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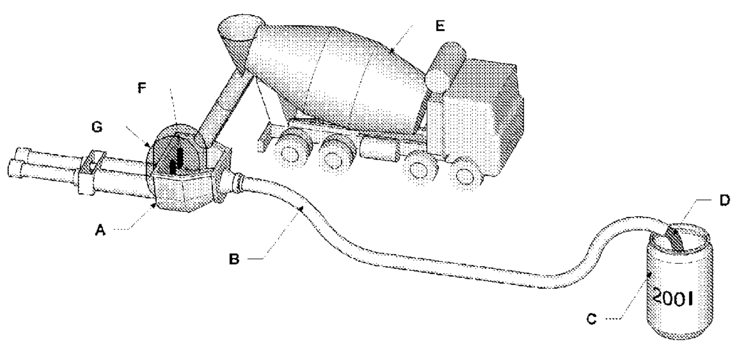
(54) Title: METHOD FOR IMPROVING THE DEGREE OF FILL OF VOLUMETRIC CONCRETE PUMPS

Fig. 1:



(57) Abstract: The present invention relates to a method of increasing and equalizing the degree of fill of the transport cylinders and the pump efficiency of volumetric pumps in the pumping of cement-based compositions by use of at least one vibrating element in the feed funnel of the pump.

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METHOD FOR IMPROVING THE DEGREE OF FILL OF VOLUMETRIC CONCRETE PUMPS

The present invention relates to a method of increasing and equalizing the degree of fill of the transport cylinders and the pump efficiency of volumetric pumps in the pumping of cement-based compositions.

The term “cement-based compositions” generally refers to concretes and mortars which differ essentially in terms of the average particle size of their aggregates (gravels; sands). For the purposes of the present invention, “cements” are finely milled inorganic materials which solidify and cure automatically after mixing with water as a result of chemical reactions with the make-up water and remain solid and dimensionally stable after curing even under water and thus provide permanent bonding for the entire building chemical composition. Cements are therefore also referred to as inorganic or hydraulic binders.

Cements comprise portland cements, iron portland cements, aluminate cements (e.g. slag cements) and trass cements. Cement-based compositions can, as a mixture, comprise not only the hydraulic component cement but also additives without active functionality, e.g. fillers (inorganic aggregate material), or having (re)active functionality, e.g. dispersants, curing accelerators or retarders, air pore formers, antifoams, fibers.

Dispersants are usually organic polymers which modify the rheology of the cement composition so that it is easier to handle and/or allows the use of smaller amounts of make-up water. Dispersants exert an overall influence on the processability of cement-based compositions and, in particular, improve their kneadability, flowability, sprayability, paintability or pumpability.

Cement-based compositions such as concrete which are sprayed or squirted onto a substrate have to set very quickly on the surface to be covered. Strongly accelerating compounds, which include sodium aluminate and alkali metal hydroxides, are therefore used for such a specific use as spray concrete. Spray concrete is conveyed to the installation site in a closed pipe/hose, there applied pneumatically from a spray nozzle and compacted by the impingement energy. Unlike the case of conventional concreting methods in which the fresh concrete is firstly fully mixed, then introduced by means of pump appliances into shuttering and only then compacted, in the case of spray concrete a plurality of these operations occur simultaneously: two different mixing methods are employed, viz. the wet spraying process and the dry spraying process. In the wet spraying process, cement, aggregates and water are mixed and conveyed by means of a concrete pump to a spray nozzle from where the mixture is converted into spray by means of the compressed air supplied to the nozzle and applied. The wet spraying process generally makes it somewhat simpler to achieve uniform qualities of the cement-based composition and of the applied layer during the entire spraying operation. The finished mixture is placed in usually funnel-shaped input containers and conveyed through the hose by means of a piston pump or a screw pump. The introduction of air finally occurs at the nozzle at the end of the hose, as a result of which the spray concrete is accelerated so that good compaction and thus optimal adhesion to the (tunnel) surface is obtained.

In the pumping of cement-based compositions, it has to be noted, in particular, that rheology, viscosity and stickiness of the composition are dependent on various factors. Some of these factors are: the quality of the cement, the nature of the aggregates, the water/cement ratio and the introduction of various additives. In addition, the quality of the composition changes over the course of time. Known changes are: after-stiffening of the composition, which is reflected in a change (generally deterioration) in its rheology and therefore the pumpability, bleeding (segregation of the water) and heating of the composition as a result of chemical reactions. This leads to different cement-based compositions and composition qualities having to be pumped through the pumps, but this should always occur with a very small influence on the amount pumped. Since the direct measurement of the amount pumped by means of a flow meter is extremely costly, this is generally dispensed with and the amount pumped is calculated as empirically determined experience value on the basis of the theoretical amount pumped and the pump efficiency. The theoretical amount pumped can be calculated in real time from the number of strokes of the pump cylinder per unit time and the capacity of the pump cylinder. The metering-in of the additives is carried out on the basis of this calculated value. If the actual throughput fluctuates because of the nature of the cement-based composition or decreases during the pumping operation, this is an indication of incorrect metering of the additives and unsatisfactory quality of the material.

For rockfall protection in a tunnel, to form a lining layer and for insulation purposes, a spray concrete layer is normally applied to the interior wall of a tunnel under construction.

In the context of pumping of sprayable cement-based compositions, the degree of fill of the transport cylinders with flowable concrete composition generally fluctuates in the range from 75% to 85% according to present-day prior art; in extreme cases, it can drop to below 50%. The actual amount pumped is directly dependent on the degree of fill, which means that in the case of a degree of fill of the transport cylinders of, for example, 75%, the efficiency of the pump is also 75%. As a consequence, an actual amount pumped of 75% of the theoretical pump performance determined is also obtained in this example.

Proceeding from the disadvantages indicated, it was an object of the present invention to increase, equalize and/or ideally keep constant the degree of fill of the transport cylinders and thereby the pump efficiency. The primary aim was to prevent incorrect metering of the additives and avoid the indicated complicated methods of determining the actual throughput by means of a method of increasing and equalizing the degree of fill of the transport cylinders and the pump efficiency of volumetric pumps in the pumping of cement-based compositions.

This object was achieved by a corresponding method in which at least one vibrating element is used in the feed funnel of the pump.

This method results in the cement-based composition drawn in being compacted and the flow of the composition into the transport cylinder being aided and equalized at the same time. The degree of fill of the transport cylinders is increased thereby and remains virtually constant over the various qualities of cement-based compositions which occur.

In a preferred embodiment of the method, at least one vibrating element comprises at least one vibrating needle which is preferably arranged very close to the opening of the pump cylinder in the interior of the feed funnel of the pump. The geometry of the feed funnel is not a limitation.

In this context, it is particularly preferred in the method claimed that the vibrating elements are operated electrically, hydraulically and/or by means of air.

If vibrating needles are used according to the invention as vibrating element, these are preferably high-frequency internal vibrators. As vibration frequencies, preference is given to those in the range from 8000 1/min to 15 000 1/min and in particular 12 000 1/min. The operating frequency of the vibrating needles should be in the range from 50 to 60 Hz.

It is considered to be particularly advantageous for the cement-based composition used in the method of the invention to be concrete and in particular spray concrete.

In a particularly preferred embodiment of the method, the slump of the cement-based composition which is present in the feed funnel and is to be pumped is in the range from 37 cm to 52 cm, determined in accordance with DIN EN 12350-5.

Furthermore, it is considered to be particularly advantageous for the degree of fill of the transport cylinders and thus the pump efficiency to be constantly kept above 90% during conveying of the cement-based composition through the pump.

Of course, the at least one vibrating element can, within the scope of the method claimed, be combined regardless of its embodiment with at least one further vibrating element of a different construction type, but in this case these additional elements should then be placed so that they optimally support the efficiency of the actual vibrating element used according to the invention.

It can be seen from the above description that the indicated embodiments of the present invention not only fully achieve the object but also make it possible to achieve a series of further advantages, which was not to have been expected in this case.

These advantages include, in a nonexhaustive listing:

An increase in and equalization of the pump efficiency and the degree of fill of the transport cylinders, an increase in and equalization of the quality of the applied cement-based composition, cost savings due to targeted introduction of the additives, a reduction in the gap between the strokes of the transport cylinders and, resulting therefrom, a reduction in the pulsation in the pumping system, reduction of rebound during application of spray concrete as a result of the precise and constant mixing to be maintained exactly, a reduction in reject material due to unsatisfactory quality of the applied composition and also costly finishing measures. These advantages can be achieved exclusively in the case of the wet spraying process.

The method of the invention is illustrated by the following examples and figures.

Examples:

The test set-up for the trial described below is shown in figure 1:
The feed funnel of the concrete pump (A), a MEYCO Suprema double piston pump, was filled with concrete from the travelling mixer (E). The concrete (D) was pumped by means of the pump (A), optionally with or without vibration (G) of the vibrating needle(s) (F) hanging into the feed funnel, through the hose (B) into a drum (C) having a defined volume. Here, the number of strokes required to fill the drum was determined, and the time was stopped. In addition, note was taken of the pulsation at the concrete exit (D). The drums were weighed after filling with the defined amount of concrete and the weight was likewise recorded.

The concrete rheology of the concrete to be pumped was in each case determined by means of the slump in accordance with the standardized test method DIN EN 12350-5 and recorded both before and after the tests.

A concrete which had a W/C value of 0.50 +- 0.05 and comprised cement of the type CEM II A/LL 42.5 R Fluvio 4 from Holcim as cement component, about 1250 kg/m^3 of fine aggregates (0-4 mm), about 530 kg/m^3 of coarse aggregates (4-8 mm) at a ratio of fine aggregates:coarse aggregates of 70/30 and also the superplasticizer Glenium 587 in average amounts of from 1 to 2% by weight (based on the fresh total concrete composition) was used in each case.

The amount of concrete used was 450 kg/m^3.

The vibrating needles used, which were placed in the feed funnel very close to the entry point into the transport cylinder of the concrete pump, were operated at a frequency of 50 Hz.

Figure 2 shows a three-dimensional side view of the feed funnel A, the S feed diverter valve B, the concrete outlet C, the transport cylinder D, the transport cylinder opening E, the vibrating element(s) F and the schematic region of action of the vibrating element/ elements G.

The degree of fill of the concrete pump cylinder was calculated from the test results by means of the following formula:

$$\text{degree of fill } [\%] = \frac{\text{actual pumped volume [l]}}{\text{capacity of pumped cylinders [l] * number of strokes required}}$$

Results of the trial:

Table 1:

	Degree of fill of the concrete pump cylinder				
Slump	Without vibration	With mixer screw	With 2 vibrating needles**	With 1 vibrating needle**	With 2 vibrating needles*
cm	%	%	%	%	%
36	42.3				84.2
37.5	54.9	77.9	90.2	89.9	
41	83.9	85.3	90.9	90	
45	85.9	85.8	89.6		
48	82.9				85.2

*: needle type IRFU 38 from Wacker Neuson SE (high-frequency internal vibrator with integrated transformer)
**: needle type IRFU 57 from Wacker Neuson SE (high-frequency internal vibrator with integrated transformer)

The results in table 1 are shown in graphical form in figure 3.

Results:
The targeted use of one or more vibrating needles during the pumping operation enabled the degree of fill of the concrete pump cylinders to be increased and equalized over the entire range of the concrete rheologies (slump) which occurred. The use of the mixer screw also gives a visible albeit small advantage over the pump performance without mechanical action on the concrete. A large difference between the test results associated with the use of vibrating needles is found, especially in the case of poor rheology of the concrete.

Overall, the use of vibrating elements according to the present invention gives an increased and at the same time more uniform flow of the concrete. In addition, losses of plasticizers, for example due to overmetering, can be avoided.

Claims

1. A method of increasing and equalizing the degree of fill of the transport cylinders and the pump efficiency of volumetric pumps in the pumping of cement-based compositions by use of at least one vibrating element in the feed funnel of the pump.

2. The method according to claim 1, wherein at least one vibrating element comprises at least one vibrating needle which is preferably arranged very close to the opening of the pump cylinder in the interior of the feed funnel of the pump.

3. The method according to either claim 1 or 2, wherein the vibrating elements are operated electrically, hydraulically and/or by means of air.

4. The method according to any of claims 1 to 3, wherein the at least one vibrating needle is a high-frequency internal vibrator.

5. The method according to any of claims 1 to 4, wherein the cement-based composition is concrete and in particular spray concrete.

6. The method according to any of claims 1 to 5, wherein the slump of the cement-based composition which is present in the feed funnel and is to be pumped is in the range from 37 cm to 52 cm, determined in accordance with DIN EN 12350-5.

7. The method according to any of claims 1 to 6, wherein the degree of fill of the transport cylinders is kept constantly above 90% during conveying of the cement-based composition through the pump.

Fig. 1:

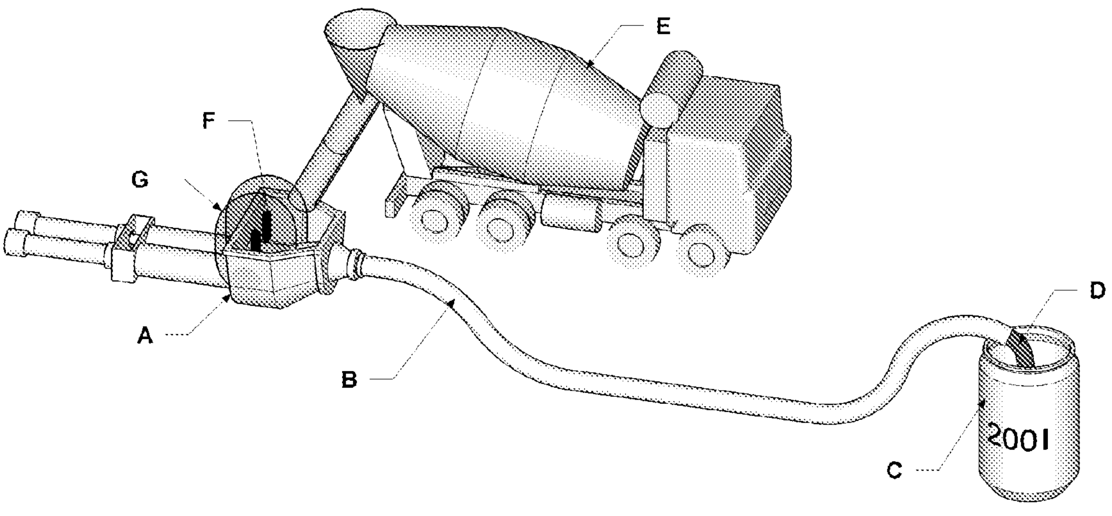


Fig. 2:

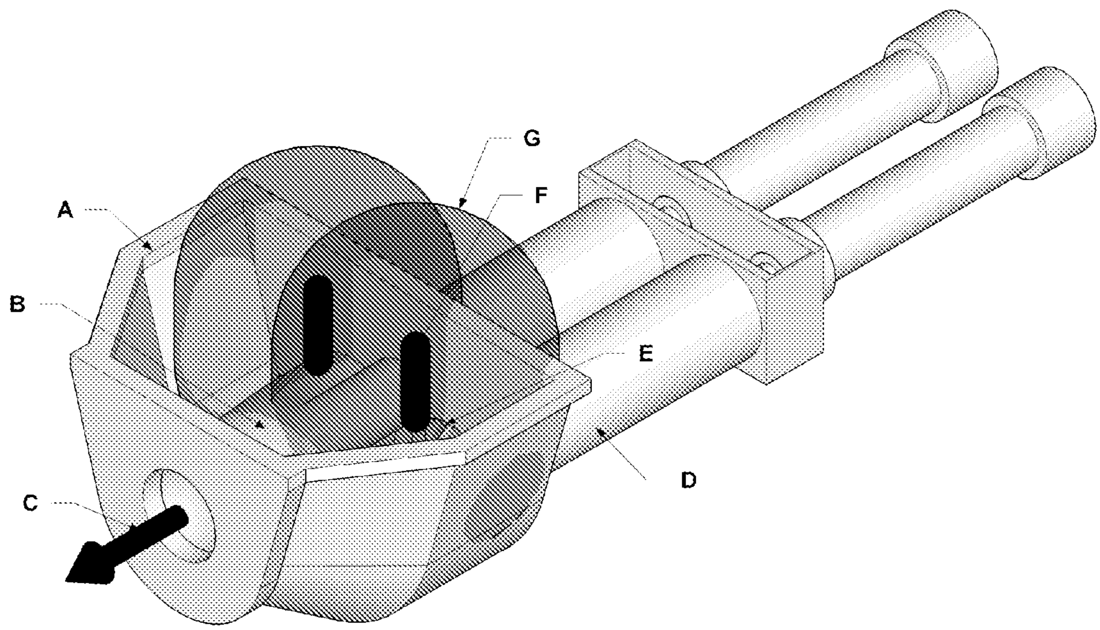
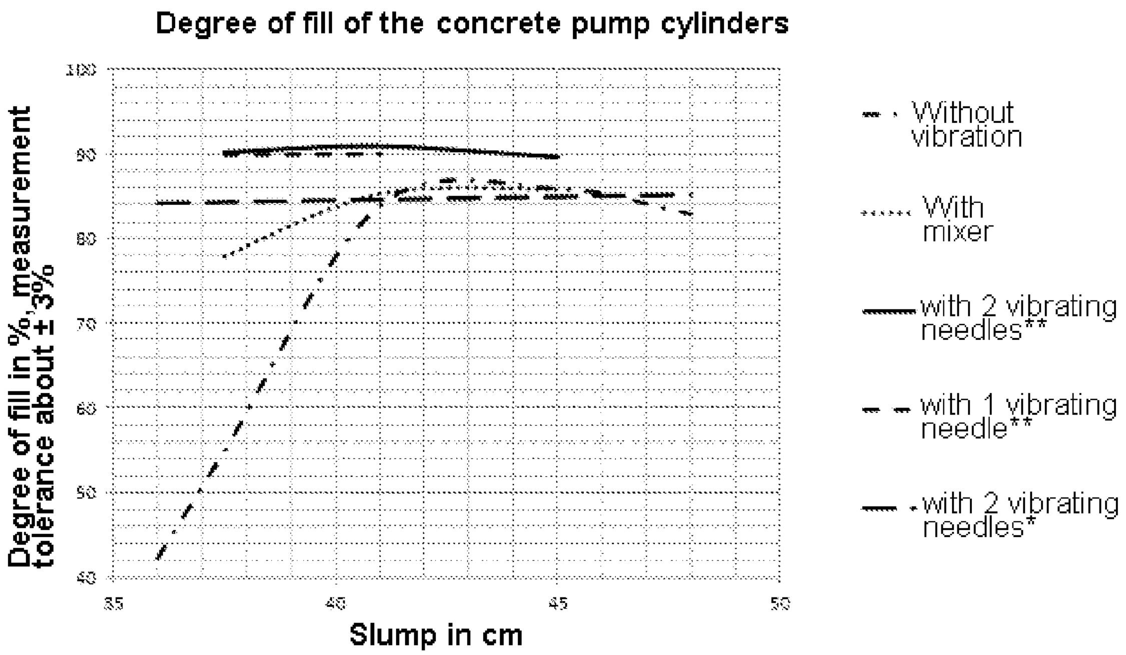


Figure 3:


Degree of fill of the concrete pump cylinders
Degree of fill in %, measurement tolerance about ± 3%
100
90
80
70
60
50
40
35
40
45
50
Slump in cm
Without vibration
With mixer
with 2 vibrating needles**
with 1 vibrating needle**
with 2 vibrating needles*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2013/051287

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC: F04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, PAJ, WPI data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 699419 A (GRANDORI CARLO), 4 November 1953 (1953-11-04); page 1, line 12 - line 19; page 2, line 47 - line 54; page 3, line 4 - line 10; figure 1; claim 1 --	1-7
X	US 2061425 A (SIEGFRED KARSTENS EDWARD), 17 November 1936 (1936-11-17); page 3, line 6 - line 13 --	1-7
X	US 2825955 A (NEVILLE EDE AINSLEY), 11 March 1958 (1958-03-11); column 2, line 53 - line 56 --	1-7
X	LV 13766 B (UNIV RIGAS TEHNISKA), 20 November 2008 (2008-11-20); abstract; page 2, line 4 - line 13; claim 1 --	1-7

☒ Further documents are listed in the continuation of Box C.　☒ See patent family annex.

* Special categories of cited documents:
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- "P" document published prior to the international filing date but later than the priority date claimed
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- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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- "&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA/SE	Authorized officer
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C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	CN 201650645 U (MACHINERY BRANCH OF XCMG CONSTRUCTION MACHINERY CO LTD CONST), 24 November 2010 (2010-11-24); abstract; figure 1; claim 1; pos 32 -- --------	1-7

Continuation of: second sheet

International Patent Classification (IPC)

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/SE2013/051287

GB	699419	A	04/11/1953	NONE		
US	2061425	A	17/11/1936	NONE		
US	2825955	A	11/03/1958	DE	1082187 B	19/05/1960
LV	13766	B	20/11/2008	NONE		
CN	201650645	U	24/11/2010	NONE		