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— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
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(54) **Title:** A DECORATIVE ELEMENT COMPRISING AN ENGINEERED STONE AND A METHOD FOR MANUFACTURING A DECORATIVE ELEMENT COMPRISING AN ENGINEERED STONE

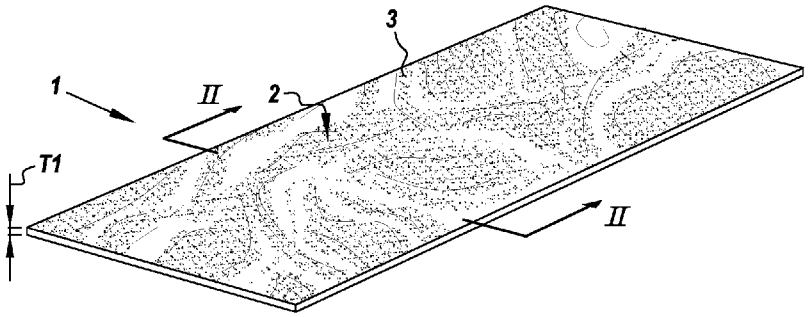

Fig. 1

(57) **Abstract:** A decorative element (1) comprising a first layer (4) made of an engineered stone, wherein the engineered stone comprise an inorganic filler bonded by means of a binder, preferably a cured thermosetting resin, characterized in that the decorative element comprises a second layer (5) disposed above of said first layer and wherein said second layer is made of an engineered stone.

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A decorative element comprising an engineered stone and a method for manufacturing a decorative element comprising an engineered stone.

The invention relates to a decorative element comprising an engineered stone and to a method for manufacturing a decorative element comprising an engineered stone. The decorative element of the invention is of the type normally manufactured in form of a slab and used as cladding of building surfaces and/or as a top for furniture, for example a kitchen countertop. In particular, the engineered stone of the invention is often known on the market as quartz.

An engineered stone comprises an inorganic filler like crushed stones, sands or other minerals but also recycled ceramic or glass, bonded by means of a cured resin. More in detail, with engineered stone is intended a composite material formed by an inorganic filler or a stone like material bonded together by means of a cured binder that it is cured at low temperature, wherein with low temperature is intended a temperature below 500°C. The binder is preferably a thermosetting resin.

Traditionally, natural stone is used as building material, especially for finishing the buildings like for example for coverings of wall or floor and for producing worktops like kitchen or bathroom countertops and vanities. Natural stones are extracted from mines and subsequently cut and polished to obtain slabs or boards of the desired shape. Due to the mine extraction, natural stones are relatively expensive and produce a high impact on the environment.

Therefore, in the past years methods for manufacturing engineered stones were developed in order to reduce costs and provide a more environmentally friendly product. A well-known example of such methods is represented by the so called Bretonstone® technology described, for example, in the document, WO 2007/138529. Said document discloses a method for manufacturing an engineered stone which comprises the step of: providing a inorganic filler, for example by grinding sand or quartz; mixing the stone or stone like material with a binder, for example a resin powder, in order to obtain a mixture;

depositing the mixture in a mold of a press, having shape and dimension similar to those of the final article; press the mixture applying vacuum, with the accompanying application of a vibratory motion at pre-established frequency; the semi-product obtained is then hardened by means of a heat curing process to obtain the engineered stone; the engineered stone is then subjected to finishing steps like cutting or polishing.

Such kind of engineered stone normally comprises a one-color decoration. Alternatively, the engineered stones comprise a décor comprising artificial veins for imitating a natural stone like marble or granite. As disclosed in WO 2009/010406 such décor is obtained by adding a coloring agent to the mixture before the mixture is deposited in the mold. The mixture is carried by an endless belt above the mold and is loaded into the mold itself by free falling from the end of the belt. The coloring agent is loaded by means of appropriate nozzles to the surface of the mixture substantially in correspondence of the end of the belt so to fall into the mold together with the mixture in a non-controlled manner. Following the vibro-compression step the pigment particles distribute in the mixture thereby generating a veined effect through the entire thickness of the engineered stone. Therefore, with this technique it is not possible to obtain an engineered stone with a reproducible and predefined décor.

WO 2016/113652 discloses equipment and a method for creating programmable chromatic effect in an engineered stone by means of a computer-controlled machine. The machine is an anthropomorphous robot or a cartesian robot provided with one or more nozzles for dispensing a coloring agent on the surface of a mixture in a temporary support. The nozzle is connected to a tool that interacts with the surface of the mixture to create grooves or holes to receive the color in order to imitate marble veins. Thus, this equipment needs a machine work of the mixture and provides for décor imitating natural stone with a relative low-quality resolution. This technology is slow and has limits in the dimension of the imitated veins that can be imitated. Moreover, it is noted that the obtained pattern is subjected to vibration and compaction so that the final pattern always differs from the starting predetermined pattern.

WO2019070621 discloses a method for improving the aesthetic quality of the engineered stone by inkjet printing a décor on a main surface of the stone.

As mentioned above, engineered stone is formed by an inorganic filler which, in most of the cases, is prevalently formed by silica sand, in particular cristobalite. Cristobalite represents the best choice for the inorganic filler for its hardness, durability and, most of all, for the aesthetical performances. On the other hand, cristobalite, as well as other crystalline silica containing minerals can lead, if inhaled, to the development of a disease known as silicosis. For this reason, several attempts have been performed to identify alternative inorganic fillers. As disclosed, for example by US20220089485 and US20220332640, these attempts have been focused on glass-based fillers, or on feldspar. Nevertheless, it remains a challenge to identify non-crystalline silica based organic filler showing comparable aesthetic performances, limited cost and consistency of supply.

The present invention aims in the first place at providing an alternative decorative element, which, in accordance with several of its preferred embodiments, is directed to solve one or more of the problems arising in the state of the art.

The present invention, according to its first independent aspect decorative element comprising a first layer made of an engineered stone, with the characteristic that the decorative element comprises a second layer disposed above of said first layer and wherein said second layer is made of an engineered stone. According to the invention, the first layer is different from second layer. Forming a multilayered decorative element may allow to combine the properties of the different layers in such a way to obtain a decorative element which may be improved in many aspects.

In the context of the invention, the engineered stone comprises at least an inorganic filler and a binder, the binder being preferably polymeric, more preferably thermosetting.

The difference between first and the second layer can be according to multiple possibilities which used either alone or in combination each other can contribute to solving on or more of the problems of the prior art.

According to the first of said possibilities, the engineered stone forming the first and the second layer can show different chemical and/or mineralogy composition of the inorganic filler. For example, in the preferred embodiment, the decorative element can comprise at least one layer having a first filler composition which is predominant in minerals different from minerals containing crystalline silica, and at least one layer having a second filler composition which is predominant in minerals containing crystalline silica. Within the context of the present invention with "is predominant in minerals different from minerals containing crystalline silica" it is meant the first composition comprises a content of crystalline silica being lower than 50% based on the weight of the first filler composition, preferably lower than 10% on a base weight, more preferably is free from crystalline silica. On the other hand, "predominant in minerals containing crystalline silica" means that the second composition comprises a content of crystalline silica being equal or above 50% based on the weight of the second filler composition. In this way it may be possible to provide a decorative element having the desired aesthetic value, which is relatively easy to achieve with crystalline silica containing minerals, and at the same time limiting the overall content of crystalline silica. It is noted that preferably, the layer having a filler composition which is predominant in minerals containing crystalline silica can show a thickness equal or lower than the layer having a filler composition which is predominant in minerals different from minerals containing crystalline silica.

In the preferred embodiment, said first filler composition comprises crystalline silica below 10 % on a weight basis, more preferably below 1 % weight. Said first filler composition can comprise calcareous minerals or other minerals different from minerals containing silica. The first filler composition can comprise silica containing minerals, although in this case it is preferred that said silica containing minerals in the first filler composition are predominant in amorphous silica, i.e. comprise more than 50% of amorphous silica based on the weight of the mineral, preferably more than 75%, more preferably more than 90 %. For example, said inorganic filler composition can comprise glass, recycled glass, frits, calcium carbonate, feldspar like albite, and feldspathoid like nepheline.

In the preferred embodiment, said second filler composition comprises crystalline silica above 50 % on a weight basis, more preferably above 90 % weight. Said second filler composition can comprise silica-based mineral, most preferably quartz and/or cristobalite. In particular said silica-based mineral forms the majority of said second filler composition.

It is also not excluded that, in some embodiments in accordance with said first possibility, said first and second layer are both formed by filler composition predominant in minerals different from minerals containing crystalline silica, albeit having different composition so that, for example, aesthetically performing but expensive fillers like frits or recycled glass can be limited to only one of the layers, whereas cheaper fillers are used for the other layer so that the overall cost of the decorative element is reduced.

It is also not excluded that, in some embodiments in accordance with said first possibility, said first and second layer are both formed by filler composition predominant in minerals containing crystalline silica, albeit having different composition so that, for example, aesthetically performing but expensive fillers like cristobalite can be limited to only one of the layers, whereas cheaper fillers are used for the other layer so that the overall cost of the decorative element is reduced.

In accordance with said first possibility, it is preferred that said first and second layer are configured such that the overall content of crystalline silica in the decorative element is below the 50%, preferably below 30%, more preferably below 25% based on the total weight of the decorative element. For example, the second layer can form less than a half of the thickness of the decorative layer, for example less than one third of said thickness. In this way, the second layer can form an upper and visible layer of the decorative element, thereby providing for an enhanced visible effect, whereas the first layer can form the majority of the thickness of the decorative layer so that the content of crystalline silica is minimized, and the risk of silicosis reduced.

According to the second possibility, said first and second layer can comprise a different color. In this way, it is possible to obtain a decorative element with an improved aesthetic

appearance. For example, according to said second possibility, the engineered stone forming the first layer comprises one or more first pigments, said first pigments being different form second pigments contained in the engineered stone forming the second layer.

According to a third possibility, one of said first and second layer can be transparent or translucent. Preferably, the other layer between said first and second layer is opaque. For example, the engineered stone of the forming said transparent or translucent layer can comprise a binder having an index of refraction which substantially identical to the index of refraction of the filler composition of the respective layer. In addition, the engineered stone forming said transparent or translucent layer is free from pigment. In this way, the other layer of the decorative element can be visible through the transparent or translucent layer so that the transparent or translucent layer can act as a protective layer for the other layer.

Preferably, the transparent or translucent layer can show a thickness which is below 3 mm, more preferably below 2 mm. By limiting the thickness of the transparent or translucent layer it is possible to increase the transparency of the layer itself.

In some embodiments, in accordance with the third possibility, the decorative element can comprise an intermediate layer between the first and the second layer. Said intermediate layer can preferably comprise a decorative pattern being visible through the transparent or translucent layer, so that the transparent or translucent layer forms a protective layer adapted to protect said decorative pattern from wear and scratch. The intermediate layer can be formed according to two main alternatives which are below described. In addition, by forming a decorative pattern in an intermediate layer, it can be possible to standardize the process for manufacturing the engineered stone of the first and the second layer, as the decorative pattern can be made in a separate layer.

According to the first main alternative, said intermediate layer can comprise a decorative foil. For example, the decorative foil can comprise a polymer-based or paper-based sheet having a printed décor on top of it. Said polymer-based sheet can be made of polyester-

based polymers or vinyl-based polymers. In some embodiments the paper-based sheet can be impregnated with a resin, preferably a polyester-based resin. The printed décor can be printed using analog printing techniques, for example rotogravure printing, or digital printing techniques, for example inkjet printing. In this way the shift from manufacturing one product to manufacturing a different product can be easily performed by changing the supply of the decorative foil. Using a polyester-based decorative foil, or a polyester impregnated paper layer, can help improving the adhesion between the engineered stones of the first and the second layer.

According to the second main alternative, the intermediate layer can be formed by a thin layer of engineered stone comprising a printed pattern formed by colored pigments distributed according to a pattern. Preferably, the printed pattern is printed on the surface of one between the first and second layer. Within the context of the present application, with printed directly it is meant that the printing operation is performed directly on the layer, in contraposition with those embodiments where the printing operation is performed on a separate printing substrate, like a foil, which is subsequently provided on the first layer. Preferably said pigments forming the printed pattern are inorganic pigments.

In accordance with any of the above-mentioned possibilities, the filler composition forming the engineered stone of the first and/or the second layer can be in form of powder, granules, shards, grains, aggregates or any other particulate form although granules and powder forms are preferred. Preferably the filler is in powder form having an average particle dimension lower than 45 μm, preferably lower than 20 μm. The filler is preferably at least the 80% by weight of the engineered stone, preferably more than the 85% and more preferably more than 90%. According to another embodiment of the invention the filler can be in form of aggregates, grains and/or granules having a particles size distribution between 0,1 and 6,5 mm, preferably between 0,1 and 2mm, 0,1 and 0,7 mm. In the most preferred embodiment, the filler is composed by a combination of powder and grains, for example said combination can comprise at least 60 wt% of grains and/or granules and between 20 to 35 wt% of powder form wherein, for example, the

granules have a particles size distribution between 0,1 and 6,5 mm and the powder have an average particle dimension lower than 45 μm, preferably lower than 20 μm.

In accordance with any of the above-mentioned possibilities the binder of the engineered stone forming the first and/or the second layer comprises, preferably substantially consists of, polyester resin preferably unsaturated polyester resin. Less preferred alternative solutions for the binder comprise acrylic resin, epoxy resin, polyurethane, rubber, vinyl ester resin or the like. The binder is preferably less than the 20% by weight of the engineered stone, preferably less than the 15% and more preferably less than 10%.

In accordance with any of the above-mentioned possibilities, the engineered stone forming the first and/or the second layer can comprise additives, like for example coupling agents, catalyst or reagents to activate or speed up hardening of the binder, and/or temporary bonding agent like glues or thermoplastic resins that temporarily bonds the filler. In the most preferred example, the additives comprise at least a silane-based coupling agent. Moreover, the additive can comprise crosslinkers and/ or catalysts to activate and/or accelerate curing of the binder.

In accordance with any of the above-mentioned possibilities, the engineered stone forming the first and/or the second layer can comprise one or more coloring agents. Said coloring agent can be in the form of dye or pigment. Pigments are normally preferred as they provide a better UV resistance to the final engineered stone. Pigments can be organic or inorganic, the latter are even more preferred as the UV resistance is further improved. Preferred colors for the coloring agent are black, yellow, white, red and green. Said coloring agent or agents can be distributed in the engineered stone in various form to form a decorative pattern that can be random or predetermined.

The decorative element has a substantially flat shape like a board, a tile or a slab. In the most preferred embodiment the decorative element is a slab wherein with slab is intended a substantial rectangular and flat form, preferably comprising a surface of minimum 1,5 square meters. In this way, the decorative element is in a shape that is sufficiently large to be versatile and adapted to be cut according to the dimension and shape of the final

destination of the engineered stone itself, like for example a kitchen or bathroom countertops. According to a preferred embodiment, the slab has a length of at least 2 m, preferably at least 2,5 m, for example 3 m or more, and a width of at least 1 m preferably 1,5 m or more. Moreover, the slab preferably shows a thickness of at least 10 mm, preferably at least 20 mm for example 30 mm. Preferably, the first and the second layer can have different thicknesses. In this way, in this way the thicknesses configuration can be arranged in such a way to maximize the effect provided by any of the layers and by the specific combination of the thicknesses.

According to its second independent aspect, the invention relates to a method for manufacturing a decorative element that comprises the steps of:

- preparing a first mixture for forming a first engineered stone comprising at least a filler composition and a binder;
- preparing a second mixture for forming a second engineered stone comprising at least a filler composition and a binder;
- providing the first mixture onto a carrier on a manufacturing line to form a first layer;
- providing the second mixture onto a carrier on a manufacturing line to form a second layer;
- compacting the first and the second mixture;
- curing the binder of the first and second mixture to obtain the engineered stone forming the decorative element.

The decorative element obtained through the method of the second independent aspect can be according to the first independent aspect. Thereto the decorative element obtained through the method of the second independent aspect can comprise one or more of the features described in relation to the first independent aspect. Similarly the filler composition, the engineered stone, the binder can comprise one or more of the features described in connection to the first independent aspect.

In the preferred embodiment the carrier can comprise a mold having at least a bottom and side walls to contain the mixture. The carrier can also comprise a lid to close the

mold. In some embodiments the mold and the lid can be made of rubber. In some embodiments, the carrier can comprise one or more paper sheets. The mold can have the shape and dimension similar to those of the decorative element to be finally obtained.

Preferably the compacting step is conducted under vacuum, i.e. vacuum is generated in the mold to help extracting air between the mixture particles. More preferably, vibration is applied to the mold or frame during the compacting step thereby helping to compact of the mixture particles, so that the porosity of the engineered stone is significantly reduced. According to a preferred embodiment both vacuum and vibration are applied to the mixture during the compression. In this way, it is possible to obtain a very high degree of compaction of the mixture that after curing will lead to an extremely low porosity.

After the compacting step, the mixtures in the mold are carried to a curing station. The cure of the binder can be obtained by means of radiation, heat, chemical curing or other suitable techniques. In the preferred embodiment, the curing step is conducted at a temperature below 500°C, for example below 200°C, for example at room temperature. In particular, in the preferred example the curing step can be thermally activated and continues in an exothermic reaction. The activation of the curing of the binder can occur at a temperature below 100°C.

After curing the engineered stone comprises a porosity below 1% in volume, more preferably below 0,5% in volume, even more preferably below 0,2%, in volume.

After curing, the engineered stone is extracted from the mold. In some, embodiments the engineered stone is cooled and/or conditioned before performing further steps.

After curing the method can comprise a calibration step and/or a squaring step. Calibration and squaring are mechanical machining steps that have the scope of providing to the engineered stone the final desired shape and dimension. In particular, calibration has the scope of flattening one or both the main surfaces of the slab made of engineered stone.

The mixtures can be provided in different forms, for example in form of a pasty material or a slip, although a dry form, for example incoherent particulate, is preferred. It is noted that the binder, in the uncured state, can be provided in solid or liquid form. In addition, the uncured binder can show some adhesive behavior that tends to stick the filler particles together.

In the most preferred embodiment method comprises, the steps of pre-compacting at least one between the first mixture and the second mixture before said first or second mixture is provided onto the carrier. Pre-compacting the mixture helps obtaining a decorative element having a thickness and a flatness closer to that desired in the final product, so that during subsequent calibration or polishing the amount of waste material can be reduced. Preferably, the pre-compaction can be obtained in a continuous process where the mixture is pressed using one or more roller, for example between two contraposed rollers.

In some embodiments of the invention, only one between the first and the second mixture is pre-compacted, the other mixture is not pre-compacted before being provided in the mold. The inventors have found that the pre-compaction can lead to a stretching of the mixture and of the pigments contained therein so that also the resulting décor is stretched in the advancing direction of the mixture between the rollers. Thanks to the combination of a pre-compacted layer and non-pre-compacted layer, the resulting decorative element can show a non-stretched décor while showing some of the advantages of pre-compaction. It is noted that the non-pre-compacted layer can be provided on the carrier forming a layer having a thickness which can be at least the double of, preferably at the least three or four time larger than, the thickness of the same layer after the compaction step and/or the curing steps.

In the preferred embodiment, the pre-compacted layer is applied first on the carrier and the non-pre-compacted layer is provided secondly on the carrier. In this way, the pre-compacted mixture can show a certain rigidity and/or flatness that can help subsequent operation that will be better described below. In other embodiments, the non-pre-

compacted layer is applied first on the carrier and the pre-compacted layer is provided secondly on the carrier.

The method can comprise one or more steps for forming a decorative pattern on the decorative element. Said decorative pattern can be provided according to several measures either alone or in combination each other

According to a first measure, wherein the pre-compacted layer is applied first in the carrier, the method can comprise a step of printing, preferably inkjet printing, a decorative pattern on the surface of the pre-compacted layer. Said inkjet printing can be performed using pigment containing inks, said pigments can preferably be inorganic pigments albeit organic pigments are not excluded.

According to a second measure, a decorative foil as described in connection with the first independent aspect is provided on top of the first layer. Preferably, in this case the first layer in the carrier is the pre-compacted mixture and the second mixture is provided after providing the decorative foil.

According to a third measure before and/or during the step of providing the mixture to the carrier a first coloring agent or a first set of coloring agent can be added to the mixture. The first coloring agent, or first set of coloring agent, can be uniformly distributed in the mass of mixture to provide basic color of the engineered stone. In some embodiments, the first coloring agent, or first set of coloring agent, can be distributed according to a random motif, like a random veined effect or a dotted effect.

According to a fourth measure a second coloring agent or second set of coloring agent can be provided according to a predetermined motif e.g. a veined effect imitating the veins or flakes of a marble, a granite or any natural stone. In a preferred embodiment the predetermined pattern can be formed using computer-controlled machines, like for example an anthropomorphous robot or a cartesian robot, provided with one or more nozzles for dispensing the coloring agent. The nozzle is connected to a tool that interacts with the surface of the mixture to create grooves or holes to receive the coloring agent.

Preferably said predetermined motif is obtained using computer-controlled machines like those described in WO 2016/113652.

With the intention of better showing the characteristics of the invention, in the following, as an example without any limitative character, several preferred forms of embodiments are described with reference to the accompanying drawings, wherein:

Figure 1 shows a perspective view of a decorative element according to a first embodiment of the invention;
Figure 2 shows on an enlarged scale the section along plane II-II of figure 1;
Figure 3 shows some steps in a method for manufacturing the decorative element of figure 1;
Figure 4 shows the view of figure 2 of a decorative element according to a second embodiment;
Figure 5 shows some steps in a method for manufacturing the decorative element of figure 4;
Figure 6 shows the view of figure 2 of a decorative element according to a second embodiment;
Figure 7 shows some steps in a method for manufacturing the decorative element of figure 6.

Figure 1 shows a decorative element 1 in form of a slab adapted for being used, for example, as a counter top in a kitchen. The decorative element 1 comprises an upper face 2 onto which is visible a decorative pattern 3 that, in the example, imitates the veining of a marble. The decorative element comprises a thickness T1 of 20 mm.

The decorative element 1 is made of engineered stone, wherein the engineered stone comprises an inorganic filler composition and a cured organic binder that bonds together the particles of inorganic filler. Represents between 85 and 95% based on the weight of the engineered stone. The binder is preferably a thermosetting resin and more in particular an unsaturated polyester resin, and represents less than the 15% of the weight of the engineered stone.

As visible from figure 2, the decorative element 1 comprise a lower first layer 4 and an upper second layer 5. In the example, the first layer 4 shows a thickness T2 that being bigger than the thickness T3 of the second layer 5 For example, the thickness T2 of the first layer 4 is three fourth of the thickness T1 of the decorative element 1 or more.

The first layer 4 and the second layer 5 are made respectively of a first and of a second engineered stone being different in that they comprise a different filler composition. In particular, the first engineered stone of the first layer 4 is formed by silica-based minerals having mainly amorphous silica, for example a feldspathoid named nepheline. The second engineered stone of the second layer 5 is formed by silica-based minerals having mainly crystalline silica, for example cristobalite.

It is noted that at the interface between the first and the second layer 4, 5 the engineered stone comprise a composition being a mixture between the first and the second engineered stone.

The decorative pattern 3 is formed in the second layer 5 by of a coloring agent mixed in the second engineered stone and disposed according to the decorative pattern 3 so that the decorative pattern 3 is present in the entire thickness T3 of the second engineered stone. The first and the second engineered stone forming the first and the second layer 4 and 5 can comprise a second coloring agent being the same or a similar color. For example, the first and the second layer 4 and 5 are white and the second layer 5 only comprising black veins formed by a first coloring agent being present only in the second layer 5.

Figure 3 shows some steps of a method for forming decorative element of figures 1 and 2. In a non-illustrated step, a first and a second mixture for forming the first and the second engineered stone are prepared, wherein said mixtures comprise the respective filler composition, the binder, one or more additive coupling agents, for example catalyst or reagents to activate or speed up hardening of the binder, and the desired coloring agent.

The method comprises a first step S1, wherein a first mixture 10 for forming the first engineered stone is deposited from a first hopper 11 on a first belt 12 that conveys the first mixture 10 through at least a couple of rollers 13 that pre-compacts the first mixture 10 and forms a strip of pre-compacted first mixture 10 that is delivered in a mold 14. The mold being a rubber mold.

The method then comprises a second step S2 wherein a second mixture 15 is provided from a second hopper 16 into the mold 14 above the first mixture 10. It is noted that the second mixture 15 is not pre-compacted before being fed in the mold 14.

The method then comprises a decoration step S3 for forming the decorative pattern 3. In particular, once the second mixture 15 is in the mold 14, a robotic arm 17 delivers the second coloring agent into the second mixture 15 according to a predetermined pattern to form the decorative pattern 3. In particular, the robotic arm 17 is adapted to carve a groove in the second mixture 15 in the mold 14 and deliver the coloring agent in the groove or deliver a quantity of second mixture 15 pre-mixed with the second coloring agent in the groove.

The mold 14 with the mixtures 10 and 15 advances in an advancing direction A to a compacting station 19 for a compaction step S4. Said compacting station 19 comprises a vibrating unit 20 and a vacuum unit 21, for the application of vibration and vacuum on the mixtures 10, 15 in the mold 14.

The mold 14 is then carried to a curing station 22 where the binder is cured in a curing step S5. The cure of the binder is activated at a temperature below 200 °C and then continues as an exothermic reaction.

After curing step S5, it is obtained a slab 23 of engineered stone, which is now made of a coherent material having a porosity below 0,2%. The slab 23 is then extracted from the mold 15 and carried to multiple mechanical machining station for finishing operations.

In a step S6 the slab 23 is calibrated to flatten the slab itself. Thanks to the pre-compacting operation, the calibration operation is improved so that less waste material is formed. This is particularly advantageous in combination with firsts mixtures 10 rich in non-crystalline silica that could be relative expensive.

Subsequently, in a step S7, the slab 23 polished so that the final surface appearance is achieved and the decorative element 1 is obtained.

Figure 4 shows a second embodiment wherein the second layer 5 is transparent. In the example, the second engineered stone forming the second layer 5 is free from coloring agent, comprises filler composition wherein the inorganic filler, for example cristobalite, is selected for being transparent and with a selected index of refraction and the binder is transparent and has the same index of refraction of the filler composition.

In the example of figure 4, the decorative element 1 comprises an intermediate layer 6 in the form of a decorative foil having a printed pattern, forming the decorative pattern 3, that is visible through the second layer 5.

Figure 5 shows some steps in a method for manufacturing the decorative element 1 of figure 4. The method of figure 5 differs from the method of figure 3 in that the decoration step S3 is performed before the step S2 of providing the second mixture 15 in them mold 14. In addition, in the method of figure 5, the decoration step S3 involves providing the decorative foil 6 from a roll 24 above the first mixture 10 in the mold 14. The decorative foil 6 can be a paper foil impregnated with polyester resin or a polyester made foil. The printed pattern of the decorative foil can be printed by means of inkjet printing or gravure printing in a separate operation.

Figure 6 differs from the embodiment of figure 4 in that the decorative pattern 3 printed directly in the engineered stone and is formed substantially an intermediate layer 6, at the interface between the first and the second layer 4, 5 formed by engineered stone with pigments distributed therein.

Figure 7 shows some steps in a method for manufacturing the decorative element 1 of figure 6. The method of figure 7 differs from the method of figure 6 in that the decoration step S3 is performed by inkjet printing the decorative pattern 3 directly on the first mixture in the mold 14 , by means of an inkjet printer 25.

Further, as is clear from the content of the description, the present invention relates to one or more of the items as listed below:

1.- A decorative element comprising a first layer made of an engineered stone, wherein the engineered stone comprise an inorganic filler bonded by means of a binder, preferably a cured thermosetting resin, with the characteristic that the decorative element comprises a second layer disposed above of said first layer and wherein said second layer is made of an engineered stone.

2. – The decorative element according to item 1, wherein the first and second layer can show:

- different granulometry distribution of the inorganic filler; and/or
- different chemical and/or mineralogy composition of the inorganic filler; and/or
- different binder composition; and/or
- different color, for example one of the layers can be transparent or translucent; and/or
- different thickness.

3. – The decorative element according to any of the preceding items, wherein at least one between the first and the second layer can have a first filler composition which is predominant in minerals different from minerals containing crystalline silica, and the other layer can has a second filler composition which is predominant in minerals containing crystalline silica.

4. – The decorative element according to item 3, wherein the first filler composition comprises a content of crystalline silica being lower than 50% based on the weight of the

first filler composition, preferably lower than 10% on a base weight, more preferably is free from crystalline silica; and/or the second filler composition comprises crystalline silica above 50 % on a weight basis, more preferably above 90 % weight.

5.- The decorative element according to item 3 or 4, wherein the first filler composition can comprise amorphous silica, feldspathoid, calcareous minerals or other minerals different from minerals containing crystalline silica.

6. – The decorative element according to any of items from 3 to 5, wherein said first filler composition filler composition can be composed of at least 50% weight, preferably at least 75% weight, more preferably at least 90% weight or even entirely by amorphous silica, feldspathoid, calcareous minerals or other minerals different from minerals containing crystalline silica.

7. – The decorative element according to any of items from 3 to 6, wherein the second filler composition can comprise silica-based mineral, most preferably quartz and/or cristobalite.

8.- The decorative element according to item 3 to 7, wherein the second layer shows a thickness equal or lower than the thickness of the first layer.

9.- The decorative element according to item 3 to 8, wherein said first and second layer are configured such that the overall content of crystalline silica in the decorative element is below the 50%, preferably below 30%, more preferably below 25% based on the total weight of the decorative element

10.- The decorative element according to any of the preceding items, at least one between the first and the second layer can be transparent or translucent.

11.- The decorative element according to item 10, wherein the transparent or translucent layer is free from pigment.

12.- The decorative element according to item 10 or 11, wherein the layer which is transparent or translucent can show a thickness which is below 3 mm, more preferably below 2 mm.

13.- The decorative element according to any of items from 10 to 12, comprising an intermediate layer between the first and the second layer.

14.- The decorative element according to item 13, wherein said intermediate layer comprises a decorative foil.

15.- The decorative element according to item 14, wherein the decorative foil can comprise a polymer-based or paper-based sheet, having a printed décor on top of it.

16.- The decorative element according to any items between 1 and 12, comprising a printed pattern which is substantially between the first and the second decorative layer.

17.- The decorative element according to item 16, wherein the printed pattern is printed on the surface of one between the first and second layer.

18.- The decorative element according to any of the preceding items, wherein the resin forms less than 15% of the weight of the engineered stone and/or wherein the inorganic filler forms between 85 and 95% of the weight of the engineered stone.

19.- The decorative element according to any of the preceding items, wherein the binder can be a thermosetting resin, preferably unsaturated polyester.

20.- The decorative element according to any of the preceding items, wherein the engineered stone can also comprise other additives like, for example, crosslinkers, coupling agents and pigments.

21.- The decorative element according to any of the preceding items, wherein the decorative element is in form of a slab.

22.- A method for manufacturing a decorative element made of an engineered stone, preferably according to any of the preceding items that comprises the steps of:

- preparing a first mixture comprising at least a first inorganic filler composition and a binder;
- preparing a second mixture comprising at least a second inorganic filler composition and a binder;
- providing the first mixture onto a carrier on a manufacturing line to form a first layer;
- providing the second mixture onto the carrier on a manufacturing line to form a second layer;
- compacting the first and the second mixtures;
- curing the binder of the first and second mixture to obtain the engineered stone forming the decorative element.

23.- The method according to item 22, wherein the step of compacting the mixture can involve a vibro-vacuum compaction step.

24.- The method according to item 22 or 23, wherein the curing step comprises a polymerization and/or crosslinking reaction, preferably said curing is heat activated at a temperature below 200°C.

25.- The method according to any of items from 22 to 24, wherein the carrier can comprise a mold having at least a bottom and side walls to contain the mixture, the carrier can also comprise a lid to close the mold.

26.- The method according to item 25, wherein the mold and the lid can be made of rubber.

27.- The method according to any of items from 22 to 24, wherein the carrier can comprise one or more paper sheets.

28.- The method according to any of items from 22 to 27, wherein after the step of curing the method can comprise one or more between the following step: calibration, polishing, squaring.

29.- The method according to any of items from 22 to 28, wherein the method comprises the steps of pre-compacting at least one between the first mixture and the second mixture before said first or second mixture is provided onto the carrier.

30.- A method for manufacturing a decorative element made of an engineered stone that comprises the steps of:

- preparing a first mixture comprising at least an inorganic filler and a binder;
- preparing a second mixture comprising at least an inorganic filler and a binder;
- providing the first mixture onto a carrier on a manufacturing line to form a first layer;
- providing the second mixture onto the carrier on a manufacturing line to form a second layer;
- compacting the first and the second mixtures;
- curing the binder of the first and second mixture to obtain the engineered stone forming the decorative element;

and wherein the method comprises the steps of pre-compacting at least one between the first mixture and the second mixture before said first or second mixture is provided onto the carrier.

31.- The method of item 30, wherein the pre-compaction can be obtained in a continuous process where the mixture is pressed using one or more roller, for example between two contraposed rollers.

32.- The method of item 30 or 31, wherein only one between the first and the second mixture is pre-compacted.

33.- The method of item 32, wherein the non-pre-compacted layer can be provided on the carrier forming a layer having a thickness which can be at least the double of,

preferably at the least three or four time larger than, the thickness of the same layer after the compaction step and/or the curing steps.

34.- The method of item 32 or 33, wherein the pre-compacted layer is applied first on the carrier and the non-pre-compacted layer is provided secondly on the carrier.

35.- The method of item 32 or 33, wherein non-pre-compacted layer is applied first on the carrier and the pre-compacted layer is provided secondly on the carrier.

36.- The method according to any of the items from 30 to 35, comprising a step of a step of forming a decorative pattern.

37.- The method according to item 36, wherein the step of forming the decorative pattern is performed between the step of providing the first mixture on the carrier and the step of providing the second mixture on the carrier.

38.- The method of item 36 or 37, wherein in case the pre-compacted layer is applied first in the carrier, the method can comprise a step of printing, preferably inkjet printing, a decorative pattern on the surface of the pre-compacted layer.

39.- The method of item 38, wherein said inkjet printing can be performed using pigment containing inks, said pigments can preferably be inorganic pigments albeit organic pigments are not excluded.

40.- The method according to any of items from 37, wherein a decorative foil is provided on top of the first layer.

41.- The method according to any of items from 36 or 37, wherein the decorative pattern can be formed by spraying a pigment in the first or second layer; and/or by carving a groove in the first or second layer and delivering a colored mixture in the groove.

42.- The method according to any of items from 30 to 41, wherein the step of compacting the mixture can involve a vibro-vacuum compaction step.

43.- The method according to any of items from 30 to 42, wherein the curing step comprises a polymerization and/or crosslinking reaction, preferably said curing is heat activated at a temperature below 200°C.

44.- The method according to any of items from 30 to 43, wherein the carrier can comprise a mold having at least a bottom and side walls to contain the mixture, the carrier can also comprise a lid to close the mold.

45.- The method according to item 44, wherein the mold and the lid can be made of rubber.

46.- The method according to any of items from 30 to 43, wherein the carrier can comprise one or more paper sheets.

47.- The method according to any of items from 30 to 46, wherein after the step of curing the method can comprise one or more between the following step: calibration, polishing, squaring.

Claims

1.- A decorative element (1) comprising a first layer (4) made of an engineered stone, wherein the engineered stone comprise an inorganic filler bonded by means of a binder, preferably a cured thermosetting resin, characterized in that the decorative element comprises a second layer (5) disposed above of said first layer and wherein said second layer is made of an engineered stone.

2. – The decorative element (1) according to claim 1, characterized in that the first and second layer (4, 5) shows:

- different granulometry distribution of the inorganic filler; and/or
- different chemical and/or mineralogy composition of the inorganic filler; and/or
- different binder composition; and/or
- different color, for example one of the layers can be transparent or translucent; and/or
- different thickness.

3. – The decorative element (1) according to any of the preceding claims, characterized in that at least one between the first and the second layer (4, 5) has a first filler composition which is predominant in minerals different from minerals containing crystalline silica, and the other layer has a second filler composition which is predominant in minerals containing crystalline silica.

4. – The decorative element (1) according to claim 3, characterized in that the first filler composition comprises a content of crystalline silica being lower than 50% based on the weight of the first filler composition, preferably lower than 10% on a base weight, more preferably is free from crystalline silica; and/or the second filler composition comprises crystalline silica above 50 % on a weight basis, more preferably above 90 % weight.

5.- The decorative element (1) according to claim 3 or 4, characterized in that the first filler composition comprises amorphous silica, feldspathoid, calcareous minerals or other minerals different from minerals containing crystalline silica.

6. – The decorative element (1) according to any of claims from 3 to 5, characterized in that said first filler composition filler composition is composed of at least 50% weight, preferably at least 75% weight, more preferably at least 90% weight or even entirely by amorphous silica, feldspathoid, calcareous minerals or other minerals different from minerals containing crystalline silica.

7. – The decorative element (1) according to any of claims from 3 to 6, characterized in that the second filler composition comprises silica-based mineral, most preferably quartz and/or cristobalite.

8.- The decorative element (1) according to any of claims from 3 to 7, characterized in that the second layer (5) shows a thickness (T3) equal to or lower than the thickness (T2) of the first layer (4).

9.- The decorative element (1) according to any of claims from 3 to 8, characterized in that said first and second layer (4, 5) are configured such that the overall content of crystalline silica in the decorative element is below the 50%, preferably below 30%, more preferably below 25% based on the total weight of the decorative element

10.- The decorative element (1) according to any of the preceding claims, characterized in that least one between the first and the second layer (4, 5) can be transparent or translucent.

11.- The decorative element (1) according to claim 10, characterized in that the transparent or translucent layer (4, 5) is free from pigment.

12.- The decorative element (1) according to claim 10 or 11, characterized in that the layer which is transparent or translucent shows a thickness which is below 3 mm, more preferably below 2 mm.

13.- The decorative element (1) according to any of the preceding claims, characterized in that it comprises a printed pattern (3) which is substantially between the first and the second decorative layer.

14.- The decorative element (1) according to claim 13, characterized in that the printed pattern (3) is printed on the surface of one between the first and second layer (4, 5).

15.- The decorative element (1) according to any of the preceding claims, characterized in that the binder can be a thermosetting resin, preferably unsaturated polyester.

16.- A method for manufacturing a decorative element (1) made of an engineered stone, according to any of the preceding claims that comprises the steps of:

- preparing a first mixture (10) comprising at least a first inorganic filler composition and a binder;
- preparing a second mixture (15) comprising at least a second inorganic filler composition and a binder;
- providing (S1) the first mixture (10) onto a carrier (14) on a manufacturing line to form a first layer;
- providing (S2) the second mixture (15) onto the carrier (14) on a manufacturing line to form a second layer;
- compacting (S4) the first and the second mixtures (10, 15);
- curing the binder of the first and second mixture to obtain the engineered stone forming the decorative element (1).

17.- The method according to claim 16, characterized in that the step of compacting (S4) the mixtures (10, 15) involves a vibro-vacuum compaction step.

18.- The method according to any claim 16 or 17, characterized in that the method comprises the steps of pre-compacting at least one between the first mixture (10) and the second mixture (15) before said first or second mixture is provided onto the carrier (14).

19.- A method for manufacturing a decorative element (1) made of an engineered stone, preferably according to any of claims from 1 to 15, that comprises the steps of:

- preparing a first mixture (10) comprising at least a first inorganic filler composition and a binder;
- preparing a second mixture (15) comprising at least a second inorganic filler composition and a binder;
- providing (S1) the first mixture (10) onto a carrier (14) on a manufacturing line to form a first layer;
- providing (S2) the second mixture (15) onto the carrier (14) on a manufacturing line to form a second layer;
- compacting (S4) the first and the second mixtures (10, 15);
- curing the binder of the first and second mixture to obtain the engineered stone forming the decorative element (1);

characterized in that the method comprises the steps of pre-compacting at least one between the first mixture (10) and the second mixture (15) before said first or second mixture is provided onto the carrier (14).

20.- The method according to claim 21, characterized in that only one between the first and the second mixture is pre-compacted.

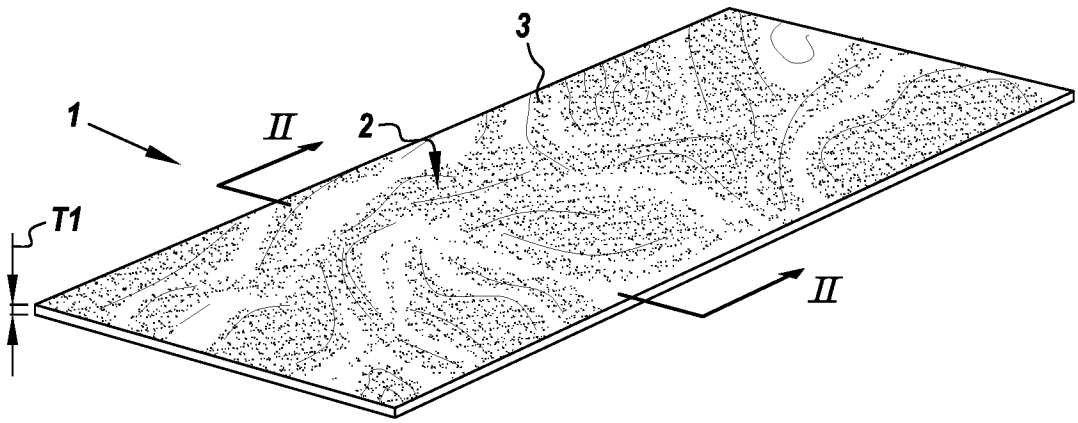

Fig. 1

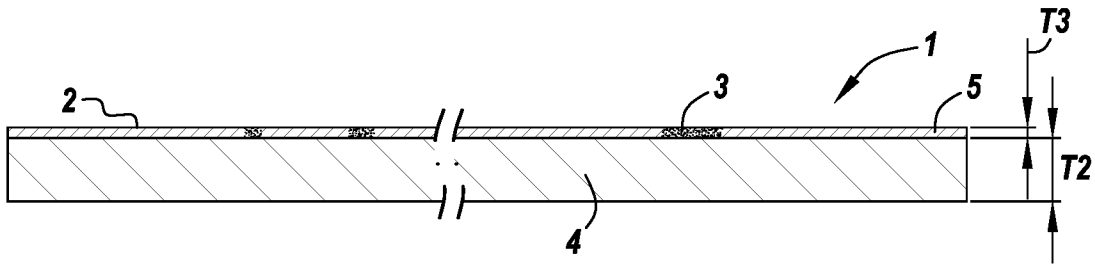

Fig. 2

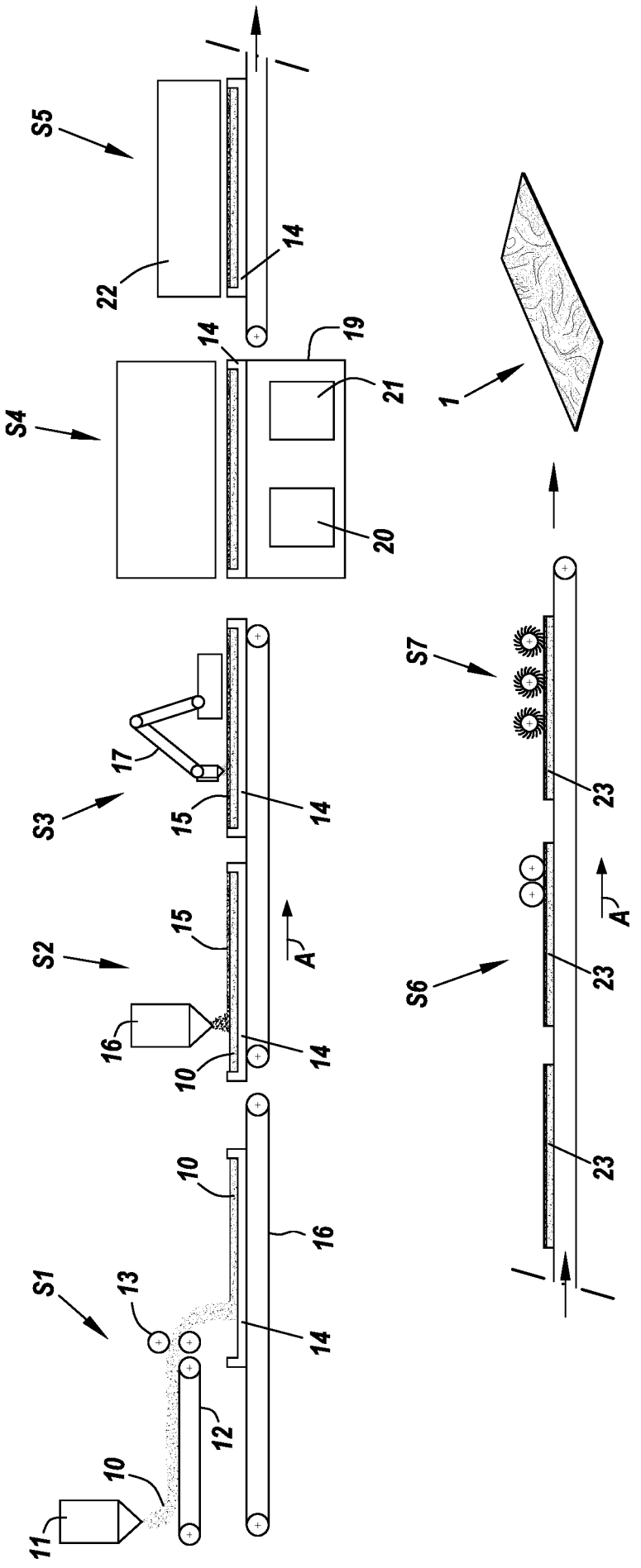

Fig. 3

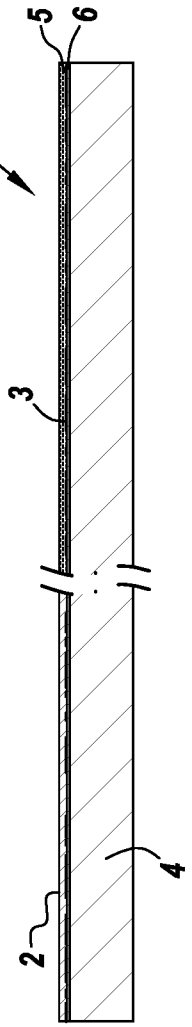

Fig. 4

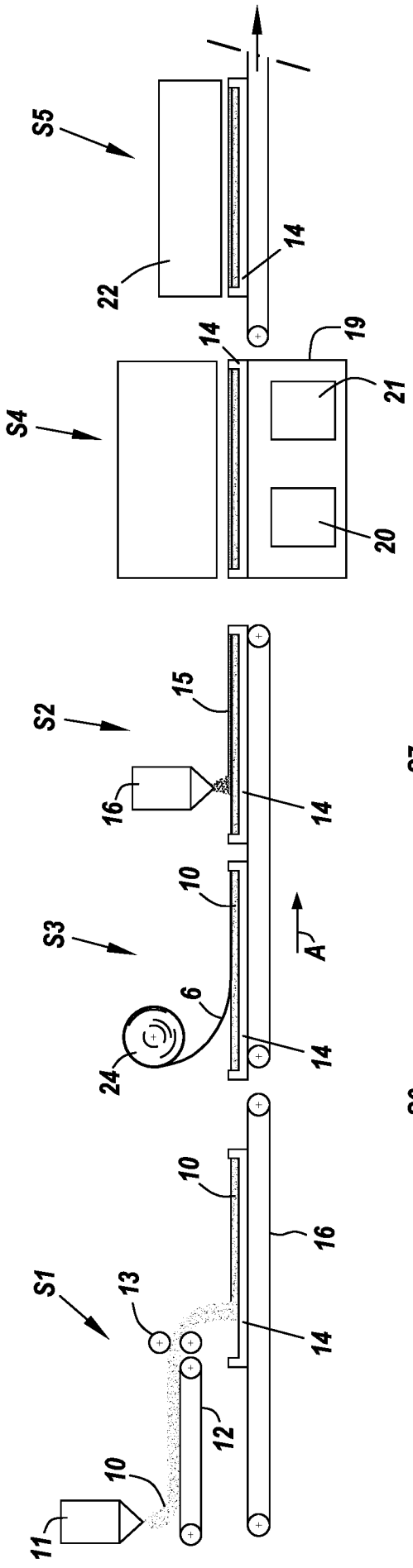

Fig. 5

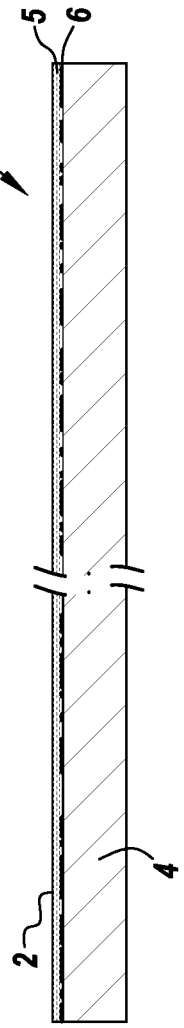

Fig. 6

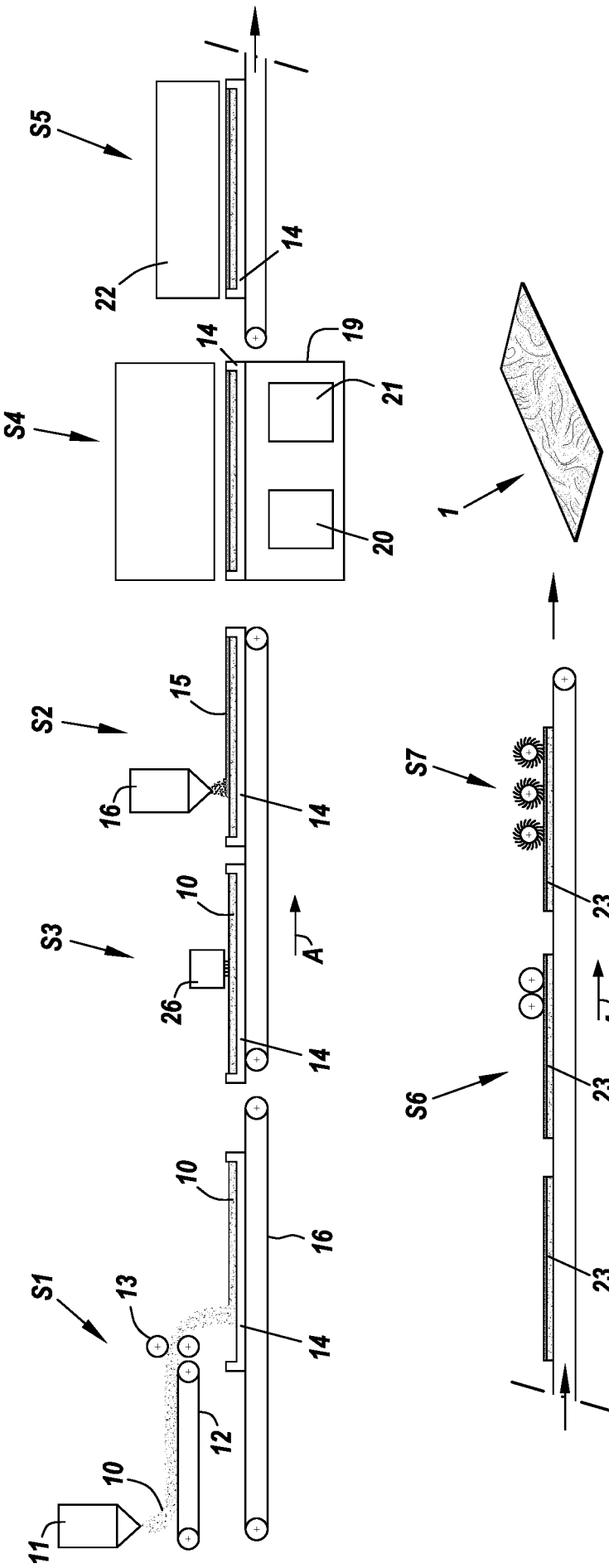

Fig. 7

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2024/055573

A. CLASSIFICATION OF SUBJECT MATTER

IPC: ***B44F 9/04*** (2024.01); ***C04B 14/06*** (2024.01); ***B28B 1/00*** (2024.01); ***B29C 67/24*** (2024.01); *C04B 18/02* (2024.01)

CPC: ***B44F 9/04; B28B 1/008; C04B 14/041; C04B 14/06; B29C 67/242; B28B 1/005;*** *C04B 18/022; C04B 2111/542; B29K 2509/14*

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)

See Search History Document

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

See Search History Document

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

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2020/0102247 A1 (FOSHAN YIXIN STONE CO. LTD.) 02 April 2020 (02.04.2020) entire document	1-4, 20
A	US 2023/0139870 A1 (DAL-TILE LLC) 04 May 2023 (04.05.2023) entire document	1-4, 20
A	WO 1999/022947 A1 (DRAGNEA) 14 May 1999 (14.05.1999) see machine translation	1-4, 20
A	US 9,707,698 B1 (XIE) 18 July 2017 (18.07.2017) entire document	1-4, 20

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"D" document cited by the applicant in the international application
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"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
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 July 2024 (17.07.2024)	**26 July 2024 (26.07.2024)**

Name and mailing address of the ISA/US	Authorized officer
Mail Stop PCT, Attn: ISA/US **Commissioner for Patents** **P.O. Box 1450, Alexandria, VA 22313-1450**	**MATOS** **TAINA**
Facsimile No. **571-273-8300**	Telephone No. **571-272-4300**

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB2024/055573

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☑ Claims Nos.: **5-19**
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).