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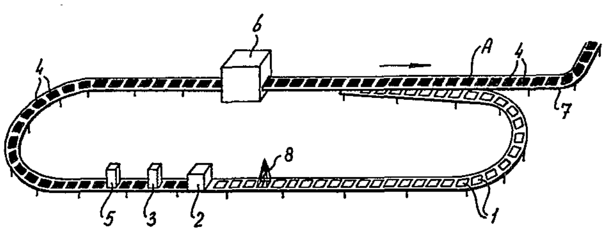
(54) Method for the non-destructive inspection of concrete or ceramic roofing-tiles or other articles.

(57) Method for the inspection of concrete or ceramic roofingtiles (4) or other articles being substantially flat but profiled and manufactured in a continuous production line, whereby each article or each n^{th} article (4) in the production line is inspected non-destructively and the measured data are stored.



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Method for the non-destructive inspection of concrete or ceramic roofing-tiles or other articles.

The invention relates to a method for the inspection of concrete or ceramic roofing-tiles or other articles being substantially flat but profiled and manufactured in a continuous production line.

In the production of concrete articles such as roofing-tiles manufactured on the assembly line it is usual to take samples regularly and to inspect said samples on a number of properties.

The inspected samples are tested on their strength destructively but also the articles being not tested on strength but on other properties one may generally consider as being lost.

The most serious problem is that the samples with respect to number and spreading may not always be considered as representative. With a number of production of 100.000 pieces in day- and night-shifts a number of 100 pieces being tested is only one pro mille. Moreover, the tests to be carried out are labour intensive and the measuring results come only much later to the knowledge of the production management.

It is yet worse that the sampling is especially limited to the day-shift or in any case less intensive at night. Further the sampling is yet concentrated on some hours after production. Scarcely, there is talk of a representative spreading of the sampling, whereas the small number of samples precludes absolutely correct conclusions.

The most ideal situation would be to test each article leaving the factory. Self-evident, it is not possible with current methods, because thereby each article would be destroyed. In any case it is desirable to take a high number of samples said number being spread better over the time.

Although in most of the cases the quality control by practice takes place in use and statically and eventual by complaints of consumers there is provided for a clear picture of the quality level said quality data comes lately back to the production management such that a real feed back to the production will come to nothing and thereby an improvement of the product and an eventual saving of material.

The circumstances leading to the eventual deviation are sometimes difficult or not at all to be recovered later on. Said deviations may also be of such a kind that the properties are only slightly effected adversely for example a too high thickness by which it is a question of material wastage.

The production of the articles is usual carried out automatically and at deviations it always deals with high numbers of articles having said wrong properties. The invention has the object to improve the known method by inspecting non-destructively each article or each n^{th} article in the production line and to store the measured data. In this way it is possible to intervene early in the production by which the number of articles not meeting the specified requirements are kept as low as possible.

According to the invention the inspection can be carried out statically and/or dynamically. In a static inspection each n^{th} article is removed from the production line inspected in static condition and fed back to an empty position in the production line.

In a dynamic inspection each article or each n^{th} article is inspected in the production line itself. Thus, the articles are not removed from the production line.

The invention will be explained by reference to the drawing, in which:

Fig. 1 shows perspectively an embodiment of a production line for concrete roofing-tiles; and

fig. 2 is a schematic side-view of an apparatus for removing roofing-tiles from the production line for a static inspection and feeding back again.

Firstly fig. 1 is elucidated.

In a horizontal track bottom molds 1 are fed successively to a roofing-tile press 2. Such a roofing-tile press 2 implemented as extrusion device is filled with concrete mortar pressed through the extrusion mouth. The extrusion opening is bounded at the lower side by the advanced bottom molds 1. Thus, the cavities in the bottom molds 1 are filled up with concrete mortar. At 3 a slurry is fed onto the top surface of the molded roofing-tiles 4 and at

5 a granulate is supplied.

The roofing-tiles 4 being wet yet are transported further in the bottom molds.

At 6 the roofing-tiles 4 with the bottom molds 1 are stacked in racks and advanced into a drying device not shown. At 6 the dry roofing-tiles 4 still in the bottom molds 1 come back again to the production line.

The cured roofing-tiles 4 are lifted from the bottom molds 1 and advanced on a conveyor 7 to a packing device (not shown). The empty bottom molds 1 are fed back to the roofing-tile press 2. Before the bottom molds 1 arrive there they pass a device 8 in which they are sprayed with molding oil.

Such a production line is known in practice.

According to the invention the roofing-tiles can be inspected at different locations and on different quantities.

The inspection can be static or dynamic.

In a static inspection a roofing-tile is lifted from the production line, inspected and fed back to an empty place in the production line. Then, one has the time available for the inspection under control.

This is not the case in the dynamic inspection. Then the roofing-tile remains in the production line and the inspection must be carried out in a time period determined by the speed of the production and moreover, a moving article must be inspected.

At the "wet" side, so between the devices 5 and 6, in fact only the thickness of the roofing-tiles 4 being wet yet can be measured, said roofing-tiles 4 seat yet in the bottom molds 1. Consequently the thickness of the bottom molds is measured also.

The spacing between the measuring location of the thickness of the wet roofing-tiles immediately after the extrusion and the supply of empty molds before the roofing-tile press is known both in measure and in number of roofing-tiles respectively molds.

The thickness of the molds - which may be vary by gradual wear - can be measured at said location - thus before the roofing-tile press - . Said thickness is stored in a memo-register and processed in measuring mold with roofing-tile. The memo-register is reloaded continuously with a measuring number (at the left hand and right hand measured at the edge), whereas the processed number is cleared.

By subtracting the thickness of the mold (the relation between the thickness of the edge and the thickness at the roofing-tile valley is known) a real roofing-tile thickness is attained at two measuring locations. The adjustment of the thickness can be corrected, eventually automatically by hydraulic or mechanic means.

The storage of the thickness of the roofing-tile may be continuous, but deviations exceeding a predetermined - preadjusted - tolerance can be signalized for immediate action. For example, red light: too high thickness and yellow light: too thin.

At the "dry" side, thus after curing of the roofing-tiles, more measurements can be carried out. Now, said measurements are carried out for roofing-tiles without bottom molds either statically or dynamically.

In the static method each cured roofing-tile is tested stationary, at least the roofing-tile is removed from the production line. Thus, said static inspection takes place behind the device 6 and after the roofing-tiles 4 are separated from the bottom molds 1, for example at the location A. A device to be used therefore is schematically shown in fig. 2.

The device shown in fig. 2 consists of two towers 9 and 10 alongside and above the transporter and therebetween the measuring table 11.

The n^{th} roofing-tile 4 to be inspected statically actuates an elevator in the tower 9 when the roofing-tile is positioned in the tower 9. Said elevator moves the roofing-tile 4 stepwise upwards until the top level is reached. Then, a reciprocating plunjer 12 is activated shifting the n^{th} roofing-tile 4 onto the measuring table 11. Simultaneously, an arm 13 having a paw 14 moving with the plunjer shifts the roofing tile already inspected to the tower 10 in which an elevator is provided moving stepwise and downwards the roofing-tile and moving it back to an empty place on the conveyor 7. At retracting the plunjer 12 the paw 14 tilts and is inactive.

During inspection the roofing-tile is stationary on the measuring table 11. The higher the number n the more time is available for the static inspection.

The roofing-tiles which need not to be inspected are normally advanced further on the conveyor 7.

The roofing-tile to be inspected is pointed out by a counter and a photo-cell.

Dependent on the adjustment each n^{th} roofing-tile is removed from the production line and supplied. Herein with "n" each number is meant between 20 and 100 for example. If n = 20, 5% of the roofing-tiles is inspected.

Since the roofing-tiles 4 advance with a high velocity (1,0 - 1,2 m/sec.) on the conveyor 7 the roofing-tile 4 arrived in the tower 9 should be taken from the production line with the high speed.

As soon as the roofing-tile stops on the measuring table 11 measuring sensors not shown will measure the width at two locations and transmit said width as a signal to the storage apparatus.

In the same way two measuring sensors at preadjusted locations will ascend from below and measure the length at two locations.

For example, the thickness is measured and also transmitted by a measuring sensor of the shear type. Said measurement of thickness is also effected at two locations.

The weight of the roofing-tile is measured by means of pressure boxes on which the respective strips seat.

Thereafter, the strength of the roofing-tiles is measured with an ultrasonic measurement, in which a transmitter beneath the roofing-tile contacts the roofing-tile through a conductive medium, for example water, and at the upper side a receiver receives in the same way the measuring signal.

While the geometric data are displayed in mm and the weight in gram, the strength will only become known by a so-called reference cipher. By comparison with destructive strength measurements of roofing-tiles of which the reference cipher is known the reference ciphers are given an absolute value.

After the measurement in the above-mentioned apparatus the roofing-tile is shifted to an equal lift belt in the tower 10. Simultaneously with the rising lift belt, said lift belt moves downwards so that the roofing tile is placed on the conveyor belt 7 where before a roofing-tile is lifted from.

The available measuring time is dependent on the number of sampling, for example with each 20th roofing-tile this is 10 sec. gross. With each 10th roofing-tile this is 5 sec. gross.

It is clear that regular tests by the quality controller are not superfluous but serve as assistance and control of the automatic control. In addition to the above-mentioned measurements the following are always necessary yet:

1) measurement of waterabsorption
2) the rain test on a test roof
3) measurement of the operative width
4) frost resistance
5) measurements of a concrete and slurry compound
6) measurements of raw materials.

In the dynamic method each roofing-tile (or each second or third roofing-tile) is inspected which is too rapid for the apparatus of the static method.

The roofing-tiles to be measured advance with a conformable movement in this case 1.00 à 1,20 m/sec. by means of a conveyor belt in the direction of the packing station.

The roofing-tiles are separated from their molds and are supplied with a maximum velocity of 1,20 m/sec and a minimum spacing of 100 mm between the roofing-tiles.

The measurement of width (at two locations of the roofing-tile simultaneously or after each other) will preferably be carried out on a conveyor belt being approximately 100 mm narrower than the roofing-tile to be measured. The roofing-tile is positioned correctly for the measurement by means of an adjusted guide. At the location of the measurement of width the side-guide of the roofing-tile on the belt is open such that the measurement may be effected freely and non-obstructed.

The measurement of width may be carried out by a mechanic sensor on predetermined locations, in which the switch on is provided by a photo-cell eventually coupled with a counter.

However, it is better to implement the contactless measurement by glassfibre optics, in which the transmitted light beam from each fibre is received through reflection and the corresponding glassfibre. By positioning in this way a number of glassfibres in a slotted nozzle a high accuracy is attained.

In order to obviate inaccuracies by milled edges, beards or the like an inclined arrangement can be chosen for measuring only the upper edge.

Basically, the measurement of length may be implemented optically in the same way, in which the location of measurement is preferably at the valley (thus the lowest portion of the roofing-tiles surface), i.e. at two locations simultaneously or after each other. Mechanical measurement of length is more difficult here by the fact that the roofing-tile is advanced in the measuring direction.

If the measuring sensor would assume the same displacement velocity as the roofing-tile along a specified path this is possible in a mechanical way.

Further, at the location of the measurement of length a roofing-tile must be advanced on cables (thus free accessible from below), on which said roofing-tile moves with a velocity of 1,00 à 1,20 m/sec.

The measurement of thickness is also carried out when it is advanced on cables.

There are two methods conceivable for said measurement of thickness, i.e.

1) a mechanical measuring method in which a measuring sensor contacts the upper side of the roofing-tile and a corresponding measuring sensor the lower side of the roofing-tile. The measuring locations should be in an area where are no elevations, ribs or reinforcements. The measuring cipher can be measured by means of a shear movement with potentiometer or by means of the measurement of displacement of the lower and upper measuring sensor from a fixed frame work.
2) a contactless measuring method in which an ultrasonic measuring head produces a sound signal in the product through a suitable medium, for example water and measures the echo thereof. With a known spacing between measuring head and lower side of the roofing-tile the thickness can be determined.

The weight of the roofing-tile can be determined by means of a weighing belt. Said weighing belt is accommodated in the cable conveyor such that the roofing-tile is free delivered from the cables. The length of the weighing belt is maximally 100 mm longer than the roofing-tile to be weighed.

The weighing operation of the roofing-tile with belt should be carried out such that the horizontal forces are eliminated. Therefore the weighing belt is supported on pressure boxes the centre of which is at the level of the roofing-tile. Moreover, the weighing belt should be supported against horizontal movements, whereas vertical movements must be not obstructed.

The strength of the roofing-tiles should be measured non-destructive. As a method therefore it is thought of measurements with ultrasound, in which the measuring heads above and beneath the roofing-tile transmit respectively measure through a suitable medium, for example water, a sound signal representing as reference the structure. From comparing measurements with destructive tests of strength said dimensionless reference cipher may be translated into real strength ciphers.

In fact, among all measurements the measurement of thickness and the establishment of the weight are of main importance. Said two values determine the compactness rate of the concrete.

A further important inspection comprises the establishment whether the roofing-tile is provided with the necessary suspension cams. Said cams are constituted by cavities in the bottom molds 1. When for example the spraying device 7 has delivered too much molding oil said cavity is partly filled up with oil and a correct cam cannot be molded. A cam can also break off during the molding and transport.

Said cams can be missing at the left hand or right hand.

A simple method for ascertaining whether the left hand cam is present comprises the step of urging the roofing-tile downwards at said location. If the left hand cam is lacking the roofing-tile tilts up at the right hand. This may be determined by a switch or photo cell. This is also in force for the right hand cam.

With the method according to the invention differing correct roofing-tiles are not rejected. It is only measured and stored.

CLAIMS

1. Method for the inspection of concrete or ceramic roofing-tiles or other articles being substantially flat but profiled and manufactured in a continuous production line, characterized in that each article or each n^{th} article in the production line is inspected non-destructively and the measured data are stored.

2. Method according to claim 1, characterized in that during the inspection the articles remain in the production line so that the inspection is carried out dynamically.

3. Method according to claim 1, characterized in that during the inspection each n^{th} article is removed from the production line, inspected in static condition and fed back to an empty position in the production line.

4. Method according to claim 1, 2 or 3, characterized in that the inspection comprises the step of measuring the thickness of the article at at least two locations.

5. Method according to claim 4, characterized in that the thickness of the article is measured in that condition.

6. Method according to claim 5, in which the wet articles each lie on a metal bottom mold, characterized in that the thickness of the bottom mold is determined and stored in a memory and that subsequently the thickness of each wet article is established including the thickness of the bottom mold.

7. Method according to claim 6, characterized in that the measurement of thickness of the wet article on the bottom mold is effected with electrical and pneumatical approach switches at two locations of the article.

8. Method according to one or more of the preceding claims, in which the articles are dried on the bottom molds and subsequently fed back in the production line, whereafter the dried articles are removed from the bottom molds and are supplied to a discharge conveyor, characterized in that the thickness, the length, the width and the weight of the dried articles are determined statically or dynamically.

9. Method according to claim 8, characterized in that the thickness is determined through mechanical contact with the upper- and lower side of the article with means known per se.

10. Method according to claim 8, characterized in that the thickness is determined without mechanical contact by means known per se such as approach switches activated by photo cells, ultrasonic sound.

11. Method according to claim 8, 9 or 10, characterized in that for measuring the length each article or each n^{th} article is transported longitudinally on two cord conveyors or the like, said articles are spaced apart.

12. Method according to claim 8, 9, 10, 11 or 12, characterized in that for measuring the width each article or each n^{th} article is conveyed on a belt or the like, being narrower than the articles.

13. Method according to claim 8, 9, 10, 11 or 12, characterized in that the length and the width of the articles are determined by measuring means known er se such as infrared measuring apparatus, photo cells or fibre optics.

14. Method according to one or more of the preceding claims, characterized in that the strength of the articles is determined by ultrasonic means known per se measuring the compactness of the articles as well as the existence of cracks or the like.

15. Method according to one or more of the preceding claims, characterized in that the presence of suspension cams and the like is ascertained by supporting the articles at the cams on a belt or the like and subsequently pressing on the left or right side of the article by which the article by lacking of a right hand or a left hand cam tilts.

16. Method according to one or more of the preceding claims, characterized in that the color of the surface of the articles is compared with standard colors.

17. Method according to one or more of the preceding claims, characterized in that the articles having deviatíons exceeding a preadjusted tolerance are removed from the production line.

18. Device for removing the n^{th} dried article from the production line, the static inspection thereof and the feed back to the production line, characterized in that the device consists of two towers having elevators and therebetween a measuring table.

19. Device according to claim 18, characterized in that the elevators move the articles to be inspected stepwise upwards respectively downwards and that means operating in horizontal

direction are provided for advancing the upper article to be inspected from the one tower to the measuring table and simultaneously to displace the article being already inspected to the second tower.

fig-1

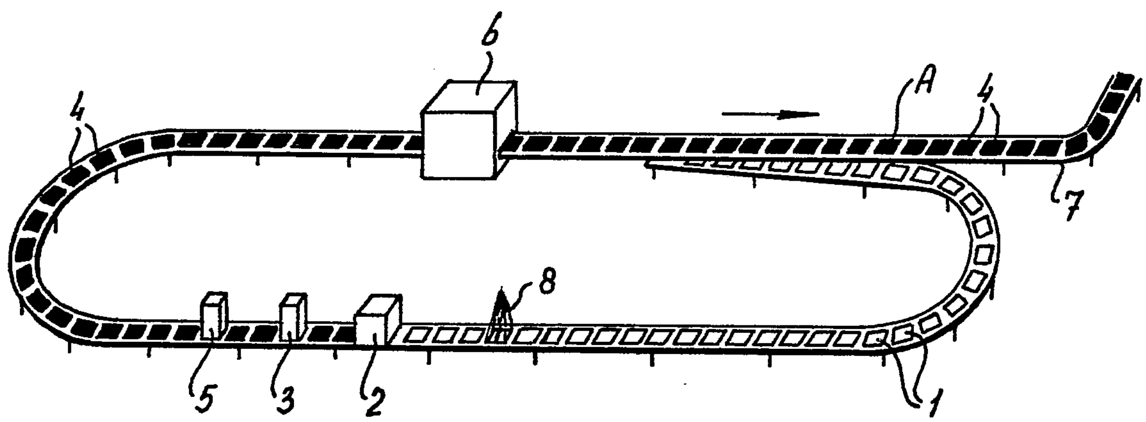
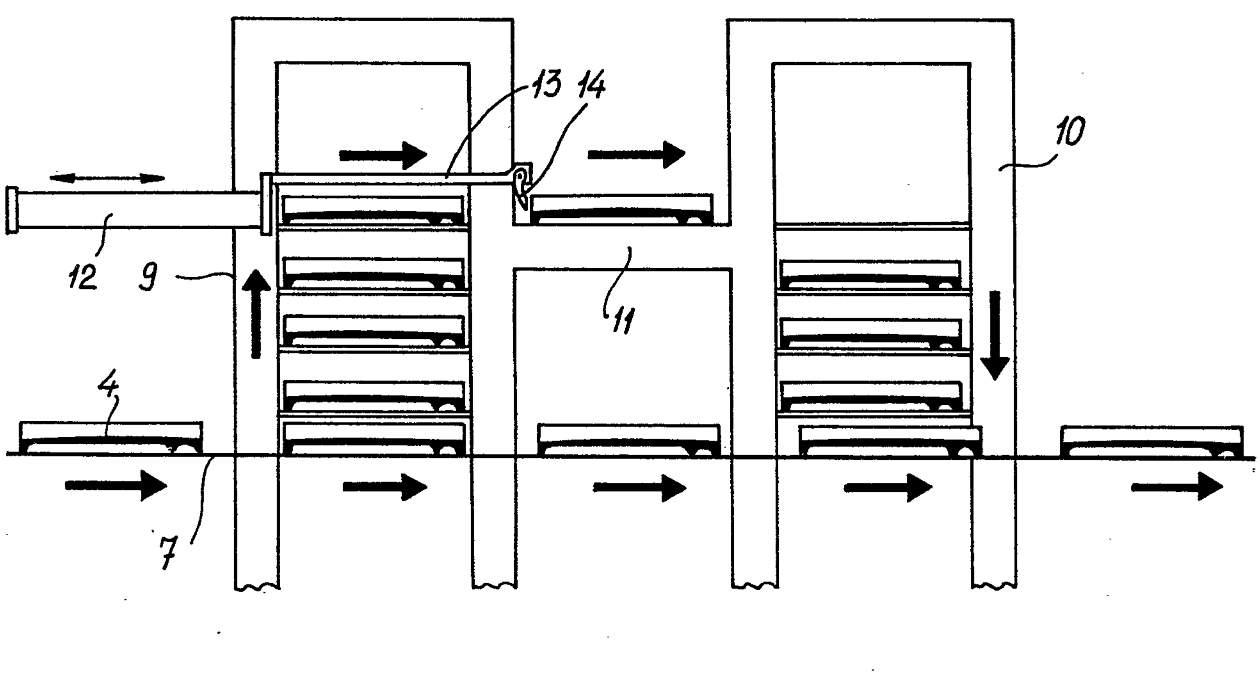


fig-2



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European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 81 20 0549

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
	US - A - 3 666 093 (LA VERNE THORNTON) * Abstracts; figures *	1,2,4, 10,13, 17
	US - A - 3 941 686 (J.W. JUVINALL) * Abstract; figure 1 *	1,2,8, 10,13, 17
	DE - A - 2 907 700 (GUSTAVSBERG) * Claims; figures *	1,2,8, 10,13, 17
	DE - A - 2 809 803 (A. CONSTANTINI) * The whole document *	1,3,16, 17-19
A	DE - A - 2 333 164 (C. KELLER) * Claims; figures *	1
A	FR - A - 2 226 220 (VILLEROY & BOCH KERAMISCHE WERKE) * Claims; figures *	1
A	DE - C - 593 018 (MASCHINENFABRIK G. DORST) * Claims; figures *	1,2,4 9,17

CLASSIFICATION OF THE APPLICATION (Int. Cl.³)

G 07 C 3/14
B 28 B 11/00

TECHNICAL FIELDS SEARCHED (Int. Cl.³)

G 07 C 3/14
3/00
B 28 B 11/00
B 07 C 5/34
5/36

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	08-09-1981	DAVID

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