RESEARCHES ABOUT THE MANUFACTURING OF THE SILICONE RUBBER MOULDS

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Abstract. In the leather confection industry, the silicone rubber mould are used in printing by stamping, on the footwear or on the Morocco parts, of the symbols, noting, ornaments, etc. The paper presents some researches about the technologies used in this moulds realization.

1. INTRODUCTION

The flexible moulds made from silicone rubber are used in the leather confections industry for the obtaining by stamping, on the footwear or on the Morocco leather parts, of the symbols, noting and ornaments. The stamping is a printing process made for the realization of a drawing, on the material surface, using a plastic deformation process. In the silicone moulds, the stamping takes place on the plane parts, which contains polymerized vinyl chloride into their structure, using a special technology which realizes the heating of the polymer layer in a radio-frequency electrostatic field, until the thinning stage and then, the changing of the layer using a compression process. There are two technological variants for the stamping in silicone moulds: the obtaining of the stamped parts from plastically using a gelatinization process and the obtaining of the plane parts from the polymerized vinyl chloride powder using a sintering process.
Using the stamping technology with silicone moulds, the costs become lower. This technology is used when the models need a large time for the realization with classic methods or they have many compound parts with complex and different ornaments.
The paper presents some technological aspects about the parts stamping using the silicone moulds and aspects about the technologies used for these moulds realization.

2. THEORETICAL PART

In the leather confection field, the moulds made from silicone rubber are used for the stamping operations, in three technological variants: the stamping of the parts which content layers of polymerized vinyl chloride in their structure; the stamping and the gelatinization, in the same time, of some plastically pulps; the stamping and the sintering, in the same time, of the polymerized vinyl chloride powder [1].

a. Stamping of the parts which have polymerized vinyl chloride in their structure

Regularly, these materials have, in their structure, a textile material base, a polymerized vinyl chloride layer having a porous structure (its thickness represents about 60% from the entire thickness), a polymerized vinyl chloride layer having a compact structure and, eventually, a polyurethanes finish layer.
The stamping takes place [1] in a silicone rubber mould with a cavity which have 2-2,5 mm depth. The mould will be realized copying a primary model using a special technique. The silicone rubber mould hardness is 55-60^{0}Sh. This means that, the profiled details which will be printed on the stamping material will have a small high to avoid their buckling deformation. With the same purpose, the stamping pressure has a very small value, about

1,7 daN/cm^2. The heating of the thermoplastic film of the stamped part will be made with radio-frequency currents until the thinning temperature of the polymer. As an effect of the thinning and of the pressure used for the part pressing in the mould cavity, after the cooling, the part will have printed the model of the mould cavity. The presence of the porous layer into the part structure has its contribution at the stamping process; the polymerized vinyl chloride part will be heated, in the radio-frequency field, until the thinning temperature, 160-180^{0}C; at the porous layer level, the temperature of the gaseous captive into the micro-cells is 170^{0}C and its pressure is 2,82 daN/cm^2, when the outsider pressure is 1,7 daN/cm^2. In these conditions, in the same time with the thinning process, the internal pressure is higher then the external pressure, with more then one atmosphere, and the polymerized vinyl chloride will be pushed from the interior to all the unevenness of the moulds (no matter how fine they are), suffering, in the same time, a new thermal expansion process.

So, it can say that, without this layer, the forming process would need a higher pressure of the installation. Studying all the details of the process, it can conclude that the thinning (which takes place in both layers of PVC) and the thermal expansion of the microcellular layer push the compact layer into the mould unevenness. Contacting the mould, the compact layer will be cooled until 130-140^{0}C. For the obtained plastic deformation keeping, after the mould was opened, the part will still be kept into the mould another 10-15 seconds, so, the cooling will go on. Under 90-100^{0}C, the model obtained by stamping will keep its design, a long time.

In the same time with the stamping process, a thermoplastic layer will be transferred. In this case, there are two solutions. The first solution means that between the detail and the stamped piece there is a printing foil which has a polyethylene or a polystyrene film on which it is settle down a pulp based on a thermoplastic polymer (its melting point has a small value-100-120^{0}C), which contents coloring agents or even small dimensions metallic powder (under 0,1μm). By heating, the pulse will pass on the part surface. The other solution refers to the diversification of the stamped products and it means that it will use some moulds variants which realize the stamping, on an existing part, of another colored part. In this case, the designing of the mould cavity must allow this operation. This aspect is represented in fig. 1 [1].

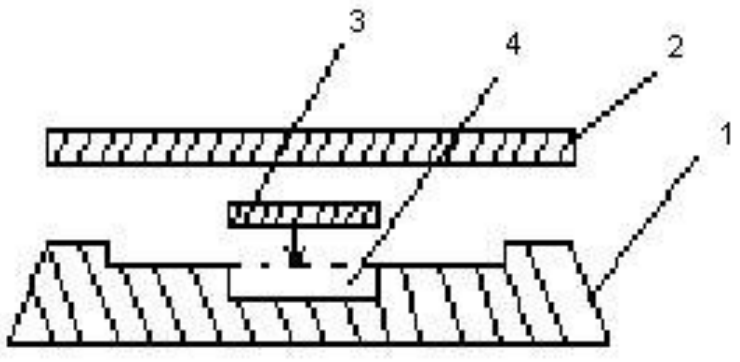

Figure 1. Mould used for the simultaneously stamping of the two parts
1- silicone mould; 2- part A; 3- part B; 4- cavity for the stamping of the part B

During the stamping process, under the heat influence, the detail will be welded on the vamps.

b. *Parts stamping gelatinization some plastically pulps*

In this case, on a textile material base, it will settle down, in the same time with the stamping process, a layer made from a plastically gel. The stamping process takes place in the same time with the plastically gelatinization. In this technology, the silicone mould has, on its outline, a collecting channel which takes the plastically excess, just before the pressing of the detail into the mould cavity, as fig. 2 shows, [1]

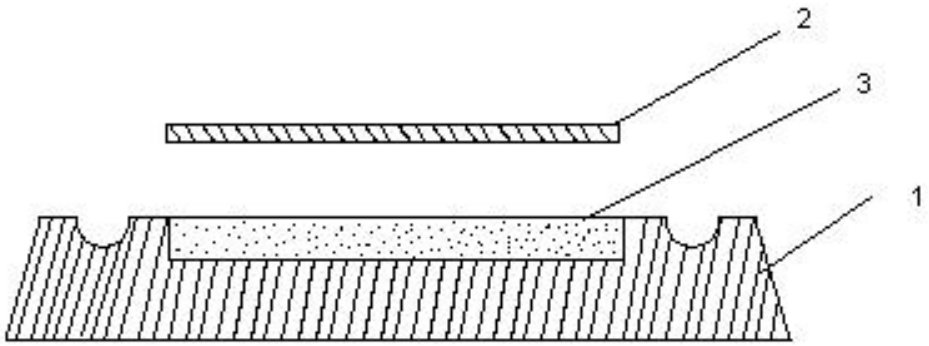

Figure 2. Mould used for the stamping of the plastically pulp
1-silicone mould with a collecting channel; 2- stamped part; 3-plastisol pulp

c. Part stamping by some polymerized vinyl chloride powders sintering

This technique gives the possibility to stamp a part, using a sintering process of a polymerized vinyl chloride powder into a silicone mould. The sintering is the welding, densification and re crystallize process, by thermal activation, of powders or granules agglomerates, [2,3]. During the sintering process, the granules or the powders are firmed going to some inter granules bridges building which are continuous and stable. So, using a sintering process, it will obtain a continuous and dense film.

These moulds [1] have a cavity with a bigger depth, 4-5 mm, in which it will settle down the PVC powder. After the sintering process, the dense layer will have a 2-2,5 mm thickness, which is, as a matter of fact, the part thickness. The process stages are: the cavity of the silicone mould is filled with a polymerized vinyl chloride powder; as a radio frequency currents effect, the powder is heated and plasticized; the layer thickness decreases because of the sintering process beginning. In this moment, the base made from a textile or leather split material it settled down. This so made assembly goes to a pressing machine where the heating process goes on, and the sintering process of the polymerized vinyl chloride ends, in the same time with the stamping process.

In the case of the stamping technologies by the gelatinization of some plastically pulps or by the sintering of some PVC powders, in the same time, it can realize the vamps finishing, by spraying of the mould cavity with a polyurethanes film.

The heating equipments with radio-frequency currents have the power values between 1,5 and 50 kW, depending on the surface of the heated part.

The stamping optimal time depends on the material. In usual conditions, this time is 10-15 s, when there are stamped parts which have polymerized vinyl chloride in their structure and it is 25-30 s when the stamping is by the plastically gelatinization or by the PVC powder sintering.

In the manufacturing process, alter a certain using time, the moulds must be replaced. The realization of some identical moulds, using the initial models, is not possible because, in time, they are deformed. This is the reason because, just at the beginning, in the same time with the silicone moulds realization, it realizes the polyurethanes standard moulds, using the same primary model.

3. EXPERIMENTAL PART

As the classic technology in silicone mould realization shows, the stages are: the realization of the primary model which will be reproduced in the mould cavity, the proper mould obtaining and the standard mould obtaining. In the cases when there are realized moulds variants, there are all these stages and more additional operations.

3.1. Realization of the primary model

When this technology is applied, it will pick models with complex ornaments, whose realization, using classic methods, needs a very long time. Using the silicone moulds stamping technology, the product realization is cheaper. The primary model means the part or the parts assembly whose models may be complete reproduced into the silicone mould cavity.

The parts are plane and they are made using a classic technology. Because the copying technology by stamping reproduces identical any detail placed on the primary mould surface, it will use leather which have a clear drawing of the pits.

The parts borders which will be assembled by sewing will be buckled. For the buckling area of the parts borders it will resort to the straight attenuation; it gives a precise line of the buckle border and, in the same time, a little thickening of the borders. For the parts which are placed at the inferior side of the joint, it will resort to an oblique attenuation with finite dimensions, the breadth of the attenuation being adopted 6-8 mm.

For the sewing, it will use a thick string, it prefers a string which has 50/3 Nm fineness. The sewing step will be bigger, 2-3 steps per centimeter, in comparison with 4-5 steps per centimeter usually used. As ornaments of the parts, it can be used complicated decorative sewing with different thicknesses strings seams.

The borders of the parts, when they are not buckled, are indented or punched. In some holes case, their diameters will be bigger than the leather thickness; so, the profile of the mould cavity will not be damaged during many usages.

The primary model used for the silicone mould obtaining must be perfectly plane. This kind of experimental primary model is represented in fig. 3 [4].

Figure 3. Experimental primary models

For the obtaining of a perfectly plane surface, after all operations made for the primary model realization it will be glued on a leather split for the stamping. For the stamping process realization, the assembly will be placed so that, the parts constitutive of the primary model will contact the plane surface of the pressing machine and the leather split will contact the inner tube of the pressing machine. Under the pressure, the unevenness resulted at the primary model realization (the parts sewing by overlying, the buckling of the parts borders, the realization of some decorative elements, etc.), are transferred to the split layer so that, in the end, the primary model surface becomes perfectly plane. The primary model is glued on a board base which has 0,8-1 mm thickness and then, on a

glass or a aluminum rectangular plate. The glass or aluminum plate has 5-7 mm thickness and dimensions with 10-15 cm bigger then the primary model outline once. The so obtained experimental model will be used for the obtaining of the silicone mould.
Considering the economic criteria, when the primary model is designed and realized, the parts made for one pair of footwear will be designed symmetrically so that, it will not be necessary two moulds, one for the right foot and the other one for the left one. Also, a mould might be used for 2-3 numbers represented successive sizes. So that, it will realize the mould for the maximum size and then, it will re-cutting-on for the smaller sizes.

3.2. Silicone mould obtaining

The experimental model, which realization was presented in chapter 3.1, will be placed in a rectangular polyurethanes frame which have de 8 mm height, as fig. 4 shows. Into this frame, it will cast a silicone rubber pulp.
The silicone rubber pulp has, in its composition, silicone oils which have a linear polymers structure. The reticulation of the linear polymers for the silicone rubber obtaining will be realized using structural or metallic peroxides which form oxygen bridges between the filamentary chains of the neighboring molecules.

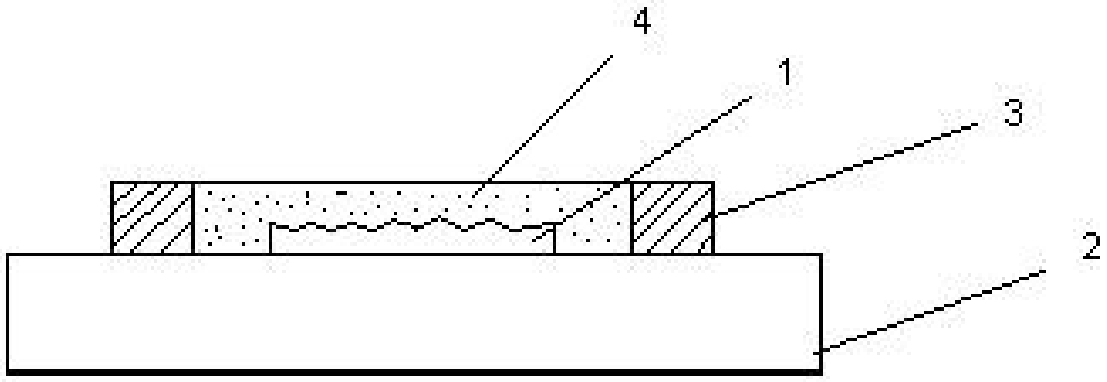

Figure 4. Obtaining of the silicone mould:
1-experimental primary model; 2-platform of the pressing machine; 3-polyurethanes frame; 4-silicone rubber mould

The reticulation will be made blending, in a sensitive way, some peroxides with silicone oils and then, with or without their heating. The reticulation without heating takes place a longer time, about 24 hours.
The reticulation in heating, at 150 ^{0}C and under pressure, goes a few hours. This time may be decreased if some catalysts, such as: lead oleate, silicagel, boric acid esters, etc. are used. An additional 1% of lead oleate decreases the reticulation time from hours to a few minutes.
Before the reticulation and the activation agents putting in, it will be introduced different fillers, such as: mineral substances (chalkstone, kaolin, calcium lime, magnesia and lead monoxide), glass fibers, aluminum powders. As solvents, it will use the anon. As peroxides, it will be introduced structural peroxides. After the blending, the still fluid mixture will be cast over the primary mould.
To avoid the gluing of the pulp on the contacted surfaces, the surfaces will be lubricated with ant adherent oil.
Before the pulp of silicone rubber casting, it must be eliminated the air into the mixture. The presence of the air will determine the discontinuous structure formation which will go to the decreasing of the mould resistance. After the pump casting, the assembly represented in figure 4 will be covered with a plastic foil which has 0,6-1mm thickness. The

entire assembly will be pressed. After the finishing of the silicone pulp reticulation process, it will separate the experimental silicone rubber mould. The obtained mould will be machine worked for the thickness leveling, the plate preparation, the elimination of the captive air, etc. In these conditions, the mould will have a thickness about 7 mm. The so realized models of the silicone moulds are showed in fig. 5.

Figure 5. Silicone moulds

Figure number 6 shows the technologic steps in the obtaining of one stamped part, primary model and silicone rubber mould and part with stamped ornaments.

Figure 6. Most important stages of stamped part realization

3.3. Standard mould obtaining

The standard mould has a model identically with the primary model used for the silicone rubber mould realization. The experimental mould is used for: the realization, in a short time, of the silicone rubber mould damaged during the work; the keeping, in a data base, of the primary models which will be used, if it is necessary, for the obtaining of the moulds identically with the moulds already used in production. Following all these aspects, the standard mould will be made from a polyurethanes material which keeps the design and the dimensions in time.

The technological stages for the polyurethanes standard mould realization are presented in figure 7.

The silicone rubber mould will be mounted on a glass or aluminum plate with 7-10 mm thickness and than it placed on the inferior platform of the pressing machine. On the mould surface, it will settle down, in a thin layer, an ant adhesive material or even silicone oil. Into the mould cavity, it will cast a uniform level of the polyurethanes blend. On the mould surface, it will be placed a board plate which have 0,5-0,7 mm thickness, on which it will adhere the polyurethanes blend. The pressing machine is closed and the chemical

process of the polyurethanes blend structuring takes place. After the structuring, the polyurethanes standard mould is easily separated by the silicone rubber mould due to the ant adhesive layer. These kind of standard moulds are represented in fig. 8.

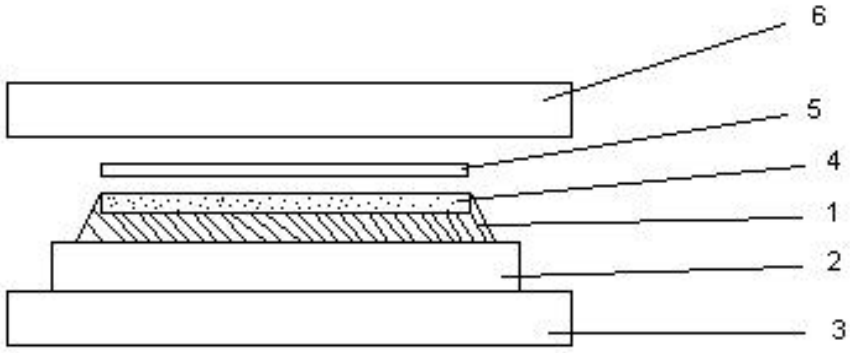

Figure 7. Realization of the polyurethanes standard mould
1- silicone rubber mould;2- aluminum or glass plate; 3- inferior platform of the pressing machine; 4- polyurethanes blend; 5-suport; 6- superior platform of the pressing machine

Figure 8. Polyurethanes standard moulds

For the polyurethanes blend obtaining it will use hydroxylation polyester which was introduced into the blend in a 90% ratio together with three isocyanides in 10% percentage. Because the so obtained product will be used only as a experimental model, no other materials will be added into the blend. Before the casting, the polyurethanes blend will be degas 5-10 minutes. The cast of the blend will be executed in maximum 15 minutes from its preparation to avoid the increasing of its viscosity due to the reticulation process. After the separation, the experimental mould will be placed in a horizontal position a few hours to stabilize it, and than, it may be hanged in vertical position.

CONCLUSIONS

- As components of the footwear or Morocco leather products, there are often, parts or complex decorative models whose realization, by using classical methods, asks long operational times and, as a result, high costs. Using the stamping technologies with silicone moulds, the costs for this kind of products decrease.
- The using of the silicone rubber moulds in the stamping of the parts which have polymerized vinyl chloride into their structure, is based on some fundamental characteristics of this kind of rubber: it participates at the dielectric heating process of the polymerized vinyl chloride without itself heating; it has resistance at high temperatures, its heating being by conductivity; it has a local hardness bigger than the fluid polymerized vinyl chloride hardness; in a fluid state, before the finishing of the

structure, it can follow all fine details of the plane surface due to the superficial proprieties (they give a good displayed behavior).

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