

Description

The present invention concerns a method for the setting-up of moulds for the injection moulding, particularly of tools for the injection moulding of plastics material. Hitherto, high grade tools had to be machined out of fine steel blocks; the quality and dimensional accuracy of the injected workpiece depended and always still depend predominantly on the hardness of the tool material. The processing in the manner of cutting is correspondingly lengthy and expensive so that the production of the tools in the case of complicated shapes each time requires a high investment which is worthwhile only in the case of very high piece numbers.

If one steps to the setting-up of such tools, one must previously be as certain as possible that the tool to be produced exhibits the final structure optimum for the distribution and the use. Modifications to the tools are performable either not at all or only to a small extent, for example by means of electrical spark erosion, a lengthy and quite expensive operation. Modifications of greater extent can be brought into being only through the production of new tools.

Although a tool of less hard material is cheaper to manufacture, it does, however, withstand fewer "shots" and produces workpieces of lesser accuracy. In terms of costs, such cheaper tools are worthwhile only in the case of articles which do not have to exhibit exact measurements and the piece numbers of which are relatively small, such as, for example, in the case of toys. Simple tools of that kind for correspondingly simple workpieces are for example cast of zinc alloys; they are, however, also moulded from a primary mould core galvano-plastically

as hard nickel mould sets. The cast tools produced on a zinc base, moreover, exhibit the disadvantage that zinc tends to the formation of shrinkage fissures.

These simple tools in the best case withstand 5000 to 10000 production operations, whilst fine steel tools of high grade alloyed glass-hard steel readily endure one million "shots".

If one would before the setting-up of high grade tools test the workpieces thereby that one initially produces them by way of trial by simpler tools, one would first have to carry the always still relatively high costs of the trial tools and for the other thing run the risk that the test trials could be more or less worthless because of the insufficient and uncertain accuracy.

The high costs of the setting-up of high grade injection tools according to the previous methods block the mobility of the injection moulding technique quite appreciably. Each manufacture of new models is a great investment risk. Although the high tool costs play a secondary role in cases where a model has "settled" on the market, the pressure for the new investment, however, appears as soon as the market demands changes.

These conditions are typical for the plastics material industry in general as well as also particularly for the tyre industry, which is at present disposed in a phase of continuous innovation, because it still always seeks better profiles for the winter tyres as replacement for the studded tyres. In test trials, the profiles were often cut out of smooth projectors, because the setting-up of small series in the injection moulding process is too expensive, particularly since six or more segment-shaped tools are required for a single tyre, which tools are

then combined into a complete tool. Shape-conditioned changes in special tyres, such as tyres for the road construction and earth working, for agricultural tractors and for cross-country vehicles, entail costs which are much too high in relation to the piece numbers.

Similar cost difficulties also appear in the case of injection moulding of metal, although the tools are here not quite so expensive, however also not so durable.

This problem is old and occupies the expert right from the emergence of the extruder. Already in 1942 appears the US-PS 2 293 571 STOSSEL, which proposes a, in principle, technically feasible problem solution in which a primary mould was produced out of an easily mouldable material (a suitable metal was proposed) and provided in the electrolysis or galvanic process with an overlay of a metal of lower melting point, such as, for example, tin. On this separating layer a metal of high melting point, such as, for example, fine steel, was then sprayed-on in molten state with a spraygun, which formed the hard surface of the mould to be set up. After that one heated the whole so far that the lower melting separating layer melted; one could then release the newly set-up mould part from the primary mould core and backfill with an unyielding mould mass.

As already stated, this process indeed in principle showed the correct way, but exhibited considerable technical deficiencies and has not been able to be continued. Already the bringing about of the separating layer by means of electrolysis or galvanising was too costly and too complicated, moreover the thin, lower melting metal separating layer was already partly melted off with the spraying-on of the very much hotter mould layer. Finally, the high temperature (melting point

of the tin) required for the separation led to distortion and placed the accuracy of the prepared mould in question. The obligation, on this account, to produce the primary mould core out of metal or out of a similar rigid material, brought substantial manufacturing costs and the distortions, necessarily to be taken into account as a consequence of the release of the mould from the mould core, required in many cases, where dimensional accuracy was concerned, measuring and rectification before the next moulding process.

The present invention proceeds from the just described state of the art. It has the task of counteracting the deficiencies of the known process according to the US-PS 2 293 571 as well as the remaining specified aggravations at the respective mould constructions and to create a method for the setting-up of moulds for the injection moulding, which on the one hand are producible substantially more rapidly and much more favourably in costs and on the other hand are just as high grade and exhibit just as hard and accurate mould surfaces as the qualitatively best tools machined out of fine steel blocks.

The task of the invention is solved thereby that initially a water-resistant covering layer consisting of an aqueous solution of a hydrosol, a latex, acrylic resin, quartz powder and alkyd lacquer and - after drying thereof - with the separating layer consisting of an aqueous solution of glue, carbohydrates, quartz powder and metal powder, is coated on the primary mould core, whereafter ceramic or metal is sprayed on the thereby prepared mould core and forms a ceramic or metal mould shell, which after subsequent backing with unyielding material represents a mould part, which is releasable from the primary mould core by means of introduction of water into the water-soluble separating layer. The water-resistant covering layer solution,



to be coated directly on the primary mould core, can be composed as following:

Latex	38% by weight,
water	25% by weight,
quartz powder	25% by weight,
acrylic resin	8% by weight,
hydrosol	3% by weight and
alkyd lacquer	1% by weight.

The covering layer has the purpose of protecting the primary mould core before damage, which could otherwise come into being with the high temperatures arising in consequence of the spraying-on of fine steel or ceramic.

The separating layer is formed through spraying-on of a separating layer solution of following components:

Relieved water	38% by weight,
quartz powder	36% by weight,
liquid sugar	15% by weight,
glue	8% by weight and
metal powder (nickel)	3% by weight.

As with the water soluble covering layer, there is concerned simple and commercially available substances.

The backing to be introduced by and in the sprayed-on mould core can consist of epoxyde resin reinforced by quartz sand, metal powder or the like, or also of cast metal.

In a preferred embodiment of the invention the backing is filled into a housing inverted over the mould core and the metal mould shell produced through spraying-on.

This housing can be provided with a cover, which by a cover rim, structured in the shape of a conical shell, engages into the housing at all sides and rests on the backing.

In a preferred embodiment of the invention an additional copper layer is coated after the spraying-on of a fine steel shell onto the mould core.

Example of embodiment

The example of embodiment described in the following is related to the setting-up, according to the invention, of moulds (tools) for the injection moulding of plastics material workpieces.

There show:

Figure 1 the front elevation of a plastics material shell (prototype), to be set up by such a tool, in perspective view,

Figure 2 the plastics material shell of Fig. 1 in a rear view,

Figure 3 partially in section X-X of the Fig. 1, that part of the tool, which is remote from the extruder and consisting of a fine steel mould shell, according to the invention, which corresponds to the surface structure of the plastics material shell of Fig. 1, with an epoxide resin quartz sand backing and embedded in a steel housing with steel lid,

Figure 4 partially in section X-X of the Fig. 2, that part of the tool which is near to the extruder and consisting of a fine steel mould shell, according to the invention, corresponding to the surface structure of the plastics

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- material shell of Fig. 2, with an epoxide resin and quartz sand backing, embedded in a steel housing,
- Figure 5 in the section X-X of the Figures 3 and 4 (of the injection unit of the extruder partially in section), the tool composed of the tool parts of Figs. 3 and 4 at the extruder,
- Figure 6 the tool part of Fig. 3, remote from the extruder, produced at a primary mould core of gypsum and structured in correspondence with the surface of the shell of Fig. 1 and surrounded by a steel housing with cover, which receives the backing of epoxide resin and quartz sand,
- Figure 7 a greatly enlarged illustration of the detail "A" of the Fig. 6, however without the symbol of the backing,
- Figure 8 the steel housing with cover, both in perspective view and
- Figure 9 both tools with backing of cast metal and correspondingly simplified housing cover.

The reference symbols applied in the figures indicate:

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| 1, 2 | Prototypes of the workpiece to be set up |
| 3 | Primary mould core |
| 4 | Support for the primary mould core 3 |
| 5 | Water-resistant cover layer on the primary mould core 3 |
| 6 | Water-soluble separating layer |
| 7 | Fine steel layer |
| 8 | Housing around the fine steel layer 7 |
| 9 | Backing at the fine steel layer 7 |

- 10 Cover of the housing 8
- 11 Cover rim
- 12 Incline, in the shape of a conical shell, of the cover rim 11
- 13 Opening in the middle of the cover
- 14 Tool part remote from the extruder
- 15 Tool part near to the extruder
- 16 Metallic backing
- 17 Screws for the fastening of the rimless cover 10
- 18 Copper layer on the fine steel layer 7
- A Detail from Fig. 6 (Fig. 7)
- B Sprue bore in the tool part 15
- E Injection part of the extruder

Initially, primary mould cores 3 (Fig. 6) of gypsum are set up with the aid of prototypes 1 and 2 (Figs. 1 and 2). The primary mould core 3 shown in Fig. 6 corresponds to the surface structure of the prototype 1. The primary mould core (not drawn) corresponding to the prototype 2 (Fig. 2) is cast of gypsum in analogous manner. However, also other materials can be employed for the mould core insofar as they exhibit temperatures around 100°C without deforming, thus for example wood, plastics material or similar. The primary mould core 3 must be water-resistant, insulated, free of fat, and handy.

Each primary mould core 3 is set up on a geometrically planar support 4 and the water-resistant cover layer 5, given in claim 2, is applied by a commercially conventional paint spraygun up to a layer thickness of 15 to 30 micrometres. After drying-out of the cover layer 5, the water-soluble separating layer 6 described in claim 3 is sprayed

on, and namely up to about the same layer thickness as for the cover layer 5. In most cases, an overall layer thickness of 30 micrometres suffices for both the layers.

Concerning the nature of the solutions specified in the claims 2 and 3, it is to be stated that the water-resistant solution 5 has the purpose of creating a water-resistant film on the surface of the primary mould core 3, which is also temperature-resistant. The water-soluble solution 6 forms on the water-resistant layer 5 a water-soluble film which is composed in such a manner that it itself under the impact and the heat effect of the metal spray jet enters into no connection with the water-resistant layer 5, thus remains separated from this chemically and mechanically. In the case of primary mould cores 3 of gypsum, wood, plastics material and similar, at which no temperatures above 100°C arise, the same water-resistant layer 5 can be employed for the spraying-on of many fine steel moulds.

The recipes stated in the claims 2 and 3 are to be regarded as optimum examples. Several usable recipes can be composed within the scope stated in claim 1 (without specific statement of quantity).

The drying-out of the layers 5, 6 can be accelerated, if desired, through heat. For the purpose of a particularly smooth surface of the primary mould core, one can cautiously grind down the mould core, but in that case must take care that the separating layer 6 is not ground through.

One then applies molten fine steel by the metal spraygun onto both the primary mould cores 3. During the spraying-on, care is to be taken that no overheating of the fine steel layer 7 occurs. The spray spacing between spraygun and primary mould core should amount

to at least about 30 to 50 centimetres and the spraying-on takes place in several sections so that a short pause is inserted after each spray section in order that the sprayed fine steel can cool down each time.

At temperatures above about 130°C, the separating layer 6 will give access to the fine steel layer 7 and let compressed air or compressed gas penetrate between primary mould core and fine steel layer. The fine steel layer lifts off from the primary mould core and is thereafter unusable.

Here, the high carbohydrate content (liquid sugar, claim 3) acts as warning signal: the liquid sugar burns with smoke development already at 100°C. The operator of the spraygun then knows that he must introduce a short pause in order that the fine steel layer can cool down.

In order to attain a thickness of the fine steel layer 7 of about 1 millimetre, 15 to 20 individual layers are required. For the employment of the fine steel shells 7 as mould parts of a tool for the injection moulding of plastics material, one does not, however, require shells of such thickness, but can content oneself with substantially lesser thicknesses, approximately between 0.1 and 0.5 millimetres, because the fine steel shell 7 has no kind of carrying function in the compound tool, as shall be explained further below. The hardness of the material is primarily decisive for the use of the fine steel mould shell 7 as injection moulding mould. By contrast to every other deformation principle, the material hardness plays no part in the present method; even the hardest chrome steels let themselves be flame-sprayed without any difficulty.

In case the application of the fine steel takes place in an oxygen-free spray cabin according to DE-GM 82 25 728 (later OS 32 33 925),

the fine steel mould shells 7 formed at the primary mould cores 3 will be sinter-free and exhibit a similar structure as cast workpieces or such set up by means of machining operation. They then also let themselves be polished accordingly. In the case of spraying-on of fine steel, particularly of Cr-V steel or Mo-Al steel, in a spray cabin filled with nitrogen, an additional nitro-hardening takes place automatically.

After cooling-down of the fine steel mould shells 7 resting on the primary mould cores 3, a respective upwardly and downwardly open housing 8 is set up around each mould shell 7 and filled up to the rim with a mixture of epoxide resin and quartz sand, the backing 9. Laid onto the housing 8 is a cover 10, which by a cover rim 11 protrudes into the housing 8. The cover rim 11 exhibits an incline 12 in the shape of a conical shell. The cover 10 possesses an opening 13 in its middle. The cover 10 is pressed against the housing 8 in such a manner that the epoxide resin quartz sand mixture bears firmly against everywhere, also against the fine steel mould shell 7. The cover rim 11 is so dimensioned that it is to be introduced into the housing 8 only with effort so that it also requires no securing in order not to be able to be withdrawn negligently or even to drop out. Housing 8 and cover 10 are illustrated in Figure 8.

The backing 9 can also consist of a mixture of epoxide resin and iron powder, epoxide resin and glass powder (or glass balls); it need only be absolutely inelastic and unyielding and absorb very great forces (spray force on the one hand and closing force on the other hand) without yielding.

After the filling-in of the backing 9, water is introduced between

the primary mould core 3 and the fine steel shell 7. The water-soluble separating layer 6 dissolves and the tool 14 and 15 lets itself be separated from the primary mould core.

The injection unit E of an extruder is connected with the complete tool 14 and 15 at the sprue bore B arranged in the tool part 15. Acting on the tool part 14 remote from the extruder is the closing force which corresponds to the spray force acting on the tool part near to the extruder; the complete tool 14 and 15 is compressed by both these forces. The forces are very great; according to machine size and workpiece size, they can amount to between 10 and 5000 Megaponds. Since these forces act on the cover 10, any possible yieldability of the backings 9 is absorbed by the covers in that the cover rims 11 push into the backings 9 insofar as any yieldability should still be present there.

An absolute non-yieldability of the backings is attainable thereby that each backing is set up of metal which is of low melting point and cast in molten state into the housing 8. This procedure presupposes that the fine steel shells 7 are previously brought to a temperature which is near to the melting point of the metal provided as backing, because the fine steel shell could otherwise distort. The primary mould core 3 must therefore be set up of correspondingly heat-resistant material, for example copper (melting point around 1080°C), whilst the backing can then consist of zinc (melting point around 420°C) or of bronze (melting point around 700°C).

On the heating-up of the primary mould core 3 and the fine steel shell 7, separating layer 6 and cover layer 5 combust so that the separation of the workpiece parts 14, 15 has already taken place during the filling-in of the metallic backing 16.

Since the metallic backing 16 is entirely unyielding, the cover 10 can act on the closing forces without rim and collar lying on the backing and be held fast by screws 17 or the like, cf. Fig. 9.

The metallic backing is mandatory in the case of injection moulding of metal, furthermore in the production of car tyres, in that the injection moulding mass in this method takes place at temperatures which a primary mould core of gypsum, synthetic material or similar does not bear. The setting-up of tools for the tyre manufacture takes place segment by segment and these segment tools are then assembled into an annular complete tool.

When it is important to attain as rapid and uniform as possible a heat removal from the fine steel shell 7, it is expedient to spray on a copper layer 18 after spraying-on and cooling-down of the fine steel shell 7.



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Patent Claims

1. Method for the setting-up of moulds for injection moulding, particularly of tools for the injection moulding of plastics material, in which the mould consists of a primary mould core, which is provided with a separable separating layer and after that with a sprayed-on layer of molten metal on this, characterised thereby, that initially a water-resistant covering layer (5) consisting of an aqueous solution of a hydrosol (e.g. an aqueous dispersion of acrylate), a latex (e.g. polyvinylacetate), acrylic resin, quartz powder and alkyd lacquer and - after drying thereof - with the separating layer (6) consisting of an aqueous solution of glue, carbohydrates, quartz powder and metal powder, is coated on the primary mould core (3), whereafter ceramic or metal is sprayed on the thereby prepared mould core (3, 5, 6) and forms a ceramic or metal mould shell (7), which after subsequent backing (9, 16) with unyielding material represents a mould part (14, 15), which is releasable from the primary mould core (3) by means of introduction of water into the water-soluble separating layer (6):

2. Method according to claim 1, characterised thereby, that the water-resistant covering layer solution (5) is composed as following:

Latex (e.g. polyvinylacetate)	38% by weight,
water	25% by weight,
quartz powder	25% by weight,
acrylic resin (acrylate)	8% by weight,
hydrosol (e.g. HYDROSOL of Hüls-AG)	3% by weight and



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alkyd lacquer (e.g. ALKYDAL of 1% by weight.
Hüls AG)

3. Method according to claim 1, characterised thereby, that the water-soluble separating layer (6) is composed as following:

Relieved water	38% by weight,
quartz powder	36% by weight,
liquid sugar	15% by weight,
glue	8% by weight and
metal powder (nickel)	3% by weight.

4. Method according to claim 1, characterised thereby, that the backing (9) consists of epoxyde resin reinforced by quartz sand, metal powder or the like.

5. Method according to claim 1, characterised thereby, that the backing (16) consists of cast metal.

6. Method according to claim 1, characterised thereby, that the backing (9, 16) is filled into a housing (8) inverted over the primary mould core (3) and the metal mould shell (7).

7. Method according to claims 1 and 6, characterised thereby, that the housing (8) is provided with a cover (10), which by a cover rim (11), structured in the shape of a conical shell, engages into the housing at all sides and rests on the backing (9).



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8. Method according to claim 1, characterised thereby, that an additional copper layer (18) is applied after the spraying of a fine steel shell (7) onto the primary mould core (3).