales avant que ledit raidissement précoce ne commence.

2. Procédé selon la revendication 1, **caractérisé en**

ce que la pâte est amenée à bouger du point de contact entre l'eau et l'agglomérant jusque dans le moule de fonte ou buse ou sur la surface souhaitée en moins de 3 secondes.

3. Procédé selon la revendication 1 ou 2, **caractérisé en ce que** la pâte n'est pas malaxée et sa structure n'est pas perturbée après le raidissement précoce immédiatement après que la maniabilité précoce a commencé.
4. Procédé selon la revendication 3, **caractérisé en ce que** la pâte n'est pas mélangée et sa structure n'est pas perturbée après 30 secondes suivant l'apport de la pâte dans le moule de fonte ou la buse ou sur la surface souhaitée.
5. Procédé selon l'une quelconque des revendications 1 à 4, **caractérisé en ce que** le temps pris par la pâte pour se déplacer du point de contact entre l'eau et l'agglomérant jusque dans le moule de fonte ou la buse ou sur la surface souhaitée est tellement court que lorsque la pâte est dans la possibilité de bouger librement en la faisant tomber d'une vis transporteuse horizontale avec un diamètre de vis de 100 à 200 mm d'une hauteur de 0,5 m dans un premier tas sur un plan horizontal à une vitesse de production correspondant à 2 m³/h de béton consolidé, pendant 10 secondes à la maturité correspondant au moment d'amener la pâte dans le moule, la buse ou sur la surface souhaitée et à la maturité de 5 minutes après ledit moment sur un dernier tas, le dernier tas est au moins 50 % plus grand que le premier tas.
6. Procédé selon l'une quelconque des revendications 1 à 5, **caractérisé en ce que** la valeur de la résistance de pénétration de la pâte mesurée à une maturité qui est comptée depuis le moment d'amener la pâte dans le moule, et dont la maturité est 1/10 de la maturité correspondant à la limite de vibration de 3,5 MPa selon la norme ASTM C 403-92 d'une pâte consolidée de comparaison qui a été mélangée avec un procédé selon la norme DIN 1045 et présente des proportions identiques, est au moins deux fois la valeur de la résistance de pénétration de la pâte de comparaison à une maturité correspondante, mesurée par un pénétromètre.
7. Procédé selon l'une quelconque des revendications 1 à 6, **caractérisé en ce que** la pâte est chauffée ou une sous-pression y est appliquée ou du dioxyde de carbone, de la vapeur et/ou de l'air chaud est conduit à travers la pâte.
8. Procédé selon l'une quelconque des revendications 1 à 7, **caractérisé en ce que** le rapport eau/matériau solide de la pâte est adapté pour une fonte de

glissière au moyen d'une machine à extruder.

9. Procédé selon l'une quelconque des revendications 1 à 8, **caractérisé en ce que** un agglomérant dont le temps de fixation est inférieur à 30 minutes après avoir ajouté l'eau est utilisé.
10. Procédé selon l'une quelconque des revendications 1 à 9, **caractérisé en ce que** la fonte est transportée sans faire vibrer le moule ni la buse.
11. Procédé selon l'une quelconque des revendications 1 à 10, **caractérisé en ce que** la composition de la pâte et les proportions de mélange des matières premières, y compris les éventuels pigments, sont modifiées sans interrompre le processus continu.
12. Procédé selon l'une quelconque des revendications 1 à 11, **caractérisé en ce que** des fractions d'agrégat avec différentes tailles de particules sont fournies dans la chambre de malaxage dans des proportions telles qu'une répartition souhaitée de taille de particule est obtenue.
13. Procédé selon l'une quelconque des revendications 1 à 11, **caractérisé en ce que** les particules d'agrégat sont broyées dans le dispositif de malaxage.
14. Procédé selon la revendication 13, **caractérisé en ce qu'une** seule fraction d'agrégat ayant une taille de particule indéfinie est fournie à la chambre de malaxage et cet agrégat est broyé dans la chambre de malaxage en présence d'un agglomérant et de l'eau et d'éventuels additifs et adjuvants.
15. Procédé selon la revendication 14, **caractérisé en ce que** la répartition souhaitée de taille de particule est obtenue par rapport au broyage qui se produit dans la chambre de malaxage.
16. procédé selon la revendication 15, **caractérisé en ce que** la répartition de taille de particule est réglée en modifiant la puissance de broyage du dispositif.
17. Procédé selon l'une quelconque des revendications 1 à 16, **caractérisé en ce que** des fibres sont ajoutées à la pâte, soit pré-coupées soit de manière que les fibres soient coupées à partir d'un tissu continu lors de l'alimentation, les fibres étant dispersées de manière égale dans la pâte.
18. Procédé selon l'une quelconque des revendications 1 à 17, **caractérisé en ce qu'il** produit une pâte microhomogène dans laquelle le ciment, la silice, le pigment, la poussière inerte et autres agglomérants ont été cassés et les particules ont été dispersées de manière égale.

19. Procédé selon l'une quelconque des revendications 1 à 18, **caractérisé en ce que** le dispositif de malaxage évacue soit en continu soit par impulsions.

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Fig.1.

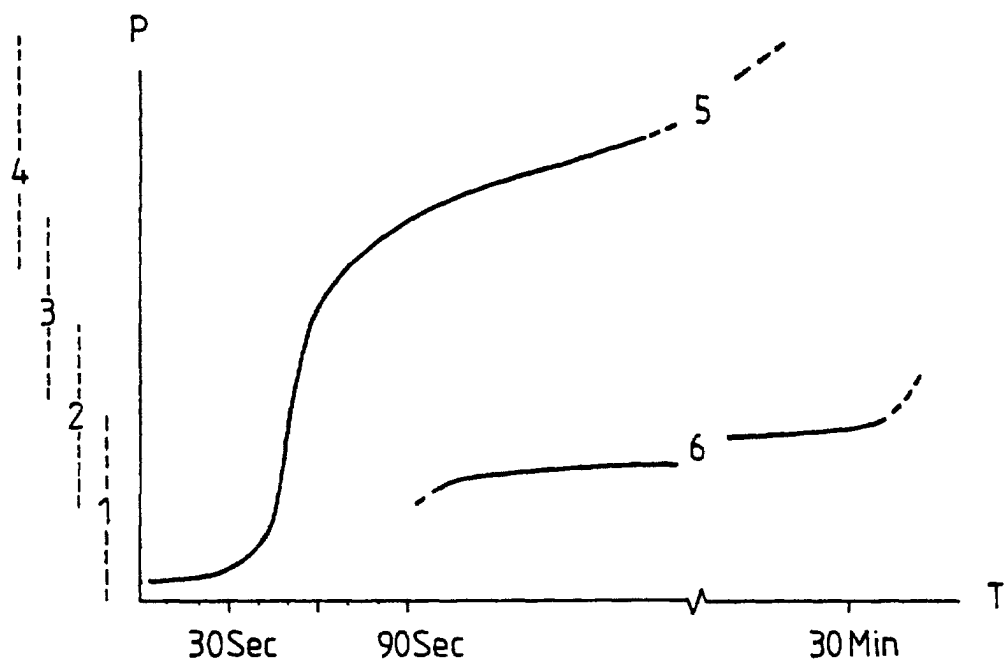


Fig.2.

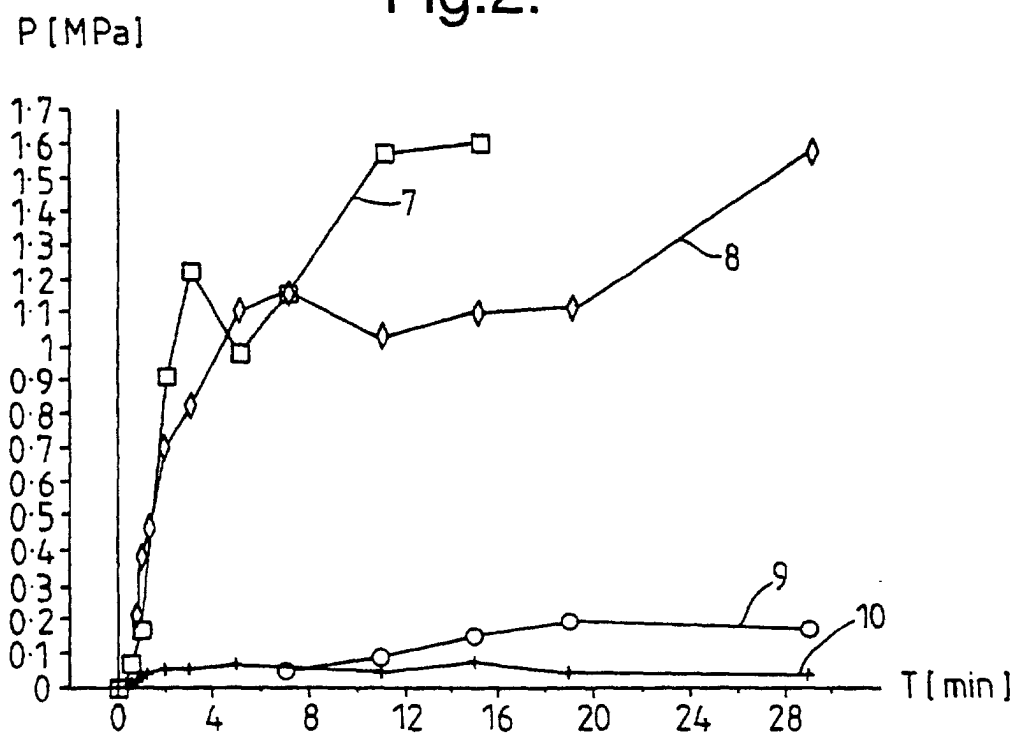


Fig.3.

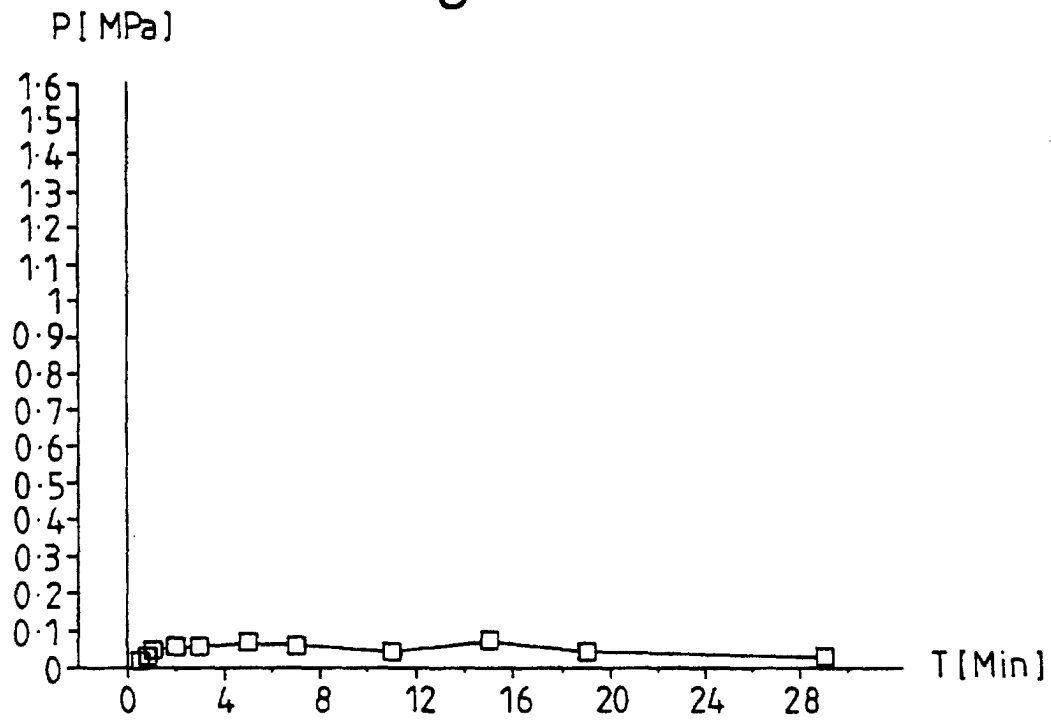


Fig.4.

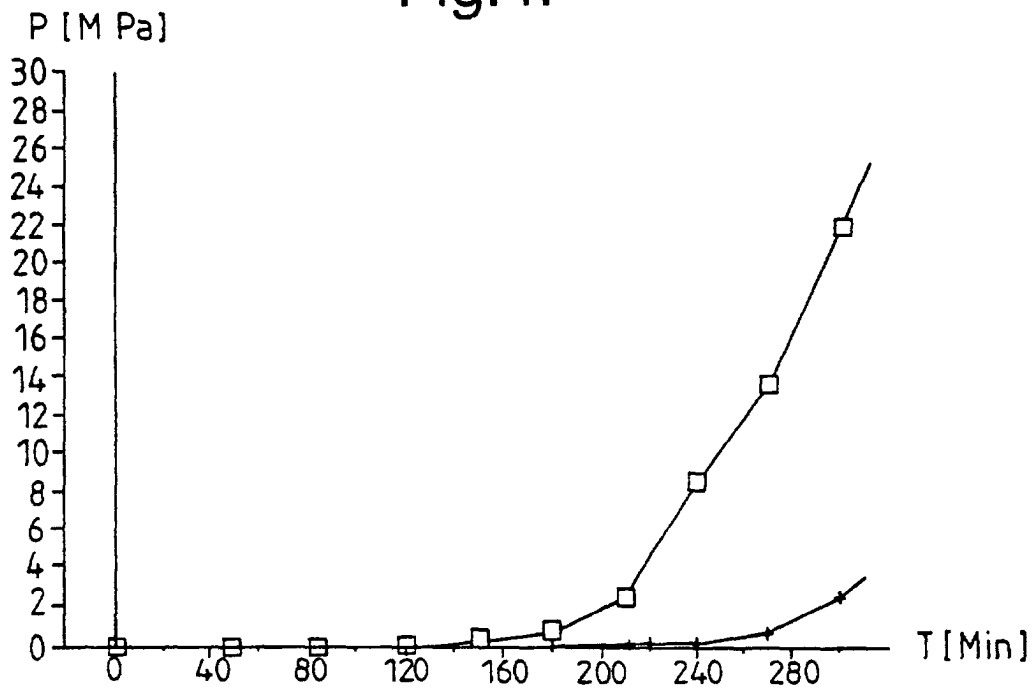


Fig.5.

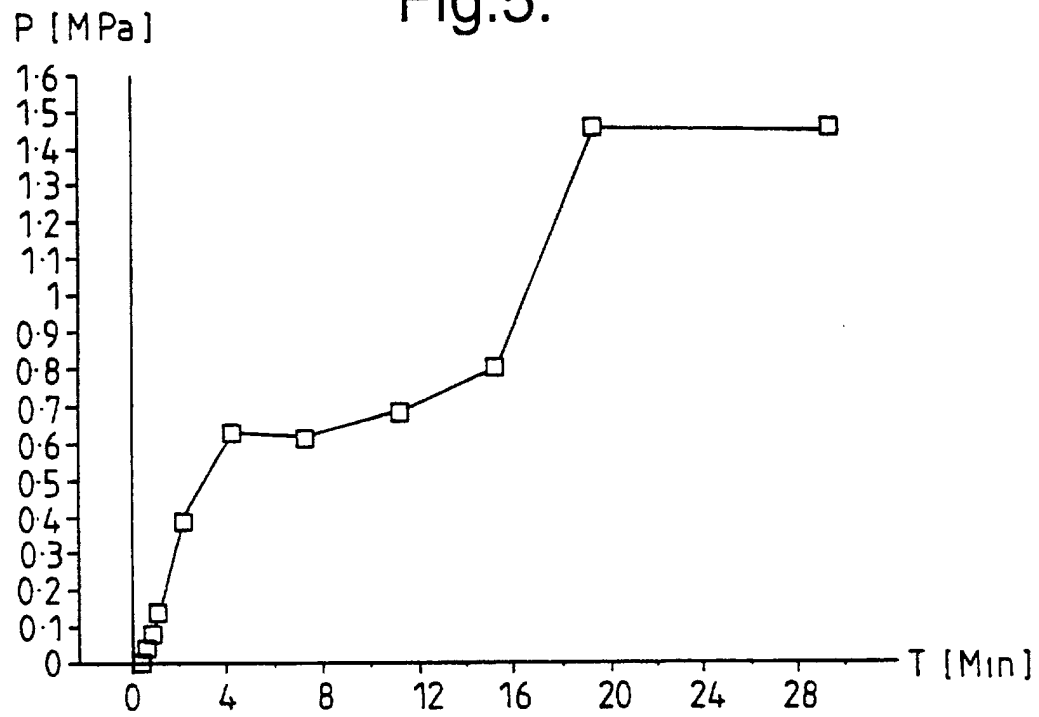


Fig.6.

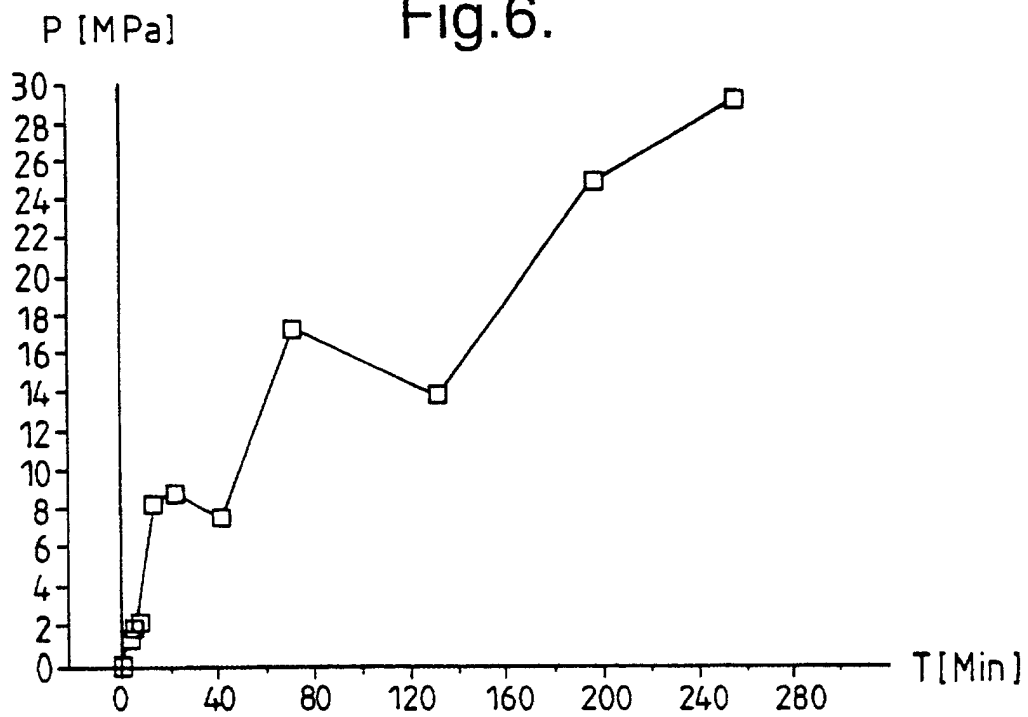


Fig.7.

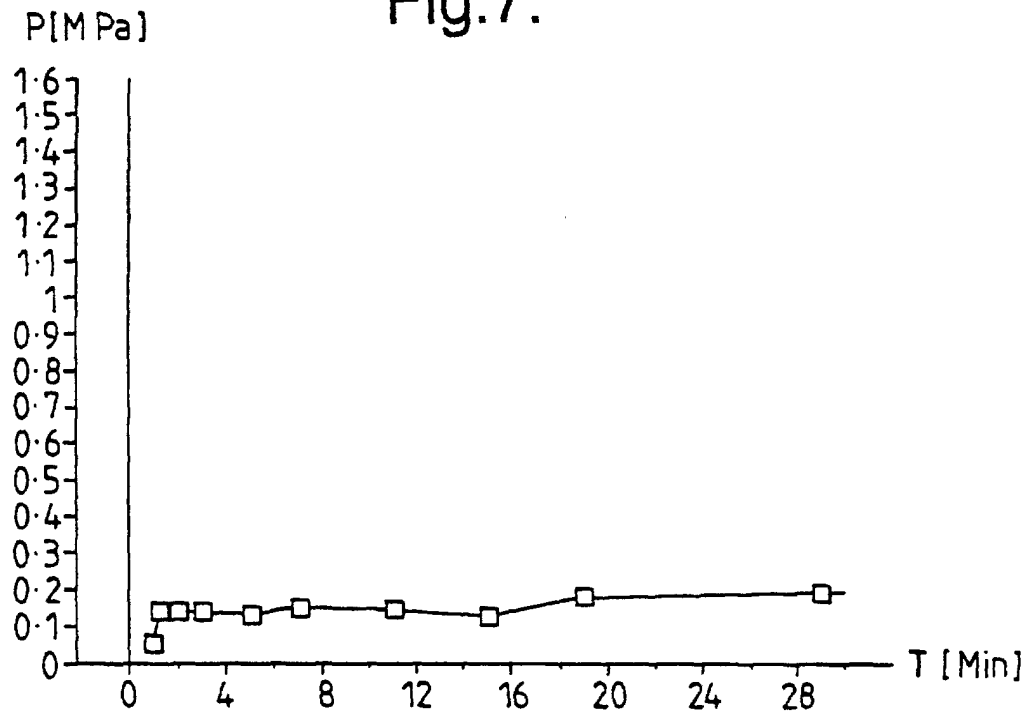


Fig.8.

