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METHOD FOR BARREL OR VIBRATORY FINISHING AND SOFT METALS WITH FLEXIBLE ORGANIC POLYMERIC FINISHING MEDIA

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FIG. 1

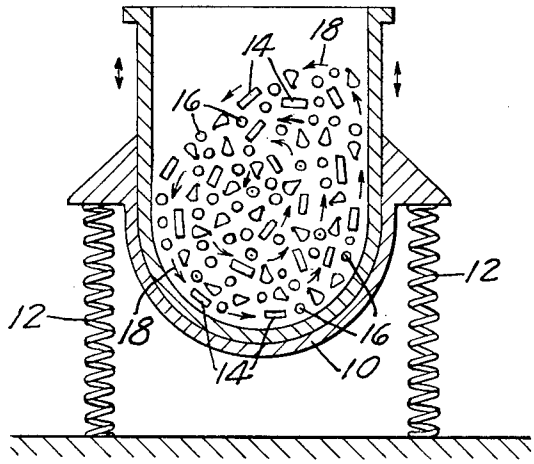
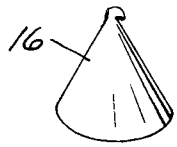


FIG. 2



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METHOD FOR BARREL OR VIBRATORY FINISHING AND SOFT METALS WITH FLEXIBLE ORGANIC POLYMERIC FINISHING MEDIA

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ABSTRACT OF THE DISCLOSURE

A method for mechanical barrel or vibratory finishing of soft metals and plastics employing a finishing media consisting of discrete flexible polymeric shapes having a Shore D hardness of 45 to 80 at room temperature, the hardness of said shapes being inversely variable with temperature, preferably formed from a resilient polyester resin containing finely divided abrasive having particle diameters below 30 microns, the said method including the steps of first agitating in the presence of media at a low temperature whereby increased hardness of media increases metal cut rate and subsequently raising the temperature whereby the metal cut rate is decreased but the surface smoothness produced on articles is greatly increased, plastics being finished in cold water to increase cut rate and minimize softening and swelling.

This invention relates to a method for industrial barrel or vibratory finishing. More particularly, the invention relates to a method of employing flexible polymeric media having the capability of producing highly smooth surfaces on soft metal and plastic articles.

The finishing of polymeric plastics and softer metals, such as zinc die castings, brasses, copper, and aluminum alloys, is commercially accomplished by either hand or semi-automated buffing, which is objectionable due to high direct labor costs and the dirtiness of the operation. A second commercially-used method involves mechanical finishing in rotating barrels or vibrating tubs in the presence of media which usually consist of natural stones, fine abrasives bound together by rigid resins, or fused ceramics. Previously, sythetic media have been formed from hard ceramics and plastics, i.e. those having a Shore D hardness of 90 or more, because high hardness was believed necessary to reduce the wear rate of the media. Plastic media in the past which contained no abrasive have not proved suitable for cutting (i.e., removal of significant amounts of surface material from the parts being finished) soft materials such as plastics; externally added abrasives are rapidly flushed away by the large quantities of water required for keeping the parts clean during the finishing operation. In vibratory finishing equipment the use of such external abrasives is in any case a cumbersome, messy, and costly added step.

Insofar as we are aware, abrasive-filled plastic media have in part always contained abrasives of 100 microns or more in diameter and/or have been formed from very hard, rigid binders. Such media have been found in themselves to impinge and dent articles made from soft materials. Thus media such as wood, corncobs, and the like, have been used for forming smooth finishes on soft materials. The latter media, however, provide such a slow

rate of finishing that the tumbling or vibration must be carried on for a period of several days, thus objectionably tying up the finishing equipment and the parts being finished.

In accordance with the present invention, media are used which enable the formation of a fine, highly smooth surface finish on soft articles with greatly increased speed and economy. The media used in invention, further, have a temperature variable hardness such that the rate of abrasion and the smoothness of the surface produced can be varied by adjusting the temperature of the finishing operation. The media of this invention are preferably used by vibrating the media and articles to be finished in water.

The finishing operation of this invention can be carried out initially at a low temperature, which increases the hardness of the media, thereby in turn increasing the cut rate of material from the surface of the parts being finished. The finishing operation of this invention wherein the cut rate is controlled by altering the temperature, can be carried out using media having coarser abrasives than 30 microns, if desired, so long as the desired decrease in hardness with increasing temperature occurs. As the finishing operation progresses, the temperature of the water can be increased, thereby softening the media, consequently improving the smoothness of the surface produced, while reducing the cut rate. Thus, both rough and fine finishing cuts, which formerly had to be conducted in the presence of two separate media, can, as a result of this invention, be carried out in the same agitator without need for removing the parts and exchanging one media for another. The economies resulting from this degree of control provide by the process of this invention will readily be apparent to those skilled in the art.

Briefly summarized, the media used in invention are organic polymeric shapes containing at least 20% by weight of an abrasive filler. The shapes have a Shore D durometer hardness (initial reading) at room temperature between about 45 and 80. Preferably the hardness of the media decreases substantially, as the temperature is progressively increased. Preferably the media decrease to a Shore D hardness below about 35 if the temperature is increased to 212° F. The abrasive filler used has a hardness greater than 4 on the Mohs scale, and is essentially free of abrasive particles greater than 30 microns in diameter. Preferably the abrasive has an average particle diameter below 15 microns. While the finishing operation can, broadly, be carried out in water at temperatures ranging from 32° to 212° F., finishing is preferably initially carried out at a temperature in the range of about 35° to 50° F., and subsequently at a raised temperature of about 100° to 125° F. in the case of metal finishing. In the case of plastics it is preferred to keep the articles below about 50° F. in order to avoid undue softening of the plastic articles being finished. The media of this invention are in a size range such that they have a maximum dimension of about ⅛ to 2 inches (0.32 to 5.1 cm.).

The finishing of soft plastics, for example cellulose acetate or cellulose propionate used in eye glass frames, buttons, etc., has presented particular finishing problems, which, prior to this invention, resulted in costly finishing techniques. Presently such materials are finished dry in rotating barrels using wood pegs and an added loose abrasive. The rough cutting operation is typically carried on for 20 to 50 hours using a coarse added abrasive, and is followed by a refining cut of 20 to 40 hours using a finer added abrasive. Thus, a total of 40 to 90 hours

of finishing is required to finish the articles to the point where they are ready for final polishing. The finishing time employed in any given case is directly related to the condition of the articles at the outset of the finishing operation and to the final quality requirements. In one embodiment of this invention the finishing of molded plastic materials is carried out in vibratory equipment in cold water, i.e., at temperatures of 32° to 50° F., and preferably 35° to 45° F. These low temperatures appear to greatly reduce swelling and softening of the plastics due to water absorption, as compared to warm or even room temperature water, and appear to greatly reduce the finishing time by making the parts more brittle and more easily abraded. In accordance with this invention, the rough cutting can be accomplished in cold water in from 2 to 10 hours in the presence of rough cutting media, which are a rigid plastic binder containing abrasives having average particle diameters below 20 microns and preferably below about 15 microns. The rough cutting operation is followed by a refining operation using the flexible, abrasive-containing media of this invention as defined herein. For the refining step the flexible media must have a hardness at the finishing temperature less than that of the plastic being finished. The refining step of this invention can be carried out in as short a time as one to 5 hours in cold water in a vibrator. Thus, a greatly reduced finishing time of 3 to 15 hours is required to prepare plastic articles for final finishing, with results comparable to those obtained in the 40 to 90 hours required in the currently-used dry tumbling processes. Final polishing can be carried out in accordance with techniques known to those skilled in the art. The refining step using flexible media containing fine abrasive in accordance with this invention is critical to achieving the low finishing time and excellent surface finish obtainable by the cold-water plastic finishing method of this invention.

Insofar as we are aware, abrasive-containing polymeric media when used in vibratory equipment has not, prior to this invention, been capable of reducing the roughness height on the surfaces of soft metal (i.e., softer than steel) articles being finished to a value better than about 5 to 10 microinches. Roughness height is understood in the art to be the arithmetical average (a.a.) or root mean square (RMS) deviation from the nominal surface, measured normal to the nominal surface, in microinches, i.e. millionths of an inch. All measurements given here are in microinches, RMS. The media of this invention make possible highly smooth finishes in the range of one to 5 microinches (.025 to 0.13 micron).

The invention will be further explained with reference to the accompanying drawings, wherein:

FIGURE 1 is a diagrammatic cross-sectional view illustrating the process of this invention, and

FIGURE 2 is a perspective view of a typical shape used for a medium of this invention.

Referring more particularly to FIGURE 1, there is seen, diagrammatically, a preferred manner of practicing the invention, using apparatus of the vibratory type. Tub **10** or similar receptacle is fixed for vibration on mounting means **12**. Practicing the method of this invention, the receptacle **10**, articles being worked on **14**, media **16**, and usually water, are subjected to controlled gyratory vibration. The constant agitation of the parts and medium produces a scrubbing action that operates on all portions of the work load simultaneously. The motion of the vibrator contents is indicated generally by arrows **18**.

In FIGURE 2 is shown a shape of a preferred type for use in practicing the invention. A conical shape shown in FIGURE 2 can be formed by dropwise deposition of a viscous plastic on a receiving surface, or by other molding processes. The media of this invention can be made in various other shapes, such as spherical, cylindrical, oval, etc. The conical shape shown in FIGURE 2, however, has been found to provide a very desirable ability to finish the inside of cutout parts without lodging therein, and has thus been found to be particularly suitable.

As noted above, the finishing operation is preferably carried on in water, both to provide the desired ease of control of the finishing temperature, and to insure thorough flushing of abraded material from the parts.

As noted above, the media of this invention should have a hardness at room temperature of about 45 to 80. Preferably the media soften gradually as the temperature is increased to a hardness in the range of 20 to 35 at a temperature below 212° F. The preferred resins for forming media of this invention are materials which can be mixed in solvent-free liquid form and reacted within a short period of time to form cross-linked polymers having the desired hardness. Examples of the preferred resins are polyesters, polyurethanes, and epoxy resins. The preferred polymers are sufficiently soft and deformable, so that denting of the parts being finished due to impingement by the media is substantially eliminated.

The abrasive used in preparing media of this invention for producing extremely smooth surfaces contain abrasive particles less than 30 microns in diameter, as previously noted. The abrasive should have a hardness on the Mohs scale of over 4, and preferably 6 to 9. Examples of suitable abrasives are quartz, silicon carbide, alumina, flint and emery.

The media and methods of this invention are preferably carried out in vibratory as contrasted with simple tumbling type equipment, because of the increased speed of finishing obtainable. The vibrator may have a tub of either circuar or toroidal cross section, both of which types are commercially available. Preferably the tub is fixed for vibration of about ⅛ to ¼ inch in the vertical direction. Vibration of the units is generally produced by mechanical means such as an eccentric weight or by electromechanical means.

The invention will be further illustrated by the following examples, in which all parts are given by weight unless otherwise indicated.

EXAMPLE I

A thick highly viscous liquid reaction mixture was prepared by mixing 67 parts of unsaturated isophthalic polyester (Corezyn 3), 33 parts of styrene monomer, and 3 parts of benzoyl peroxide paste (the paste being formed from 50% benzoyl peroide, 50% butyl benzyl phthalate, plasticizer), and 0.2 part of a 6% solution of cobalt naphthenate in mineral spirits, and 0.2 part red pigment. 90 parts of finely divided quartz abrasive less than 15 microns in diameter were added to the mixture. Immediately after mixing, the abrasive-containing resin was cast into the form of conically shaped particles. The media particles were cured in an oven at 225° F. (107° C.) for about 20 minutes. The media had a Shore D hardness at room temperature of 55 (initial reading).

Approximately 2–2½ cubic feet (57 to 71 liters) of media of mixed sizes, selected to approximate those obtaining in a commercial operation in which large media are periodically added to those which have been abraded to a smaller size, together with about ½ cubic ft. (14 liters) of cellulose acetate plastic eye glass frames were placed in a vibrator having a 3 cu. ft. (85 liters) toroidal shaped tub. 78% of the media were cones 1¼ inch in diameter and 1¼ inch high, 17% were ¾ inch by ¾ inch (1.90 cm.), and 5% were ½ inch by ½ inch (1.27 cm.). The eye glass frames had previously been rough cut to remove large surface blemishes and flash from the molding operation. The tub was vibrated vigorously at ¼ inch (.64 cm.) amplitude for 2 hours. Cold water at 45° F. (7° C.) was fed through the vibrator at the rate of 60 gallons per hour (170 liters per hour). The eye glass frames were then ready for final polishing.

EXAMPLE II

Conical media were made using the same compositions and following the procedure set forth in Example I, with the exception that 90 parts of 100 micron quartz abrasive was substituted for the 15 micron quartz. These media also had a room temperature Shore D hardness (initial reading) of 45. The media were used for finishing cast zinc, using water of varying temperatures. The zinc parts had a smooth surface, initially, with a surface roughness height of 2–4 microinches. The media (using the same blend of sizes as in Example I) and zinc parts were vibrated for about 1 hour in water at various temperatures. After one hour of vibration at 40° F. (4° C.) a part had a surface roughness height of about 20 microinches, RMS (.51 micron). The media at this temperature had a Shore D hardness of 60 and 0.074% of the metal was removed. Another part of the same size and shape was vibrated at 75° F. (24° C.) for one hour, at the end of which the surface roughness height was 13 microinches, RMS (.33 micron). The media Shore D hardness at this temperature was 45, and the metal weight loss was .046%. A third part was vibrated at 110° F. (44° C.). At this temperature the media had a Shore D hardness of 35. This part had an average surface roughness height of about 8 microinches (.20 micron) and .030% of the metal was removed after one hour. This example illustrates the effectiveness of the media of this invention in varying the smoothness of the finish and metal removal rate by varying the finishing temperature.

EXAMPLE III

Two medias were prepared according to the procedures specified in Example I except that both were all of the ¾ x ¾ inch size. The first of these, Media A, was identical in composition to that described in Example I. The second, Media B, was identical in all respects except that the quartz abrasive was essentially 5 microns in diameter or finer. A comparison was made between Media A, Media B, and hand buffing zinc die castings and the luster of these surfaces after commercial copper-nickel-chromium plating.

Three zinc die castings having an essentially flat surface about 1¾ inches square (4.5 centimeters, square) were belt sanded flat and polished by buffing to about 1–2 microinches, RMS (.025 to .051 micron). One of these was placed, with Media A, in a tub-type vibrator and processed wet for 1 hour. One of the others was processed with Media B for one hour. Surface finish was determined, and the parts were plated with 0.2 mil (5.1 microns) copper, nickel and 0.01 mil (0.25 micron) chromium. Nickel thickness varied as indicated. Results are given in Table I.

TABLE I

	Media A	Media B	Buffed
Surface finish, microinches, RMS.	3	2	2.
Reflectivity of dot,* in inches:			
Before plating	9 (23 cm.)	18 (46 cm.)	27 (69 cm.).
With .3 mils (7.6 microns) nickel.	18 (46 cm.)	27 (69 cm.)	29 (74 cm.).
With .5 mils (12.7 microns) nickel.	27 (69 cm.)	31 (79 cm.)	32 (81 cm.).

* Dot reflectivity is the distance a 1/64" (0.40 mm.) dia. white dot, outlined in blue, will maintain its clarity. The dot can be seen 70 inches (178 cm.) from a good quality mirror, for example.

These data show that Media B is equal to buffing in developing luster after the copper-nickel-chromium plating with .3 mil (7.6 microns) nickel. Further, these data show a heavier nickel deposit is required (.5 mil) (12.7 microns) before the Media A processed part is comparable in luster.

Two zinc die castings were processed by vibratory finishing using a polymeric media having a Shore D durometer hardness of 90 containing 15 micron and finer abrasive particles for a time sufficient to reduce the surface finish to 7–8 microinches, RMS (0.18 to 0.20 micron). Both castings were then vibrated for one hour in Media A. The parts after this processing had a surface finish of 5 microinches (0.13 micron) RMS. One of the parts was plated with .2 mil (5.1 microns) copper, .3 mil (7.6 microns) nickel, and .01 mil (0.25 micron) chromium. The plated part had a slightly hazy finish. The other casting was subsequently given an additional hour of processing in Media B. This second part had a surface finish of 3 microinches (.076 micron), RMS. After plating with copper, nickel and chromium to the same thicknesses as the first part, this part had a smooth shiny surface with excellent reflectivity.

EXAMPLE IV

(A) Part A

The following materials were mixed and degassed 2 hours at 60° C. and 2 mm. pressure in a vacuum oven:

	Parts
Castor oil (anhydrous grade)	200.0
Phenylmercuric acetate (catalyst)	0.6
SiO_2, 30 micron and smaller	268.4

(B) Part B

Toluene diisocyanate (80:20 mixture of 2,4 and 2,6 isomers)	71.5
Polyoxypropylene triol, 400 molecular weight (TP440)	28.5

(C) Castings

100 grams of "Part A" were mixed with 21.0 grams of "Part B." The reaction mixture contained —NCO and —OH groups in a ratio of 1.03 to 1, and contained 90 parts silica per 100 grams of polymer. The fluid mixture was poured at room temperature into pan molds of the desired shape. The shapes were cured at 65° C. for about 15 minutes. The shapes were found to have a Shore D hardness at room temperature of 45. At 150° F. the shapes had a Shore D hardness of 35.

What is claimed is:

1. A method of mechanically finishing shaped articles comprising the steps of:
   - agitating said articles in the presence of water and a finishing medium comprising discrete, flexible, organic, polymeric, abrasive-containing shapes having a hardness inversely variable with temperature, said agitation being initially carried out at a low temperature, thereby increasing the hardness of said shapes and increasing the rate of attrition of material from the surfaces of said articles, and
   - subsequently increasing the temperature at which said agitation is carried out, thereby reducing the rate of attrition of material from the surfaces of said articles, while simultaneously increasing the smoothness of the surfaces of said articles.

2. A method according to claim 1 wherein said low temperature is less than 50° F. and said subsequently raised temperature is above 90° F.

3. A method for rapidly finishing molded plastic articles to form a smooth surface thereon substantially free of mold flash, comprising:
   - a rough cutting operation wherein the said articles are agitated in water at a temperature between 32° F. and 50° F., together with abrasive-containing media having a Shore D durometer hardness over 90 and containing abrasive particles below 20 microns in diameter, and
   - a refining operation wherein the said articles are vibrated in water at a temperature of 32° F. to 50° F. together with discrete, flexible, organic polymeric shapes having a room temperature Shore D durom-

eter hardness of 45 to 80, said discrete flexible shapes having, at the temperature of the said refining operation, a Shore D durometer hardness less than that of the said articles.

4. A method according to claim 3 wherein said articles comprise a material selected from the group consisting of cellulose acetate and cellulose propionate.

5. A method according to claim 3 wherein said vibration is carried out by rapid shaking in a vessel at a vertical vibration amplitude of about ⅛ and ¼ inch.

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HAROLD D. WHITEHEAD, Primary Examiner

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