

METHOD, ELECTRODE AND APPARATUS FOR ELECTROSTATICALLY PAINTING PARTS MADE OF DIELECTRIC OR LOW-CONDUCTIVITY MATERIAL.

The instant invention teaches a method for painting parts made of dielectric or low-conductivity material, an electrode for painting parts made of dielectric or low-conductivity material and an apparatus for painting parts made of dielectric or low-conductivity material.

The instant invention applies particularly to the carpentry and furniture industries.

The current methods for painting on wood involve sanding, staining, waiting for the stain to dry, peeling off the stain, applying a liquid finish, waiting for the liquid finish to dry and then repeating this process several times, often as many as seven times. The edges of the boards are treated separately and the two faces must be treated several times. The entire process, therefore, takes two and a half days (for a basic finish) or up to four days (for complex forms involving moldings, cuttings and grooves). Additionally, the liquid finishes are not guaranteed to hold more than one, or maybe a few years. The spectrum of colors is forcibly very limited. Finally, the coats of finish must be applied evenly; in other words, the number of coats on the two faces generally must be the same, or the board will appear warped.

Other methods for finishing wood involve coating the faces of the board with a sheet of laminated paper or veneering. Complex forms are, therefore, difficult to finish, if not impossible, by such a means of manufacture. The coatings and their bondings with the wood are of limited value against impacts to the wood.

Finally, a last method involves applying, by way of pressure and heat, a film of plastic material of different color and structure on one face and the four edges. This process is called thermoforming. This method cannot be used to cover the entirety of a board in one application. Further, the natural grain of the face of the wood may allow the film to show through. The choice of colors here, too, is very limited.

The instant invention seeks to resolve these problems by proposing a method of painting parts made of dielectric or low-conductivity material, in particular wood, an electrode and an apparatus for painting on said materials using said method.

The method described in the instant invention is a method for painting parts made of dielectric or low-conductivity material in which a paint-spraying unit including a chamber connected to both a paint outlet and a paint supply is used. This method essentially involves mechanically and electrically connecting at least one electrode to the part to be painted, creating an electrostatic field between the electrode and the paint spraying unit by applying a difference of electrical potential between the electrode and another electrode lodged in the chamber of the paint spraying unit, feeding the paint from the paint supply through the chamber to the outlet, electrically charging the paint and spraying said paint onto the part (16) to be painted.

A solid paint in powdered form is the preferred paint to be used. For example, a polyester-based, powdered paint could be used.

According to another embodiment, the method of painting involves inserting the electrode into the part to be painted. This embodiment allows for painting all external surfaces of the part to be painted.

In variation, the method of painting involves placing an electrode on at least one of the external faces of the part to be painted. Such a method limits painting to those faces not covered by the electrode(s).

The electrode according to the invention for electrostatically painting parts made of dielectric or low-conductivity material, intended to come into contact with the part to be painted is to be connected to one of the two poles of a source of electrical power contained in the apparatus; is essentially characterized by its exterior surface which contains at least one jagged portion for engaging the part to be painted, said jagged portion being the location of the so-called peak electrostatic effect.

The description which follows, referring to the attached drawings for explanatory, but not limiting, purposes allows for a better understanding of the advantages, goals and characteristics of the invention.

Figure 1 shows a succession of operations according to the instant invention in a synoptic manner.

Figure 2 is a schematic view of a painting apparatus with electrode according to the invention and it is intended as a model for operation according to the invention.

Figure 3 is a cross-section view of one embodiment of the electrode according to the instant invention.

Figure 4 is a front-view of the electrode according to Figure 3.

Figure 5 is a cross-section view of a second embodiment of the electrode according to the instant invention.

Figure 6 is a front-view according to Figure 5.

Figure 7 is a cross-section view of an electrical field generation by an electrode according to the instant invention.

Figure 8 is another embodiment of an electrode according to the instant invention.

Figure 9, shown from above and schematically, is a heating chamber of the painting apparatus according to the instant invention.

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In Figure 1, we apply the method the subject of this invention to a particular example: furniture wood. This furniture wood can be of M.D.F. (medium density fiber); in other words, a wood made in part from citrus fruit trees compressed under high pressure. This wood can also be a fiberboard and, more generally, any type of natural or recomposed wood used in furniture making. The part to be painted, as one can see particularly in Figure 2, can be in the form of a polygon-shaped board, for example rectangular or square.

In Figure 1 we have: the cut-out and formation (1), the drilling (2), the sanding and protection (3) of the edges, the sanding (4) of the entire part, the attachment (5) of the electrode, the application (6) of electrical voltage on the electrode, the application (7) of electrical voltage on the paint, the spraying (8) of the paint, the heating at low flow (9), the heating at increased flow (10), the cutting (11) of the edges and the application (12) of a glaze.

The cut-out and formation (1) exists in the prior art. It could involve, for example, cutting the part in a rectangular shape, rounding its edges and finally shaping by means of cuts and grooves. This gives the part its definitive shape. The other operations address the surface of the part to be painted. The wood to be used should preferably have a moisture content of 8% to 12%.

The drilling (2) involves creating an initial hole in the part to be painted (without splitting the wood) in order to insert the electrode. The drilling will create a recessed hole and, where the part to be painted is a board, it will be drilled such that its median axis of symmetry runs perpendicular to the two large faces of the board.

The drilling (2) for the electrodes shall be done either in an area that will later be further manufactured or an area that will be eliminated when the edges are cut. Preferably, the drilling for the electrode is then used, for example, for the hanging of a door hinge or some other hinge or mechanical element used in the assembly of the boards of a piece of furniture. Where the electrode is affixed directly to the part to be painted, no drilling is done. Drilling is likewise not done if the shape of the electrode allows for its insertion into the part to be painted without risk of splitting the latter.

The protection of the edges (3) of the board is a characteristic operation of the instant invention. The edges of the piece of wood are sanded, for example with a sand paper of 400 grain for the M.D.F. and of 220 grain for the fiberboard, then they are covered with a sealant such as a barium-based wood paste or a polyurethane-based varnish. This process involves, therefore, sealing the pores of the wood, or filling in the uneven surfaces of the wood. This protection (3) of the edges also includes a drying period which may last several hours. This protection allows the pieces of wood to stand UP to heating, even at high temperatures.

The sanding (4) is also one of the characteristic operations of the instant invention. The sanding is an action of preparing the surface prior to applying a product. The sanding eliminates fibers, impurities, grease and grooves from the surface. This sanding is done according to the method of the instant invention with a sand paper of at least 300 grain, and, preferably of 400 grain. This grain corresponds to a particular sanding operation called "egrenage" because of the fineness of the grain used. This sanding is done on all surfaces to be painted. The fineness of the grain allows for the fibers of the wood not to be opened to such an extent that, when heated in heating operations 9 and 10, there is any bubbling or significant evaporation. Thus, the state of the surface of the paint is not altered. When using a board, all sides are sanded.

The attachment of the electrode (5) involves mechanically fixing, and thus electrically fixing, the electrode to the part to be painted. According to the preferred embodiment, the electrode is inserted, preferably by force, into the hole created by drilling (2). This insertion can be done, for example, by driving or screwing. The electrode contains rigid or curved protrusions or acute angles. The electrode, therefore, contains certain concave parts. This operation is the principle characteristic of the invention because the shape of the electrode favors the development of either a spherical or a flat electrical field around the electrode once it is joined with a power source.

The application (6) of electrical voltage on the electrode involves electrically joining the electrode with a source of electrical power. Generally, it is preferred that the voltage be zero. Preferably, the electrode is joined to said power source by an electrical cable or metallic support.

The application of electrical voltage on the paint (7) is done by a method known in the prior art. It involves electrically charging powdered paint, such as a polyester powder, with an opposite charge from that which charges the part to be painted, said electrical voltage being delivered by the source of power to which the electrode is attached.

In this way, the equipotential lines are distributed throughout the part to be painted and one of them is practically identical to the volume of the part to be painted. It is notable that said effect applies to the part to be painted and, thus, the corners are painted in the same way as the rest of the part, if not better.

The spraying of the paint (8) is known in the prior art and is generally done using an electrostatic paint gun. It is the force of the spray, the static electricity and the electrical field created between the electrode and the gun that cause the movement of the powdered paint towards the part to be painted. Said electrostatic paint gun is connected to the source of power and is configured such that it electrically charges the paint whether the polarity is positive or negative.

The spraying of the paint is caused by sweeping, but the sprayed powdered paint coats with only one layer.

The heating at low flow (9) is done initially in a heating chamber into which the painted parts are introduced. The flow of hot air, which comes from the bottom of the chamber is checked by a mechanical protection. Thus, the thermal shock is limited, as is the mixture of air which could disturb the uniformity of the distribution of the paint. This heating is limited to a very short time, approximately two to four minutes, during which the paint begins to adhere to the support.

The process of heating at increased flow (10) exists in the prior art. It takes place in the rest of the chamber. The two types of heating are done, for example, in a gas oven but it goes without saying that any type of heating chamber adapted for this function could be used. Finally, in the case of parts sold in panels, the cutting (11) of the edges allows for the pieces to meet the required dimensions and for the elimination of the drilled hole (2) created for the electrode.

The application (12) of varnish exists in the prior art, and is done, for example, by blower, by roller, by automatic or manual spray gun.

It is obvious from the description of Figure 1 that the characteristic stages of the method are in order of decreasing importance.

- the use of an electrode which contains rigid or curved protrusions or acute angles and which, thus, favors the development of either a spherical or a flat electrical field around the electrode once it is joined to a power source.

- the sanding done with a sand paper of at least 300 grain, and, preferably of 400 grain, corresponding also to a method called "egrenage". This sanding lessens the roughness of the surface without making buckling possible at the time of heating.

- the protection of the edges (3) which are covered with a wood paste which may be diluted or with a polyurethane varnish. This process, therefore, involves sealing the pores of the wood, or filling in the uneven surfaces of the wood. This protection of the edges also includes a drying period which may last several hours.

In Figure 1, the method the subject of this invention is applied to a particular example, that of furniture wood. However, other examples could be used such as plaster, compost, brick, P.V.C., tile and, more generally, any material that is a poor conductor.

This method according to the instant invention could also be applied to cardboard products made from shredded materials mixed with a urea-based glue and heat compressed. The shredded materials could be folded boxes lined with a sheet of aluminum.

It is important to note that the paint can be metallic and/or cause the plating of the part to be painted or some other effect such as a granular, a hammered, a shaped or a smooth appearance.

The products made according to the method described by Figure 1 have successfully withstood resistance tests with shocks of ball bearings of up to 110 grams, tests for qualifications of lacquer paints and varnishes, adhesion trials by section on varnish or lacquer, resistance tests using scratching, cigarette burns, stains with domestic products and food products.

According to one variation, the method includes a varnish stage using clear varnish which dries to display ultraviolet radiation with a brilliance of 25% to 100%, according to the selection of the user, without requiring additional sanding. The grams per meter squared reach between 90 and 160 ideally with a precision and homogeneity of 10 grams.

According to a second variation, the method includes a varnish stage where a polyurethane varnish of traditional drying or a diluted wood paste of traditional drying is applied.

According to these two variations, the application could be done, for example, by robot, by blower, by spray gun or manually.

Figure 2 is a schematic representation of a painting apparatus according to the invention.

Figure 2 represents a paint spraying unit (13), a part to be painted (16), an electrode (17), a support for the electrode (18) and a power source (19), the paint (20), a stream of paint (21), a compressor (45) and a tank for powder (46) constituting a paint (20) supply.

The paint spraying unit (13) is configured so as to direct the stream of electrically-charged paint (21) towards the part (16) to be painted. It is of a type known in the prior art. This paint spraying unit contains an internal chamber housed within a projection gun and connected both to a paint outlet at one end and to a paint supply (46) by way of a conduit. The paint, in powdered form, is fed, using compressed air through the chamber from the paint supply (46) to the outlet. Within the chamber in the paint spraying unit is an electrode, not shown, which is electrically connected by the electric cascade of the paint spraying unit to the positive pole of the electric power source (19). The other pole of the power source (19) is electrically connected to the electrode (17) either directly or indirectly by way of the support (18). Between the electrode (17) and the electrode of the paint spraying unit, therefore, an electrostatic field is created which can be negatively or positively charged according to the selection of the electric cascade. The paint becomes electrically charged as it passes through the chamber and comes in proximity to or in contact with the electrode of the paint spraying unit. Preferably, the electric power source provides between its terminals a potential difference of several tens of kilovolts.

Step 8 of Figure 1, involves the spraying of the paint onto the part to be painted. The part has, therefore, already been sanded with a sand paper of at least 300 grain and the roughness of its edges has been plugged.

The compressor (45) injects the compressed air into the powder supply (46) according to techniques existent in the prior art in order to convert the powder into aerosol. The aerosol then passes into the paint spraying unit.

The support (18) for the electrode is configured so as to mechanically support the electrode (17) and the part to be painted (16) and so as to electrically connect one of the electrical terminals of the power source (19) to the electrode (17). The electrode (17) favors the development of either a spherical or a flat electrical field around itself once it is joined to the power source. The electrode (17) is conductive and contains jagged portions, such as for instance, rigid or curved protrusions or acute angles. Thus the electrode (17) contains certain concave parts. It is connected electrically to an electrical mass and to the part to be painted (16). The negative pole of the power source (19) will be connected to said electrical mass. It also serves as a support for the part to be painted (16).

Each protrusion which is a part of the electrode (on its surface, according to a normal plan) could have a triangular or trapezoidal section or any such form presenting a region of strong curvature at a distance from said surface.

Each protrusion could be in the form of a spike and project rectilinearly from the surface of the electrode or could be curved, for example circular, helix-shaped or curved in some other manner.

The electrode could contain a core with the protrusion(s) being located on the exterior surface of the core and being spread out radially about said surface. Such an electrode with core is intended to be inserted into the hole previously made in the part to be painted.

Such an electrode, once it is connected mechanically and electrically to a part, ie. a polygonal board, of which all of the exterior surfaces are to be painted, is inserted into the board preferably in the direction of the thickness of the board. The longitudinal axis of the core of the electrode is, therefore, perpendicular to the two large faces of the board.

The core could show a polygonal cross section but preferably the cross section of such core is circular. This core will be cylindrical or conic shaped. The protrusions of an electrode with cylindrical or conical core could each form according to one of the generators of the exterior cylindrical or conical surface of the core, or also, they could form in a curved manner on said exterior surface, for example, in helix-shape, in circle or otherwise. The protrusions of an electrode with cylindrical or conical core could also be composed of spikes forming radially with respect to the core.

Figure 3 is a cross-section view of a preferred embodiment of the electrode the subject of this invention. Figure 4 is a front-view of the same embodiment of the electrode. Said electrode, with cylindrical core, has an external thread and at least one longitudinal groove extending along the generator of the core and through the thread.

Figure 3 and Figure 4 show a part to be painted (16), an electrode (17) with a cylindrical core, external thread (22, 23, 24, 25), at least one groove, an internal cavity (28), internal thread (29), a front end (30) and a rod (32). Preferably, the electrode will have two grooves (26, 27) which are diametrically opposed. The electrode could be equipped with a greater number of grooves which would be spaced equidistant from one another. Note: the length of the electrode depends upon the thickness of the part to be painted.

The part (16) is pierced by a hole of a diameter roughly equal to the diameter at the root of thread of the external threads (22, 23, 24 and 25) and its depth is roughly equal to or superior to the length of the portion of the electrode to be inserted into the board.

The external threads (22, 23, 24 and 25) and the two grooves (26 and 27) are formed into a single thread whereby the pitch is approximately 1 mm as an example. Each piece of thread (22, 23, 24 and 25) is, therefore, roughly of the same length as the others, but shorter than one half the pitch of an helix that stops at grooves 26 and 27. The electrode (17) contains, therefore, curved and helicoidal protrusions and acute angles.

The cylindrical internal cavity (28) crosses the electrode along the longitudinal median axis of the core of the latter.

The electrode, as it is represented in Figure 3, does not contain a shouldering, but it could be outfitted with one to limit the electrode's penetration into the part to be painted (16).

The internal threading (29), or screw cutting, extends the entire length of the internal cavity (28).

The metallic rod (32) allows for the insertion of the electrode (17) into the part to be painted (16) due to its shape and the connection of electrical connectors to the electrode (17). Preferably, the rod (32) is cylindrical and has a thread at one end for screwing that extremity into the female thread (29) of the electrode (17). Said rod (32) ensures an electrical and mechanical connection between the electrode and the support for the electrode (18). Said rod can also serve as a support for the electrode.

The electrode (17) according to Figures 3 and 4 is preferably inserted by screwing. Due to the presence of the grooves, the electrode according to such an embodiment is self-screwing and its screwing into the hole causes the screwing of the latter. Thus, the thread-shaped protrusions of this electrode penetrate completely the material of the board and are in direct contact with the part to be painted which improves both the electrical and mechanical connections of the board.

Preferably, the depth of insertion of the electrode (17) into the hole drilled in the part to be painted (16) is roughly greater than one-half the thickness of the part (16) to be painted and roughly less than said width.

Figure 5 is a cross-section view of a second embodiment of the electrode the subject of this invention.

Figure 6 is a front-view of the electrode shown in Figure 5.

Figures 5 and 6 show a part to be painted (16), an electrode (17) with a core having straight, longitudinal external protrusions along its surface (33) separated by longitudinal recesses (34), an internal cavity (35), a shouldering (31) and a rod (32). This electrode contains a cylindrical core.

The straight, longitudinal external protrusions (33) and the recesses (34) form a polygonal-based prism, for example in the shape of a star. The internal cavity (35) crosses the electrode and extends along the longitudinal axis of the core of the latter. The shouldering (31) and the rod (32) which is threaded along one extremity have the same characteristics and functions as in Figures 3 and 4.

Preferably, the electrode (17) shown in Figures 5 and 6 is forcibly inserted into a pre-made hole in the board. The electrode (17), therefore, contains straight protrusions and acute angles.

Other embodiments of the electrode could conform to the spirit of the invention, such as wood screws, threaded rods, and the like.

One could also envision an electrode in the form of a thin, polygon-shaped plate with its external protrusions being located along at least one of the faces of the plate. Such an electrode could be forcibly inserted into the wooden board without any drilling of the latter, or could be inserted into an opening created by drilling or could be attached to one of the faces of the board. The protrusions of said thin, plate-like electrode could be spike-like studs or the like. The protrusions will always contain a straight triangular or trapezoidal section or a section of some shape to serve as the location of peak electrostatic effect.

The plate could contain a series of protrusions and recesses such that it would be rippled. The ripples of the plate could be triangular. The broad faces of the ripples could be smooth or could have their own protrusions such as these already described.

Figure 7 is a cross-section view of an electrical field generated by an apparatus according to the instant invention.

Figure 7 shows the equipotential lines (36, 37 and 38) generated when the inserted portion of the electrode (17) is placed under voltage in air.

These equipotential lines (36, 37 and 38) are elliptical and, in space, their surface is ellipsoidal.

It is apparent that once the electrode (17) is inserted into the part to be painted (16), the lines of the field will take on a flattened form, and that one of them will be roughly identical in form to the part to be painted (16). This is due to the dielectric quality of the material of the part to be painted (16) or to its poor conductivity.

Figure 8 is a paint heating chamber according to the instant invention.

Figure 8 shows a heating chamber (39), a zone of entry for the parts (40), an outlet zone for the parts (41), an area of heating at increased flow (42) and a path for the hot air (43) equipped with a protection (44).

The heating chamber (39) contains a zone of entry for the parts (40) which is, for example, at one end of the heating chamber while the outlet zone for the parts (41) is at the other end. Between these two zones, an intermediate zone (42) extends. In this heating chamber (39), the first phase of heating or cooking involves lower speeds of air flow than do the subsequent phases of heating or cooking in order that the paint can gel before the part enters the zone of strong air flow. The first phase of heating occurs in the zone where the air enters, whereas the next phase occurs in the rest of the chamber, in zones 42 and 41. It is important to note that the entire volume of the heating chamber is at the same temperature.

The zone of heating at increased flow (42) includes both zones 42 and 41. According to the preferred embodiment, the heating chamber is equipped all over with openings for air to enter; the entrance of the air taking place at the bottom and the openings being throughout zones 40, 41 and 42. In order that the flow of air be slowed in the zone of entry, said zone is equipped with a screen made up of a removable partition placed at the base of zone 40 to cover the openings for air to enter said zone. According to this method and heating apparatus, the parts to be painted (16) are subjected first to heating without thermal shock or mixing of air as these two events could cause the deterioration of the paint on the surface of the parts (16) given that the paint is still in solid powder form on the surface of the parts (16).

It is important to note that the temperatures and heating times to be used are those that are recommended for the powdered paint to be used because the wood, once its edges and recesses have been treated by a plugging finish, can withstand quite high temperatures without thermal dilatation.

The method and apparatus described in the instant invention can be used for painting fiberboard, compressed wood, fiberboard coated with a polyvinyl film such as polished P.V.C. or an imitation oil, wood of medium density fiber whether coarse or smooth or coated with P.V.C. or an imitation oil or a natural veneer.

It is important to note that the electrode can be a part of the finished product and, therefore, would not have to be removed from the board. Said electrode in this case could eventually serve as a brace for the board.

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**CLAIMS**

1.) An electrode (17) for electrostatically painting parts made of dielectric or low-conductivity material intended to come into contact with the part to be painted (16) and to be connected to one of the two poles of an electric power source (19) attached to the apparatus, said apparatus containing a paint-spraying unit (13) which has an electrode located in the paint passing zone, said electrode being connected to the other pole of the power source (19), said paint-spraying unit (13) serving to electrically charge the paint and to spray it onto the part to be painted, characterized by its external surface having at least one jagged portion intended to come into contact with the part to be painted, said jagged portion being the location of the so-called peak electrostatic effect.

2.) An electrode (17) according to Claim 1 characterized by the jagged portions being created by the protrusions (22, 23, 24, 25 and 33).

3.) An electrode (17) according to Claim 2 characterized by its having a core with the protrusions (22, 23, 24, 25 and 33) located on its external surface.

4.) An electrode (17) according to Claim 3 characterized by each protrusion being longiform and projecting rectilinearly.

5.) An electrode (17) according to any of Claims 2 through 4 characterized by its having a longiform core which cross section is circular with the protrusion(s) (22, 23, 24 and 25) forming an helix-shape on the external surface of the core.

6.) An electrode (17) according to Claim 5 characterized by a cylindrical core with external thread (22, 23, 24, 25) and at least one longitudinal groove (26, 27) extending along a generatrix of the core across the thread.

7.) An electrode (17) according to Claim 1 characterized by its plate-like form with the protrusions being located on at least one of the faces of said plate.

8.) An electrode (17) according to Claim 1 characterized by its rippled plate-like form

9.) An electrode (17) according to Claim 8 characterized by the ripples of the plate being triangular.

10.) An electrode according to Claims 2 and 9 characterized by the plate having protrusions on at least one of its faces.

11) Method for painting parts (16) of dielectric or low-conductivity material using a paint (20) spraying unit (13) including a chamber connected both to a paint outlet and to a paint supply (46) characterized by :
at least one electrode (17) being mechanically and electrically connected to the part (16) according to any of the above claims,

the creation of an electrostatic field between the electrode (17) and the paint spraying unit (13) by applying a potential difference between the electrode (17) and another electrode housed in the internal chamber of the paint spraying unit (13),

the propulsion of the paint from the paint supply (46) towards the paint outlet by passage through the chamber,

the electrical charge of the paint (20),
which is directed towards the part (16) to be painted.

12) Method of painting according to Claim 11 characterized by its use of a solid paint in powder form.

13) Method of painting according to Claim 11 or Claim 12 characterized by the insertion of an electrode (17) inside the part to be painted (16).

14) Method of painting according to Claim 11 or Claim 12 characterized by the placement of the electrode (17) on at least one of the external faces of the part to be painted (16).

15) Method of painting according to any of the above Claims 11 through 14 characterized by the sanding of the surfaces to be painted before the painting of them.

16.) Method according to Claim 15 characterized by the application of a sealant to the recesses and edges prior to the projection of solid paint.

17.) Method of painting according to any of the above Claims 11 through 16 characterized by the passage through a heating chamber (39) in which the low flow heating is done with lower speeds of air flow than the subsequent phases of heating.

18.) Apparatus for painting parts (16) made of dielectric or low-conductivity materials to implement the process according to any of the Claims 11 through 17 characterized by at least one electrode (17) according to any of the Claims 1 through 10.

19.) Apparatus according to Claim 18 characterized by a heating chamber (39) in which the low flow heating is done with lower speeds of air flow than the subsequent phases of heating.