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(54) Title: METHOD FOR MANUFACTURING A DECORATIVE ELEMENT FOR DECORATIVE SURFACES LIKE, FOR EXAMPLE, FLOOR, WALL OR FURNITURE SURFACES AND A DECORATIVE ELEMENT FOR DECORATIVE SURFACES

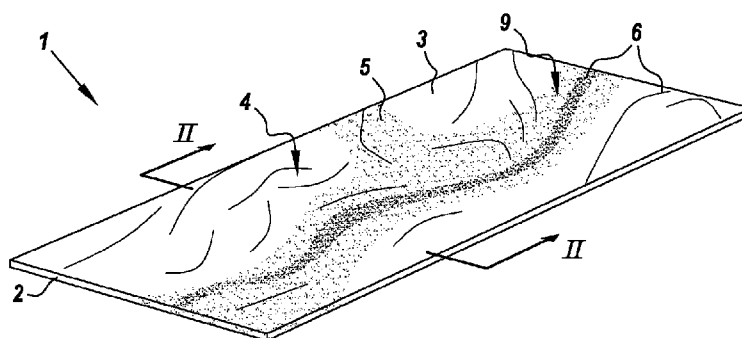


Fig. 1

(57) Abstract: A method for manufacturing a decorative element (1) comprising the steps of: - providing a substrate (2) having a first decorative pattern (5), wherein said first decorative pattern (5) is visible on at least a first surface (4) of said substrate (2); - acquiring digital copy (31) of the first decorative pattern (5) visible on said first surface (4); - generating a digital copy (32) of a second decorative pattern (6) on the basis of said digital copy (31) of the first decorative pattern (5); - feeding a printer (40) with said digital copy (32) of a second decorative pattern (6) and printing said second decorative pattern (6) on said first surface (4) of the substrate (2) to obtain the decorative element (1).

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Method for manufacturing a decorative element for decorative surfaces like, for example, floor, wall or furniture surfaces and a decorative element for decorative surfaces

- 5 The invention relates to a method for manufacturing a decorative element for decorative surfaces like, for example, floor, wall or furniture surfaces. The invention further relates to a decorative element for decorative surfaces.

More in particular, the invention relates to a method for manufacturing a decorative
10 element of the type made of an engineered stone which 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, in particular thermosetting resin. More in detail, with engineered stone is intended a composite material formed by an inorganic filler or a stone like material bonded together
15 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.

Therefore, in the past years methods for manufacturing engineered stones were
20 developed in order to reduce costs and provide a more environment 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 mineral filler, for example by grinding sand or quartz; mixing the stone or
25 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
30 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 formed by 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, because both the decoration technique and the vibro-compression step cause an uncontrolled and undetermined displacement of the coloring agent in the mixture.

WO 2016/113652 discloses an 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 inside a groove formed in the 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 created 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. The decorative element obtained through this method show a décor on the main surface which is formed by a combination of the inkjet printed pattern and the décor in the substrate. Anyway, since the final aspect of the décor in the substrate is non predictable, because of the intrinsic

characteristics of the process, as explained above, it can be particularly difficult to obtain a good matching between the inkjet printed pattern and the décor in the substrate.

The present invention aims in the first place at providing an alternative and improved method for manufacturing a 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.

Thereto, the present invention, according to its first independent aspect, relates to a method for manufacturing a method for manufacturing a decorative element comprising the steps of:

- providing a substrate having a first decorative pattern, wherein said decorative pattern is visible on at least one first surface of said substrate;
- acquiring a digital copy of at least a portion of said first decorative pattern visible on said first surface;
- generating a digital copy of a second decorative pattern on the basis of said digital copy of the first decorative pattern;
- feeding a printer with said digital copy of the second decorative pattern and printing said second decorative pattern on said first surface of the substrate to obtain the decorative element. Preferably, first and said second decorative pattern are both visible in said decorative element. In this way, since the digital copy of the second decorative pattern is generated on the final aspect of the decorative pattern in the substrate, a better match between the first and the second decorative patterns can be obtained. In fact, in this way it may be possible to compensate undesired or unpredictable variation or modification in the first decorative pattern that may have occurred during manufacturing of the substrate.

Said first decorative pattern is preferably formed by one or more pigments and/or grits distributed in the mass of the substrate so that the decorative pattern can be visible also on other surfaces of the substrate, preferably on all the surfaces. The first decorative pattern can be obtained according to several decoration techniques that involve mixing a pigments and/or grits in the mass of the substrate. A first decoration technique involves

mixing the pigments and/or grit into the mass during preparation of a mixture for forming the mass, so that the mass acquires a desired base color given by the pigment. Said mixing in the first decoration technique can be performed in such a way that the pigment can be homogeneously distributed in the mass so that said base color is uniform or in such a way that the pigment can be non-homogeneously distributed in the mass so that said base color is not uniform and the substrate comprises shade variations. In a second decoration technique, the pigments and/or grits can be spread on the mixture before or during filling a mold with the mixture so that the pigments and/or grits are located only in certain areas or portions of the mixture in the mold, for example generating a veined effect. An example of this second decorative technique is disclosed in WO 2009/010406 which is incorporated by reference in its entirety. In a third decoration technique a computer programmable machine can be configured to mix a pigment in the mixture according to a predetermined pattern, for example once the mixture for forming the substrate is already in a mold. For example, said computer programmable machine can be configured to dig a groove in the mass of mixture in the mold and then deliver the pigment in said groove, for example to obtain a veined effect according to a predetermined drawing, preferably a CAD drawing. An example of this second decorative technique is disclosed in WO 2016/113652 which is incorporated by reference in its entirety. The first decorative pattern can preferably imitate the veining and/or the graining of a natural stone.

The second decorative pattern is preferably obtained by inkjet printing. Inkjet printing is a digitally controlled operation wherein one or more printheads jet tiny droplets of one or more inks on the substrate to form the second decorative pattern. Inkjet printing is a technology that leads to highly flexible decoration processes adapted for forming designs and decors having high resolution. The second decorative pattern can preferably show a higher resolution compared to the first decorative pattern, for example a resolution above 200dpi, preferably equal or higher than 300dpi. The second decorative pattern is preferably printed only on said first surface of the decorative element. It is not excluded in deviant embodiments that said second decorative pattern can be printed also on other surfaces of the substrate. The second decorative pattern can be a stone imitating pattern.

Printing the second decorative pattern involves jetting inks belonging to a set of multiple inks like, preferably, cyan, magenta, yellow and black. It is noted that the set of ink can comprise inks related to one or more spot colors, like for example red, green, brown, white being in addition or in substitution of cyan, magenta, yellow and black. The inks
5 belonging to said set of inks can be selected on the basis of the second decorative pattern to be printed in order to reduce the amount of jetted ink. For example, for printing some marble imitating pattern, the set of ink can comprise black, white and grey ink. Preferably, the inks are pigment containing inks, where said pigment can be inorganic and/or organic. Pigments are preferred over other kinds of colorants, like dyes as they
10 show a better durability and stability especially when exposed to UV radiation, like the one coming from sunlight. Inorganic pigments are even more stable and durable than organic pigments. In the preferred embodiments of the invention, the inks are curable inks, i.e. inks that comprise a binder adapted to fix the pigment on the surface of the substrate after curing, for example by means of radiation curing. The most preferred
15 examples of binder containing inks are UV inks and hydro-UV inks. Making use of curable inks requires a curing step performed during or after printing operation. Curable inks, after curing, form a film or a material layer on the surface of the substrate on which they are printed. In less preferred embodiments, the inks can be sublimation inks. Sublimation inks are inks adapted to link to the material forming the substrate, in
20 particular a binder thereof, after activation under heat. When activated under heat, the sublimation ink, and/or a colorant contained therein, sublimates and penetrates the surface of the substrate to be thereby fixed on the substrate itself. Said printing operation and said inks are described in WO 2019/070621, WO 2024/003735, WO 2024/121738 and US 20240033969 which are herein incorporated by reference in their entirety.

25 It is noted that, before printing one or more surface preparing operations can be performed. In the preferred embodiments, said surface preparing operation can comprise one or more of the following operations:

- sanding and/or polishing said first surface of the substrate;
- 30 - heating at least said first surface of the substrate;
- providing an adhesion promoter coating on said first surface of the substrate;
- providing a primer coating on said first surface of the substrate.

Said sanding and/or polishing step can have the effect of increasing the rugosity of said first surface, preferably to improve the adherence of the ink forming the second decorative pattern, and/or the material forming a top layer above said first surface.

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Said heating at least said first surface of the substrate can have the scope of allowing quick drying of the ink forming of the second decorative pattern and/or the material forming a top layer above said first surface. Preferably, during said heating step the temperature of the at least said first surface of the substrate reaches a value between room temperature and 200°C, preferably between 50°C and 100°C.

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Said adhesion promoter coating can preferably comprise or consists of silane-based substance, to improve the adhesion between the surface of the substrate and the ink forming of the second decorative pattern and/or other material forming a top layer above said first surface. Said adhesion promoter coating can be preferably applied in the form of a liquid substance, preferably a water-based substance. It is noted that the method can comprise the step of curing and/or drying the adhesion promoter coating. In the preferred embodiment of the invention the adhesion promoter coating is transparent or translucent so that the first decorative pattern is visible through the adhesion promoter coating itself.

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Said primer coating on said first surface of the substrate can have the effect of helping the absorbing and/or adhering of the ink forming the second decorative pattern. Said primer coating can be preferably applied in the form of a liquid substance, preferably a curable substance, especially radiation curable coating. It is noted that the method can comprise the step of curing and/or drying the primer coating. In the preferred embodiment of the invention the primer coating is transparent or translucent so that the first decorative pattern is visible through the primer coating itself.

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It is noted that, after printing the second decorative pattern, one or more finishing operations can be performed. Said finishing operations can be selected from the group comprising: brushing, polishing, coating, sealing.

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In some embodiments, the method can comprise providing a protective coating on said second decorative pattern. Said protective coating can be preferably applied in the form of a liquid substance, preferably a curable substance, especially radiation curable coating. It is noted that the method can comprise the step of curing and/or drying the protective coating. In the preferred embodiment of the invention the protective coating is transparent or translucent.

The method of the invention can comprise a step of polishing said protective coating, so that a desired matte or glossy finish can be achieved.

In some embodiments said protective coating can be applied in multiple coating steps. Preferably, between said multiple coating steps a sanding operation can be performed.

Said primer coating, protective coating and in general said surface preparing operation, and said finishing operations are described in WO 2024/003735 and WO 2024/121738 which are herein incorporated by reference in their entirety.

The second decorative pattern can be preferably according to two preferred possibilities herein below described.

According to a first possibility said second decorative pattern represents the main decorative pattern visible on said first surface. For example, said second decorative pattern can cover 50% or more, preferably 80% or more, more preferably the totality of the first surface of the decorative element. For example, the second decorative pattern can cover completely the first decorative pattern so that the first decorative pattern forms a background for the second decorative pattern. In this case, both the first and the second decorative pattern are visible on the first surface of the decorative element. It is also possible that the second decorative pattern can cover completely the first decorative pattern so that the first decorative pattern is not visible through the second decorative pattern. In this case, the second decorative pattern can provide for a highly realistic and aesthetically valuable appearance of the decorative element on its first surface, whereas the first decorative pattern being visible on the other surfaces of the decorative elements

can contribute in forming the realistic effect by giving an impression of continuity of the decorative pattern from the first surface to the other surfaces of the decorative element. The solution of the first independent aspect can ensure that the said continuity is easily obtained irrespective of any unpredicted or unpredictable feature of the first decorative pattern.

According to a second possibility, said second decorative pattern represents details or additional features integrating the first decorative pattern, which in this case represents the main decorative pattern. According to this second possibility, the first and the second decorative pattern are always both visible on the first surface of the decorative element, so that the first and second decorative pattern form a combined decorative pattern on said first surface. In this way, the second decorative substrate can improve the realistic appearance of the first decorative pattern. On the other hand, since the second decorative pattern is used only for enrich the décor on the first surface and the décor is mainly formed by the first decorative pattern, it is possible to limit the resolution mismatch between the décor on the first and the décor on the other surfaces that can sometimes be perceived in the first possibility where the. In accordance with said second possibility the said second decorative pattern can cover 80% or less, preferably 50% or less of the first surface of the decorative element. In case the second decorative pattern being a stone imitating pattern, the second decorative pattern can for example represent additional veins, flakes and/or color shades to enrich the natural feeling of the decorative element.

The invention as defined in the first independent aspect can be performed according to multiple embodiments, two preferred of which are herein below described.

In the first of said preferred embodiment of the invention, said step of generating the digital copy of the second decorative pattern can be performed by a machine-learning model. In this way, the generation of the second decorative pattern, and the digital copy thereof, can be simplified being less cumbersome for human operators. An additional advantage of generating the second decorative pattern with a machine learning model is that it can be reduced the need for extraction of real natural stones for tacking pictures that could form the basis of the second decorative pattern. In some embodiments, the

machine-learning model can be configured to identify a feature within the digital copy of the first decorative pattern corresponding to a feature of the first decorative pattern. The machine-learning model can be configured to predict a related feature of the second decorative pattern based upon the feature identified within digital copy of the first decorative pattern. The machine learning model can be fed with the acquired digital copy of the first decorative pattern and can be configured to identify a predetermined first group of information on the first decorative pattern and to generate a new second decorative pattern based on said group of information. For example, said first group of information can comprise one or more information selected from the group comprising: color coordinates, for example measured in one or more locations on the first decorative pattern; kind of decorative pattern, for example, in case of a stone imitating pattern, the kind of stone; in the case of a stone imitating pattern, information concerning the veining or flakes, for example, position, direction, length width of said veins or flakes. Based on said first group of information, the machine-learning model can generate the second decorative pattern in such a way that, for example in the case of stone imitating pattern, it represents the same kind of stone, includes the same or similar colors, and/or the position, direction and/or dimensions of the veining and/or flakes correspond at least in part, for example in such a way that there is a partial or total overlap, with the veining or flakes of the first decorative pattern. The machine-learning model can also be fed with a second group of information that preferably represents a source for the prediction of the second decorative pattern, for example said second group of information can comprise a set of images of natural stone so that the machine-learning model can learn how to generate the a second decorative pattern that can imitate features of a real natural stone or of a certain kind of natural stone.

In accordance with the second of said preferred embodiments, the step of generating said digital copy of the second decorative pattern involves an image editing operation performed on a starting digital copy of the second decorative pattern. In this way, the generation of the digital copy of the second decorative pattern can be simplified and less cumbersome since it is performed from the starting digital copy of the second decorative pattern for a specific product. In addition, since in this second preferred embodiment it is not required the complete generation of the second decorative pattern following the

acquisition of the first decorative pattern, the time between the step of providing the substrate and the step of printing the second decorative substrate can be reduced thereby increasing the productivity of the method. For example, the step of generating the digital copy of the second decorative pattern can be an adaptation of the starting digital copy of the second decorative pattern to the acquired digital copy of the first decorative pattern.

For example, said adaptation can involve one or more of the operations selected from the group comprising: color change, dimension change, pattern distortion. The method of the second preferred embodiment can involve identify a predetermined first group of information on the first decorative pattern, compare them to a third group of information of the starting digital copy of the second decorative pattern, and performing said image editing operation on the basis of said comparison. For example, said comparison can involve determining, for example measuring or calculating, a difference between an information of said first group, for example a value thereof, and a corresponding information of the third group, and the image editing operation can be performed in such a way to modify the information on said third group in such a way to minimize, possibly nullify, said difference. For example, said third and third group of information can comprise one or more information selected from the group comprising: color coordinates, for example measured in one or more locations on the first decorative pattern; kind of decorative pattern, for example, in case of a stone imitating pattern, the kind of stone; in the case of a stone imitating pattern, information concerning the veining or flakes, for example, position, direction, length width of said veins or flakes. In this way, in case during preparation of the substrate a color shift in the first decorative pattern occurred, the second decorative pattern can be modified before printing to reduce color mismatch between the first and second decorative pattern. Similarly, if for example in case of a stone imitating décor during preparation of the substrate a vein has been deformed and/or a flake had been displaced the second decorative pattern can be edited so that the matching between the first and the second decorative pattern is ensured. The image editing operation can be performed using a graphic editor software, for example Gimp or Photoshop. Said image editing operation can be performed by a human operator. It is also possible that said image editing operation is performed by means of a machine learning model.

In the preferred example the starting digital copy of the second decorative pattern can be a scanned image or a photography of a natural stone, possibly already subjected to a previous image editing operation. It is not excluded that the starting digital copy of the second decorative pattern can be any kind of design. The starting digital copy of the second decorative pattern can be connected to a starting digital copy of the first decorative pattern. In this way, for each product the digital copies of the decorative patterns can be prepared in advance with the aim of achieving a good matching between the first and the second decorative patterns themselves, and by means of the method of the invention it could be possible to compensate unexpected deformation or distortion in the first decorative pattern that could occur during the manufacture of the substrate. For example, the starting digital copy of the first decorative pattern can be a CAD drawing, or another file, preferably a bidimensional drawing file, for controlling a decorative machine, like one or more cartesian or anthropomorphic robot.

The substrate can comprise an identification element, for example a readable code, like a barcode or a QR code, associated to the starting digital copy of the second decorative and the method can comprise the step of detecting said identification element and selecting said starting digital copy of the second decorative pattern on the basis of said detection. In this way, between the preparation of the substrate and the printing of the second decorative pattern multiple operation can be performed and/or the substrate can be stocked while ensuring that a certain second decorative pattern is printed on the right correct substrate. For example, the starting digital copy of the second decorative pattern can be selected from a database. Said identification element can be preferably provided on a surface of the substrate, preferably different from said first surface.

According to any of the embodiments and or possibilities of the first independent aspect, the step of acquiring a digital copy of the first decorative pattern visible on said first surface can be performed using a digital scanner or a camera.

According to any of the embodiments and or possibilities of the first independent aspect, the substrate is in the form of a slab and said first surface is a portion of, or possibly the entire, main upper surface of said slab.

In the preferred embodiment of the invention, said substrate is made of a cured engineered stone. In the context of the present invention, an engineered stone is made of an inorganic filler and a polymeric binder and showing a porosity below or equal 0,1%.

5 The inorganic filler is preferably at least 80% by weight of the engineered stone, preferably more than 85% and more preferably more than 90%. The binder being less than 20% by weight of the engineered stone, preferably less than 15% and more preferably less than 10%. The engineered stone being obtained starting from a mixture comprising said inorganic filler and said binder.

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In the preferred embodiment the inorganic filler comprises mineral material like any kind of stone, sands, siliceous mineral material, for example quartz, silica sand, clay, feldspar cristobalite granite, talc or calcareous mineral material, for example, calcium carbonate, marble, gypsum. The inorganic filler can also comprise ceramic, glass, metals and other
15 inorganic material, for example recycled materials. The filler 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 mixture, preferably more than the 85% and
20 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.

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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
25 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 the most preferred embodiment of the invention the filler is composed for its majority, i.e. at least 50%weight, and more preferably mainly consists, of an inorganic material that is based
30 on silicon (Si). Silicon based material like siliceous minerals and glass show a good affinity with the binder so that the final bonding can be improved.

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In some embodiments, crystalline silica, feldspar or kaolin can constitute preferred choice for the inorganic filler, or at least for a majority of the filler, as they can show a relatively white color. In some embodiments, glassy and/or amorphous inorganic fillers can be preferred for forming the majority of the inorganic filler as they can reduce the amount of free crystalline silica dust in manufacturing and/or working of the decorative element.

The binder is a curable substance that is configured to be cured thereby bonding together the particles of the stone or stone like material. The binder can be in any form, i.e. liquid, solid, gel or any form that is suitable to be mixed with the filler and to be homogeneously dispersed within. In some embodiments, powder form can be preferred as reduces the possibility of contamination of the mixture from other substance, that can occur using wet form of binders. The binder can be an organic substance, for example a resin. In the most preferred example, the binder can be a thermosetting resin.

In the most preferred embodiment the binder 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 mixture, preferably less than the 15% and more preferably less than 10%. Polyester resins have shown a very high coupling capability with the inorganic filler.

In the preferred embodiment the mixture can further 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. In the most preferred embodiments, the pigments are in the form of metal oxides. Preferred colors for the coloring agent are black, yellow, white, red and green.

The method of the first independent aspect can involve manufacturing the substrate. Preferably manufacturing the substrate involves at least the steps of: preparing a mixture

for an engineered stone comprising the inorganic filler and a binder; providing the mixture on temporary support, for example a mold; forming a first decorative pattern on the mixture in the temporary support; compacting the mixture; curing the binder to obtain the engineered stone.

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The precursor mixture can preferably be as per the mixture above. Preferably, in the mixture, the inorganic filler is in the form of powder and/or grits and the binder is liquid form.

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Preferably, the mixture can be provided in a mold, especially in a rubber mold. In the preferred example the mixture can be provided directly into a mold, a frame or any other tool suitable for providing a shape to the mixture by means of hopper or feeder.

15 Before and/or during the step of providing the mixture into the mold 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 substrate 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.

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During and/or after the step of providing the mixture into the mold a second coloring agent or second set of coloring agent can be to the mixture in the mold according to a motif which can be random or predetermined. Preferably, the 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 distributor for dispensing the coloring agent. The color distributor is connected to a tool that interacts with the surface of the mixture to create grooves or holes to receive the coloring agent.

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Preferably said predetermined motif is obtained using computer-controlled machines like those described in WO 2016/113652. Preferably said computer controlled machine can be controlled through the digital copy of the first decorative pattern as described above.

- 5 The random motif formed by the first coloring agent, or first set of coloring agents, or the predetermined motif formed by the second coloring agent, or second set of coloring agents, or preferably a combination thereof, forms of the first decorative pattern of the decorative element. Said first decorative pattern is present in the substrate and in particular is present through the entire thickness of the substrate. In practice said first
10 decorative pattern forms a three-dimensional décor.

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
15 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 a substrate having an extremely low porosity.

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It is to be noted that as a consequence of the compacting step the powders and grains forming the mixture in the mold can be subjected to a displacement that modifies the motif of the first and/or second coloring agent. Therefore, the final first decorative pattern will inevitably comprise random features so that each substrate will have be unique and
25 differs from the other.

After the compacting step, the mixture in the mold is 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
30 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.

- 5 After the step of curing, the steps of manufacturing the substrate can comprise one or more steps between calibration, squaring and/or polishing.

In a special embodiment, that can also be applied in combination with the first and or second embodiment, the second decorative pattern can be configured to hide a visual
10 defect present in said first surface of the substrate. Said visual defect can be an impurity in the mixture, for example one or more stones or sand grains having a different color from the others forming the inorganic filler, or another visual defect deriving from the manufacturing process present in the substrate. In this way, inkjet printing can be used to correct defects of the material or of the manufacturing process in such a way to reduce
15 waste, or to increase the quantity of product classifiable as first choice consequently reduce quantity of product in classifiable as second choice. For example, the machine learning model already described in reference to the first main embodiment, can be configured to identify said visual defect and generate a digital copy of a decorative pattern that, once printed and overlapped to the visual defect, can hide said visual defect.
20 Said special embodiment is particularly useful in case the substrate shows a first decorative pattern in form of a uniform color, for example, white, where defects, even tiny, like impurities are more noticeable.

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

- Figure 1 shows an axonometric view of a decorative element;
Figure 2, in an enlarged view, shows a section according to plane II-II of figure 1;
30 Figure 3 shows an enlarged view of area F3 of figure 2;
Figure 4 schematically shows some steps of a method for manufacturing the decorative element of figure 1;

Figure 5 shows some details of a step of the method of figure 3 according to a first embodiment of the invention;

Figure 6 shows some details of a step of the method of figure 3 according to a second embodiment of the invention.

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Figure 1 shows a decorative element 1 in form of a slab. The decorative element 1 comprises a substrate 2 and a top layer 3 covering an upper first surface 4 of the substrate 2.

10 The substrate 2 is made of an engineered stone, wherein the engineered stone comprises an inorganic filler and a cured organic binder that bonds together the particles of inorganic filler. The inorganic filler is based on silicon oxide like silica or feldspar. The binder is preferably a thermosetting resin and more in particular an unsaturated polyester resin.

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The decorative element 1 comprises a combined decorative pattern 9 formed by a first decorative pattern 5 and a second decorative pattern 6 that are both visible from the top surface of the decorative element 1 itself.

20 The first decorative pattern 5 is a three-dimensional decoration that is present in the entire thickness of the substrate 2 and, in the example, represents an imitation of marble veins and flakes. The second decorative pattern 6 is a printed pattern that is present in the top layer 3 and, in the example, shows additional veins and flakes of the imitated marble. The second decorative pattern 6 has a higher resolution than that of the first decorative
25 pattern 5.

As shown in figure 2, the top layer 3 comprises, from bottom to top: a primer coating 7, an ink layer forming the second decorative pattern 6 and a protective coating 8. The primer coating 7 is acrylate based and comprises a UV cured substance. The primer
30 coating 7 is transparent. The ink layer forming the second decorative pattern 6 is formed by inkjet printed inks. Said inks forming the second decorative pattern comprise a UV

cured binder and inorganic pigments. The protective coating 8 is acrylate based and comprises a UV cured substance. The protective coating 8 is transparent.

Figure 4 shows some steps in a method, according to the invention, for manufacturing
5 the decorative element of figures 1 and 2.

In a step S1 a mixture 10 is provided into a mold 15 for manufacturing the substrate 2. The mixture 10 comprises the inorganic filler and the binder.

10 The filler is composed by a combination of powder and grains, for example said combination comprises 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 . The filler is preferably at least the 80% by weight
15 of the mixture, preferably more than the 85% and more preferably more than 90%.

The binder is in powder form and form up to 10% by weight of the mixture.

The mixture 10 further comprises additives, like for example coupling agent, catalyst or
20 crosslinkers.

In step S1 the mixture 10 is deposited from a hopper 11 on a first belt 12. A feeder 13 feeds a first set of coloring agents 14 to the mixture 10 on the first belt 12. By virtue of the advancing of the first belt 12, the mixture 10 with the first coloring agents 14 falls
25 into the mold 15 disposed on a second belt 16 placed below the first belt 12. As a consequence of this fall, the first coloring agent 14 is randomly distributed into the mixture 10 in the mold 15.

Once the mixture 10 is in the mold 15, a robotic arm 17 delivers a second set of coloring
30 agents 18 into the mixture 10 according to a predetermined motif. The motif obtained by the combination of the first set of coloring agents 14 and the second set of coloring agents 18 substantially form the first decorative pattern 5. The anthropomorphic robot 17 is

controlled by a control system CS that commands the robot 17 itself according to a starting digital copy of the first decorative pattern 5, in particular a CAD file.

5 The mixture 10 in the mold 15 advances in an advancing direction A to a compacting station 19 for a compaction step S2. Said compacting station 19 comprises a vibrating unit 20 and a vacuum unit 21, for the application of vibration and vacuum on the mixture in the mold 15 that leads to the compaction thereof.

10 During said vibration and vacuuming, the mixture 10 inside the mold, and the first and second coloring agents 14, 18 can be displaced so that the final first decorative pattern comprises unpredicted and random features, for example an unpredicted flake, or a displaced or deformed vein.

15 The mixture 10, yet in the molding, is then carried to a curing station 22 where the binder is cured in a curing step S3. The cure of the binder is activated at a temperature below 200 °C and then continues as an exothermic reaction.

20 After curing step S3, the obtained substrate 2 of engineered stone, which is now a coherent material having a porosity below 0,2%, is then extracted from the mold 15 and carried to multiple station for finishing operations on the substrate 2.

In mechanical machining step S4 the substrate 2 is calibrated to flatten at least the upper surface thereof and rectified so that it finally reaches the desired final dimension.

25 Subsequently, at least the first surface of the substrate 2 is mechanically treated in a polishing step S5. The polishing step S5 is conducted using abrasives having a CAMI Grit designation between 300 and 600 grits, preferably 400 grits.

30 After polishing step S5 a scanner 30 acquires a digital copy 31 of the first decorative pattern 5 on the upper first surface 4 of the substrate 2, in an acquisition step S6 and sends it to the control system CS for the generation of a digital copy 32 of the second decorative pattern 6 as it is shown in Figure 5.

Figure 5 illustrates an embodiment of a control system CS that includes a number of clients 33, a server system 34, and a data repository 35 communicably coupled through a network 36 by one or more communication links 37 (e.g., wireless, wired, or a combination thereof). The clients 33, generally, can include any hardware or software device that accesses a service made available by the server system 34. For instance, the scanner 30, the antropomorphic robot 17 and a printer 40 (of Figure 4 and a a communicatively coupled with one or more computing device 38 may be a client, such that, for example, the scanner 30 is able to send and receive information (e.g., digital images) with the control system CS. The control system CS, generally, can execute applications and analyze data associated with images, for example, the digital copy 31 of the first decorative pattern 5 such as may be acquired in the performance of the methods disclosed herein. The control system CS may execute a machine-learning model 50 to evaluate the digital copy 31 of the first decorative pattern 5 and generate the digital copy 32 of the second decorative pattern 6.

In the embodiment of Figure 5, the machine-learning model 50 comprises a machine-learning module 51 coupled to one or more data stores, for example, data within the data repository 35. For instance, in the embodiment of Figure 5 the data within the data repository 35 may include data from a training data store 52 and/or inputs 53.

As also shown in Figure 5, the machine-learning module 51 can access data, such as data from the training data store 52, receive inputs 53, and provide an output 54 based upon the inputs 53 and data retrieved from the training data store 52. Generally, the machine-learning module 51 utilizes data stored in the training data store 52 pertaining to surfaces of natural materials, like marble, that decorative elements are intended to imitate to enable the machine-learning module 51 to predictively derive the digital copy 32 of the second decorative pattern 6 to be printed on the first surface 4 of the substrate 2.

Generally, the inputs 53 can comprise one or more constraints or limitations that may affect the way in which the machine-learning module 51 is trained. The inputs 53 can be provided as separate inputs, as a single input, or as a vector or matrix of input values.

The inputs 53 may be received, for example, from an equipment operator or other user. In various embodiments, the inputs 53 may define, for instance, constraints or parameters for the machine-learning module 51.

5 Generally, the machine-learning module 51 is a learning machine exhibiting “artificial intelligence” capabilities. For example, the machine-learning module 51 may utilize algorithms to learn via inductive inference based on observing data that represents incomplete information about statistical phenomenon and generalizes it to rules and to make predictions on missing attributes or future data. Further, the machine-learning
10 module 51 may perform pattern recognition, in which the machine-learning module 51 “learns” to automatically recognize complex patterns, to distinguish between exemplars based upon varying patterns, and to make intelligent predictions. In some embodiments, the machine-learning module 51 can perform optimization to narrow down the data used to allow the machine-learning module 51 to operate efficiently, even when large amounts
15 of historical training data are present, and/or when complex input parameters are present.

The machine-learning module 51 can comprise and/or implement any suitable machine-learning algorithm or methodology, examples of which may include, but are not limited to, artificial neural networks (ANNs), deep neural networks (DNNs), deep reinforcement
20 learning, convolutional neural networks, decision trees, support vector machines, Bayesian networks, genetic algorithms, and the like, and combinations thereof.

At a high level, the machine-learning module 51 may receive inputs 53 comprising constraints, parameters, and training data, for example, data from the training data store
25 52 to perform learning with respect to the natural marble that the decorative element is intended to imitate. For example, in some embodiments, the machine-learning module 51 may “learn” or be trained by processing the training data, more particularly, the data from the training data store 52, which includes a plurality of batches of data, each batch representing each of a data for each of a plurality of scenarios. Each batch of data may
30 include known inputs, in particular a first group of information 55 identified in the digital copy 31 of the first decorative pattern 5. For example, said first group of information 55 comprises one or more information selected from the group comprising: color

coordinates, for example measured in one or more locations on the first decorative pattern; kind of decorative pattern, for example, in case of a stone imitating pattern, the kind of stone; in the case of a stone imitating pattern, information concerning the veining or flakes, for example, position, direction, length width of said veins or flakes.

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As the machine-learning module 51 processes the training data, the machine-learning module 51 may form one or more probability-weighted associations between the various known inputs and the respective outcomes. As training progresses, the machine-learning module 51 may adjust weighted associations between various inputs, for example, according to a learning rule, in order to decrease the error between the inputs and their respective outputs. As such, the machine-learning module 51 may increasingly approach a target output until the error is acceptable.

As such, based on processing the training data, for example, data from the training data store 52, the machine-learning module 51 provides, as an output 54, a prediction of the second decorative pattern 6 to be printed on the upper first surface 4 of the substrate. That is, once the machine-learning module 51 has been trained using the training data, the machine-learning module 51 may be used to evaluate the acquired digital copy 31 of the first decorative pattern 5 and, also, determine the second decorative pattern 6 based upon the evaluation of the first decorative pattern 31. For example, the machine-learning module 51 may be used to predict a second group of information 56 in the second decorative pattern 6 based on the first group of information 55.

The trained machine-learning module 51 undergoes one or more evaluation, validation, and/or or testing protocols to determine whether or not the trained machine-learning module exhibits sufficient ability to predict decorative patterns. For example, the trained machine-learning module may be evaluated and/or tested using at least a portion of the training data (e.g., an evaluation data subset). During the evaluation procedure, the trained machine-learning module may process evaluation data and the results of the evaluation may be compared to an acceptable error threshold. If the error exhibited by the trained machine-learning module is not acceptable, the machine-learning module may be retrained. In various embodiments, the trained, and optionally retrained,

machine-learning module may be subjected to any desired number of evaluations, testing, and or verification stages. When the error exhibited by the trained machine-learning module is acceptable error across the desired number of evaluations, testing, and or verification stages, the machine-learning model may be considered ready for use.

5

Coming back to figure 4, substrate 2 is moved to a first coating station 41 for the application of the primer coating 7 in a first coating step S7. The first coating station 41 comprises one or more coating rollers 42 and one or more Gallium UV Lamps 43 for the gelling of the primer coating 7. The primer coating 7 is preferably applied in an amount

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The substrate 2 is then moved to a printing station 44 for printing the second decorative pattern 6 in a printing step S8. The printing station comprises a single pass inkjet printer 40, connected to the control system CS, and UV LEDs 45. The printer 40 is configured

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to print at least 4 inks, cyan, magenta, yellow and black, with the possible addition of one or more spot colors, preferably white ink. The inks are UV curable pigmented ink. The pigments are an inorganic ink. The control system CS feeds the digital copy 32 of the second decorative pattern 6 to the printer 40 for printing the second decorative pattern 6 on the substrate 2. After printing the inks are gelled using the UV LEDs 45.

20

The substrate 2 is then moved to a second coating station 46 for the application of a the protective coat 8 in a second coating step S9. The second coating station 46 comprises one or more coating rollers 47, one or more Gallium UV Lamps and one or more Mercury HG UV lamps 48 for the curing of the protective coating 8. After application the basecoat

25

is fully cured using the Gallium UV Lamps and the Mercury HG UV lamps 47.

After fully curing of the protective coating 8, the substrate 2 is then moved to a second polishing station 49 for performing a second polishing step S10 to achieve the final desired gloss degree. The decorative element 1 is then finally obtained.

30

Figure 6 shows a second main preferred embodiment of the invention, that differs from the preferred embodiment of Figure 5 only in the step of generating the digital copy 32

of the second decorative pattern 6. In this second preferred embodiment, the generation of the digital copy 32 of the second decorative pattern 6, involves an adaptation of a starting digital copy 57 of the second decorative pattern 6. The starting digital copy 57 of the second decorative pattern 6 is an image previously edited, for example starting
5 from an image of a natural marble, resembling the desired combined decorative pattern 9 for the product. In the second main preferred example, the first group of information 55 identified in the acquired digital copy 31 of the first decorative pattern 5 are compared to a corresponding third group of information 58 in the starting digital copy 57 of the second decorative pattern 6 so that a deviation of the acquired first decorative pattern 5
10 from the expected pattern can be determined, and the second decorative pattern 6 can be adapted to compensate said deviation.

In this example of the second main preferred embodiment, said adaptation is performed in an image editing operation performed by an operator using an image editing software,
15 like, for example, Photoshop®.

The present invention is in no way limited to the hereinabove described embodiments, but such decorative element and method of manufacturing the decorative element may be realized according to different variants without leaving the scope of the present
20 invention.

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

- 25 1. A method for manufacturing a decorative element (1) comprising the steps of:
- providing a substrate (2) having a first decorative pattern (5), wherein said first decorative pattern (5) is visible on at least a first surface (4) of said substrate (2);
 - acquiring digital copy (31) of the first decorative pattern (5) visible on said first surface (4);
 - 30 - generating a digital copy (32) of a second decorative pattern (6) on the basis of said digital copy (31) of the first decorative pattern (5);

- feeding a printer (40) with said digital copy (32) of a second decorative pattern (6) and printing said second decorative pattern (6) on said first surface (4) of the substrate (2) to obtain the decorative element (1).

5 2. The method according to item 1, wherein said step of generating the digital copy (32) of the second decorative pattern (6) is performed by a machine-learning model (50).

10 3. The method according to item 2, wherein the machine-learning model (50) is configured to identify a first group of information (55) within the digital copy (31) of the first decorative pattern (5).

15 4. The method according to item 3, wherein the machine-learning model (50) is configured to predict a second group of information (56) of the second decorative pattern (6) based upon the first group of information (55) identified within the digital copy (31) of the first decorative pattern (5).

20 5. The method according to item 1, wherein said step of generating the digital copy (32) of the second decorative pattern (6) involves an image editing operation performed on a starting digital copy (57) of the second decorative pattern (6).

25 6. The method according to item 5, wherein said image editing operation is performed by a human operator, preferably using a graphic editor software, for example Gimp or Photoshop.

30 7. The method according to item 5 or 6, wherein substrate (2) comprises an identification element associated to said starting digital copy (57) of the second decorative pattern (6) and wherein the method comprises the step of evaluating said identification element and selecting said starting digital copy (57) of the second decorative pattern (6), from example from a plurality of digital copies stored in a storage unit (35).

8. The method according to any of the preceding items, wherein said first decorative pattern (5) is an imitation of a stone.

9. The method according to any of the preceding items, wherein said second decorative pattern (6) is an imitation of a stone.

10. The method according to any of the preceding items, wherein said first and second decorative pattern (5, 6) are both visible on the first surface (4) of the decorative element, for example the first and second decorative pattern (5, 6) form a combined decorative pattern (9) on said first surface (4).

11. The method according to item 10, wherein said second decorative pattern (6) represents additional details of the first decorative pattern (5).

12. The method according to any of the preceding items, wherein the decorative pattern is configured to hide said visual defect.

13. The method according to any of the preceding items, wherein said first decorative pattern (5) is present in the entire thickness of the substrate (2).

14. The method according to any of the preceding items, wherein said substrate (2) is made of a cured engineered stone, a sintered stone or a ceramic material.

15. The method according to any of the preceding items, comprising one or more of the following steps before said step of printing:

- sanding or polishing said first surface (4) of the substrate (2);
- heating at least said first surface (4) of the substrate (2);
- providing an adhesion promoter coating on said first surface of the substrate;
- providing a primer coating (7) on said first surface (4) of the substrate (2).

16. The method according to any of the preceding items, comprising providing a protective coating (8) on said second decorative pattern (6).

17. The method according to any of the preceding items, comprising a step of polishing said protective coating (8).

18. The method according to any of the preceding items, wherein said printing operation is performed directly on said first surface (4) of the substrate (2).

19. The method according to any of the preceding items, wherein said printing operation is performed by jetting curable inks and/or sublimation inks.

20. The method according to any of the preceding items, comprising manufacturing said substrate (2), preferably wherein said substrate is made of engineered stone, and preferably wherein manufacturing the substrate involves at least the steps of: preparing a mixture for an engineered stone comprising the inorganic filler and a binder; providing the mixture on temporary support, for example a mold; forming a first decorative pattern on the mixture in the temporary support; compacting the mixture; curing the binder to obtain the engineered stone.

21. The method according to item 20, wherein one or more of said steps for manufacturing the substrate are configured to determine random features of the first decorative pattern.

22. A decorative element comprising a substrate and a decorative pattern on at least a first surface of said substrate, wherein said decorative pattern is a printed pattern and wherein said decorative pattern hides one or more visual defects of said first surface.

Claims

1. A method for manufacturing a decorative element (1) comprising the steps of:
 - 5 - providing a substrate (2) having a first decorative pattern (5), wherein said first decorative pattern (5) is visible on at least a first surface (4) of said substrate (2);
 - acquiring digital copy (31) of the first decorative pattern (5) visible on said first surface (4);
 - generating a digital copy (32) of a second decorative pattern (6) on the basis of said
10 digital copy (31) of the first decorative pattern (5);
 - feeding a printer (40) with said digital copy (32) of a second decorative pattern (6) and printing said second decorative pattern (6) on said first surface (4) of the substrate (2) to obtain the decorative element (1).
- 15 2. The method according to claim 1, wherein said step of generating the digital copy (32) of the second decorative pattern (6) is performed by a machine-learning model (50).
3. The method according to claim 2, wherein the machine-learning model (50) is configured to identify a first group of information (55) within the digital copy (31) of the
20 first decorative pattern (5).
4. The method according to claim 3, wherein the machine-learning model (50) is configured to predict a second group of information (56) of the second decorative pattern (6) based upon the first group of information (55) identified within the digital copy (31)
25 of the first decorative pattern (5).
5. The method according to claim 1, wherein said step of generating the digital copy (32) of the second decorative pattern (6) involves an image editing operation performed on a starting digital copy (57) of the second decorative pattern (6).
- 30 6. The method according to claim 5, wherein said image editing operation is performed by a human operator, preferably using a graphic editor software, for example Gimp or Photoshop.

7. The method according to claim 5 or 6, wherein substrate (2) comprises an identification element associated to said starting digital copy (57) of the second decorative pattern (6) and wherein the method comprises the step of evaluating said
5 identification element and selecting said starting digital copy (57) of the second decorative pattern (6), from example from a plurality of digital copies stored in a storage unit (35).

8. The method according to any of the preceding claims, wherein said first decorative
10 pattern (5) is an imitation of a stone.

9. The method according to any of the preceding claims, wherein said second decorative pattern (6) is an imitation of a stone.

15 10. The method according to any of the preceding claims, wherein said first and second decorative pattern (5, 6) are both visible on the first surface (4) of the decorative element, for example the first and second decorative pattern (5, 6) form a combined decorative pattern (9) on said first surface (4).

20 11. The method according to claim 10, wherein said second decorative pattern (6) represents additional details of the first decorative pattern (5).

12. The method according to any of the preceding claims, wherein the decorative pattern is configured to hide said visual defect.

25 13. The method according to any of the preceding claims, wherein said first decorative pattern (5) is present in the entire thickness of the substrate (2).

14. The method according to any of the preceding claims, wherein said substrate (2) is
30 made of a cured engineered stone, a sintered stone or a ceramic material.

15. The method according to any of the preceding claims, comprising one or more of the following steps before said step of printing:

- sanding or polishing said first surface (4) of the substrate (2);
- 35 - heating at least said first surface (4) of the substrate (2);

- providing an adhesion promoter coating on said first surface of the substrate;
- providing a primer coating (7) on said first surface (4) of the substrate (2).

16. The method according to any of the preceding claims, comprising providing a
5 protective coating (8) on said second decorative pattern (6).

17. The method according to any of the preceding claims, comprising a step of
polishing said protective coating (8).

10 18. The method according to any of the preceding claims, wherein said printing
operation is performed directly on said first surface (4) of the substrate (2).

19. The method according to any of the preceding claims, wherein said printing
operation is performed by jetting curable inks and/or sublimation inks.

15 20. The method according to any of the preceding claims, comprising manufacturing
said substrate (2), preferably wherein said substrate is made of engineered stone, and
preferably wherein manufacturing the substrate involves at least the steps of: preparing
a mixture for an engineered stone comprising the inorganic filler and a binder; providing
20 the mixture on temporary support, for example a mold; forming a first decorative pattern
on the mixture in the temporary support; compacting the mixture; curing the binder to
obtain the engineered stone.

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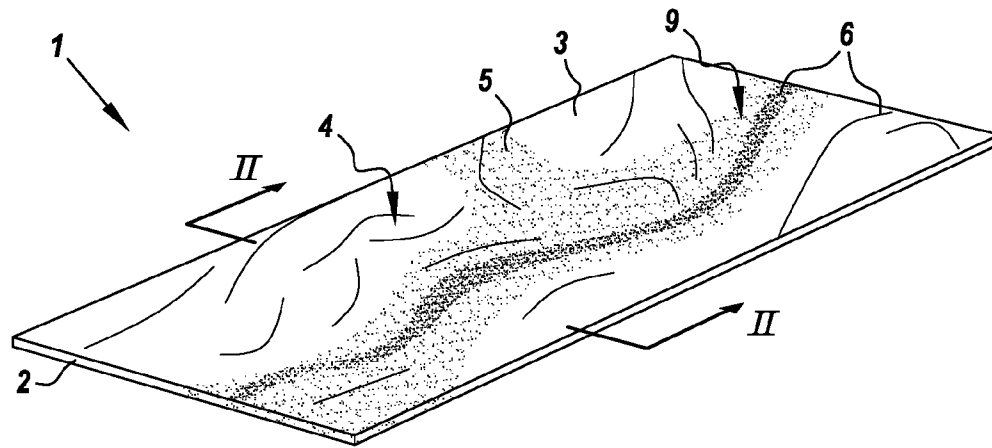


Fig. 1

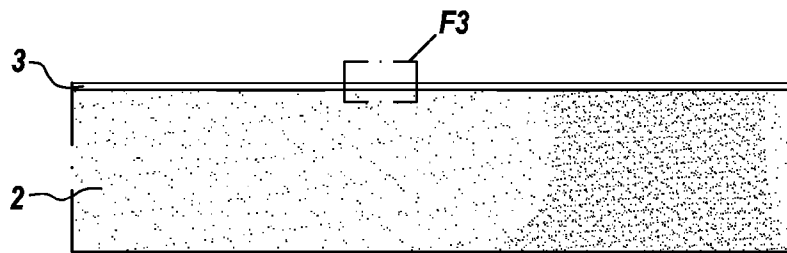


Fig. 2

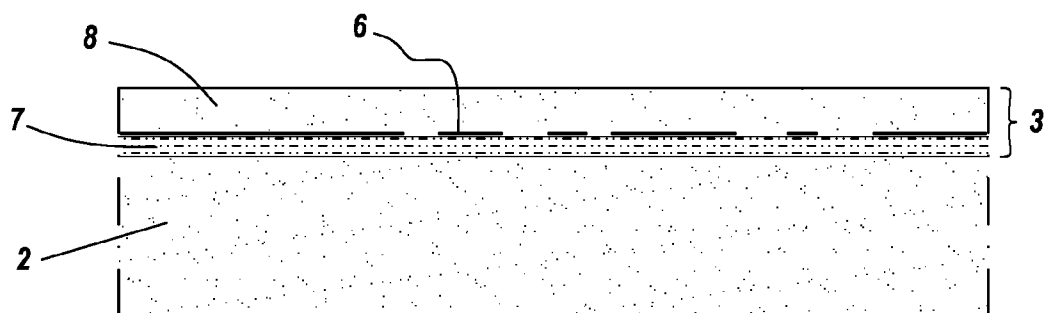


Fig. 3

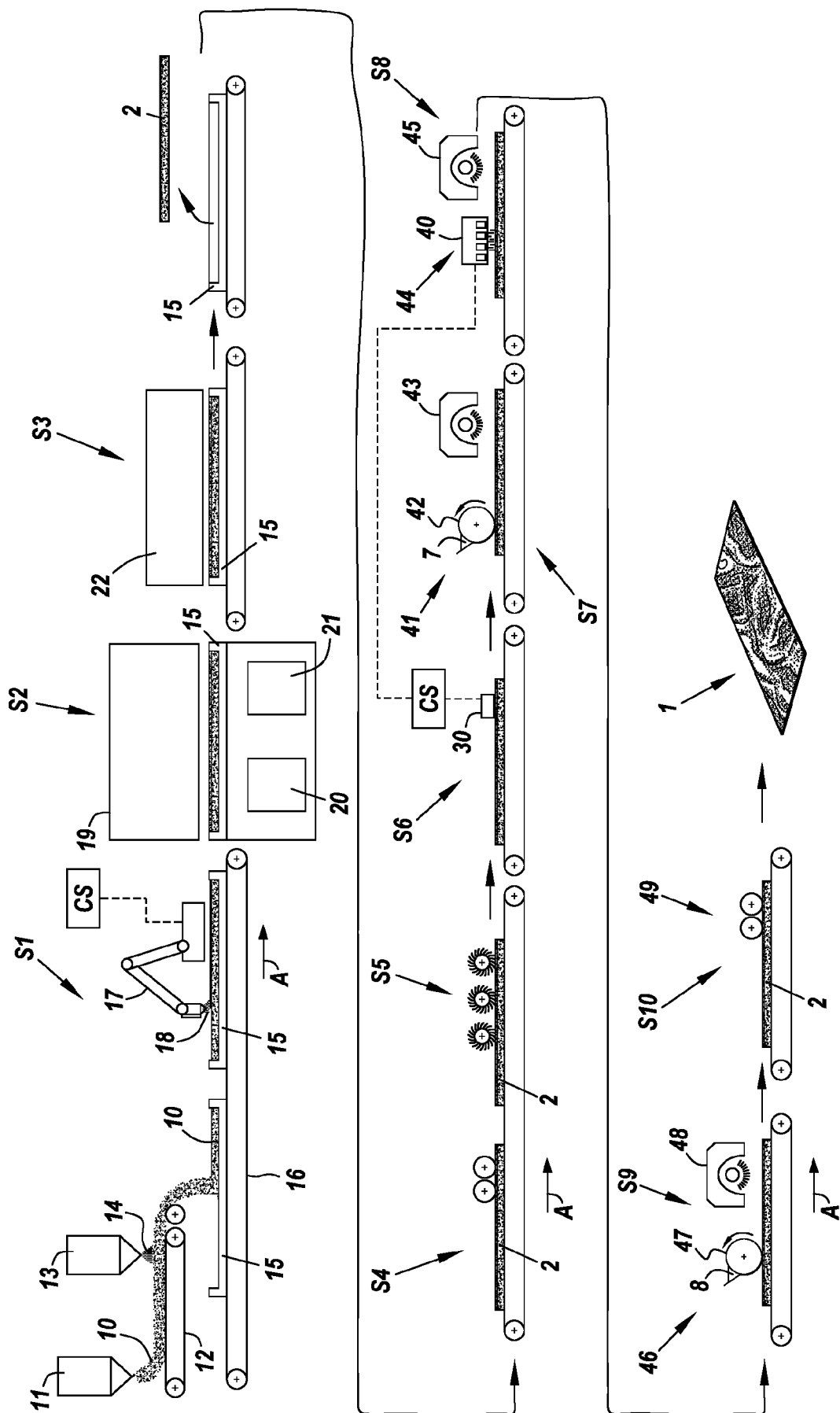


Fig. 4

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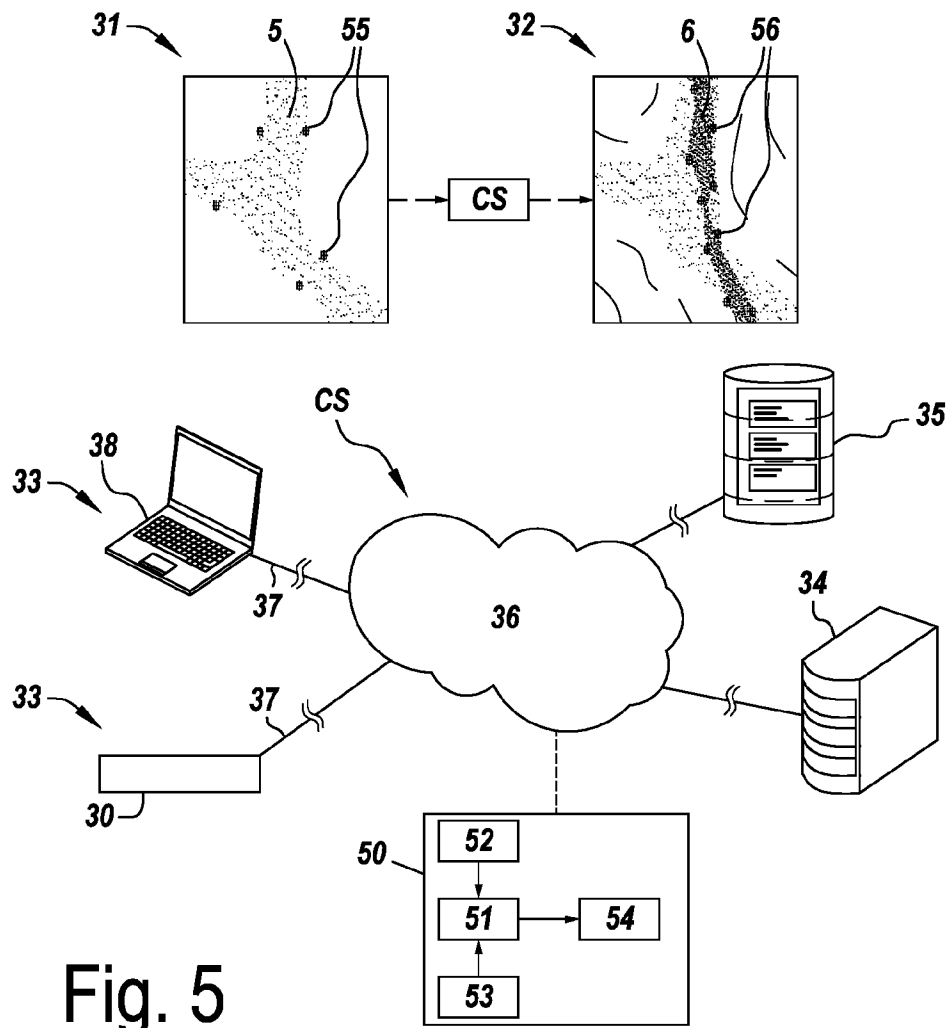


Fig. 5

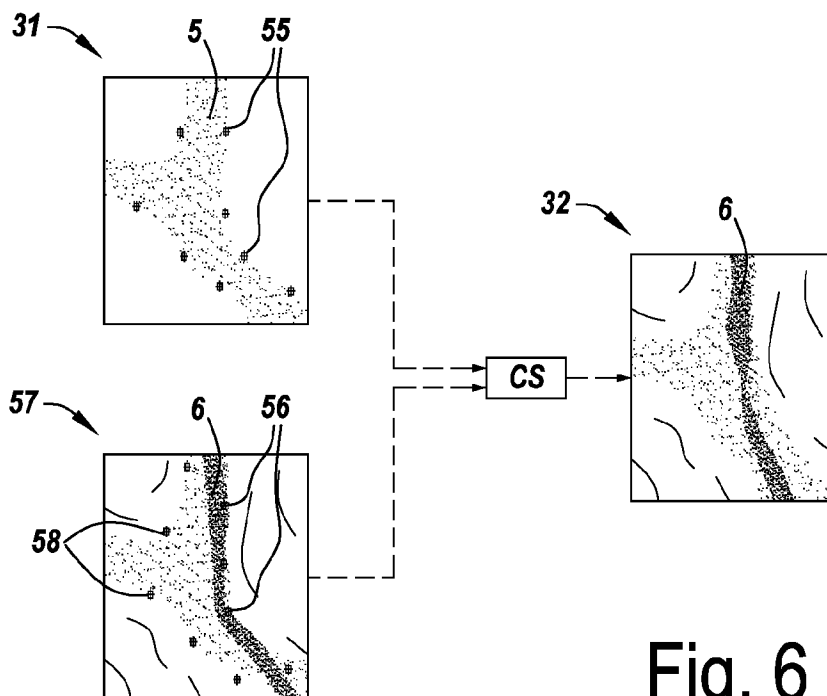


Fig. 6