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PROCESS OF MAKING MOLD OF ALLOY

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Our invention relates to molds or dies, and particularly to molds or dies which are capable of reproducing details of the finest character appearing in the master pattern or matrix. It also relates to the method of making such a mold or die and includes the creation of a new alloy structure and the process of producing the same.

So far as we are aware, it is, at present, quite impossible to make a mold or die by the ordinary casting process in which minute details of the master pattern are perfectly preserved without distortion. This is particularly true where the mold or die must be subjected, after it is cast, to a heat treatment for the purpose of hardening.

The primary object of our invention, therefore, is to produce an alloy structure which is susceptible to hardening by heat treatment, and from which molds or dies may be constructed, according to our process, which will receive and retain, without distortion, details of the finest character appearing in the master pattern or matrix.

With these objects in view our invention includes the new alloy structure hereinafter to be described; the method or process of making the same; and particularly a mold or die and the process of forming, from such an alloy, molds or dies having the above mentioned characteristics.

It is well known that ferrous alloys of the character of steel, in which carbon is present, may be tempered or hardened by heating and quenching. It is also well known that molds or dies cast of ordinary ferrous alloys and by ordinary methods, do not preserve the finer details of the master pattern. This is perhaps due to two causes, namely, the failure of the molten metal to penetrate between the finer projections or into the finer recesses of the pattern, and the tendency of the minute particles of molten metal, when cooling to cohere together and withdraw from these finer recesses, thus destroying, or at least not preserving, in the die or mold, an exact, sharply defined negative of the master pattern.

In order to produce a die or mold by a casting process, or a process analogous thereto, it is necessary to form it of a metal which will penetrate the finest details or etchings in the pattern, and to devise a method whereby the precise arrangement of the particles of metal in the mold or die, as once established by their contact with the master pattern, is preserved.

In offering a solution for this problem, our invention contemplates first, the utilization of a cold or solid metal, preferably capable of being hardened by heat treatment, and in such a state or condition that particles thereof will enter into the finest recesses or marks on the master pattern and be relatively arranged thereby; second, the temporary preservation of the relative arrangement of the particles, by causing them to cohere into a unitary mass capable of being manipulated to some extent; and third, the permanent preservation of the established arrangement of the particles by cementing them together into an alloy like structure. Our invention further contemplates the carrying out of the alloying or cementing step in such a way that elements present in the cold or solid metal used, and which are essential for hardening that metal by heat treatment, are preserved intact in the resulting alloy.

In describing our invention in detail, we will first describe the production of our new alloy in connection with the construction of a mold or die, as the two operations are conveniently carried on together, but it is to be clearly understood that the creation of our new alloy is in nowise dependent upon its connection with any particular structure.

As a cold or solid metal, we prefer to use a steel having a carbon content sufficient to render it susceptible to hardening by heating and quenching. The steel is first reduced to particles by any suitable process such as filing, grinding, cutting, chipping, or the like, and if ground, is separated from the particles of abrasive by a magnetic or other suitable process. Where the details of the pattern to be preserved in the die or mold are comparatively coarse, steel of the above character in the form of a fine "steel wool" may be used. For the preservation of minute details in any pattern, the steel should be quite finely comminuted so that the individual particles thereof are capable of entering or being arranged by those details of the pattern. For example, we have found that details as fine as the hair on the buffalo appearing upon the present United States five cent coin, are well preserved in the mold or die where the steel is sufficiently comminuted to pass a screen having 10,000 meshes per square inch, and for the finest work it is recommended that the steel be comminuted to this or a greater degree and carefully sieved to produce a uniformly graded product.

In forming a die or mold, the master pattern or matrix, which for the purpose of illustration will be assumed to be a medal or coin, is placed in the bottom of a suitable receptacle or container, capable of withstanding great pressure and of sufficient size to contain and form the mold or die itself. The finely divided steel is then sifted or shaken into the receptacle and in and about the matrix, and is, thereafter, subjected to a comparatively high pressure, say 30 or 40 tons per square inch, sufficient to force the particles of steel into the finest recesses of the pattern, and to cause the particles of steel to cohere in a solid, unitary mass, capable of being handled, or otherwise manipulated, without fracture or distortion. Where this amount of pressure is applied, the embryonic mold or die, thus formed, will have all the appearance of a piece of solid steel, and may be filed, drilled, sawed or otherwise worked upon, without injury.

After the mold is removed from the receptacle, we place it in an electric or other furnace where it may be subjected to the heat treatment hereinafter described. We now propose by the heat treatment to braze the finely divided particles of steel together into an alloy like structure by introducing into the extremely minute voids existing in the mass, a cementing and carbon sealing metal, such as copper. We prefer that the amount of cementing metal used shall be just sufficient to saturate the steel and no more. Where more than the saturating amount of metal is used, some of the finer details of the mold or die may be filled therewith and thus destroyed. The precise amount of copper to be used to procure saturation depends upon two factors, namely, the degree of fineness of the steel powder which is used, and the amount of pressure which has been applied, but it may be approximately determined by ascertaining the voids in the embryonic mold by comparing the specific gravity thereof with the specific gravity of the steel used. We find that where the steel powder has been sieved through a screen having 10,000 meshes per square inch, and the mass has been subjected to a pressure of 30 tons per square inch, the amount of copper required for saturation, is about 40% by weight of the steel mass. The required amount of copper is placed in contact with the steel in a suitable refractory carrier or container, such as asbestos, and the whole is placed in an electric furnace of the resistance type. The copper may be placed anywhere it will come in contact with the steel so that it will be drawn into the voids by capilliary attraction, and copper wire, in the required amount, simply wrapped around the steel produces very satisfactory results.

After the copper and steel are placed in the furnace a gaseous flux, such as hydrogen alone, or hydrogen diluted with nitrogen, for example, is introduced. Because of the great affinity of carbon for oxygen, the atmosphere within which the alloying is performed must be a "reducing" atmosphere, if a product susceptible to hardening by heat treatment is desired. Otherwise, oxygen present will remove the carbon from the steel and result in a product which is not responsive to heat treatment.

After the gaseous flux, creating a reducing atmosphere within the furnace, is introduced, the temperature is brought to a point somewhat above the melting point of copper, or say up to 1100 degrees centigrade. This temperature is maintained until the steel mass has been saturated with copper, which takes place quite rapidly, whereupon the temperature may then be dropped below the melting point of copper, say to 950 degrees centigrade, until the copper has frozen. The temperature to which the furnace is dropped is immaterial but the mold should, of course, not be removed until the copper has hardened.

The function of the copper is threefold. It acts as a cementing metal for the particles of steel; it forms a seal which prevents the loss of carbon; and it acts generally as a filler for the minute voids existing between the particles of steel, thereby preserving the finer details impressed in the die or mold. Metals, other than copper, may perhaps be used for this purpose, but it is quite essential that the cementing metal be of a character which will unite with the iron and carbon to form an alloy structure having a melting point above the temperature to which the mass must be subjected during the hardening heat treatment. Where copper is used, we believe a true alloy structure is created because the combination is not affected by the much higher temperature to which it is subsequently subjected in the hardening process.

Before hardening, an alloy made according to the above procedure in which steel, having a carbon content of about 1.10%, is used, will have a Brinnell hardness around 400. This hardness apparently depends somewhat upon the amount of copper present and this, of course, depends as above pointed out, upon the fineness of the steel which is used, and the amount of pressure to which it has been subjected. It is of interest, however, to note that by our process, if somewhat prolonged, copper may be introduced into an ordinary solid steel ingot having apparently no voids.

Where the master pattern or matrix has comparatively deep recesses or comparatively high projections or relief portions, we find that the details thereof are better preserved in the mold or die by following a slightly different procedure. Where such is the case, the best results are obtained by leaving the master pattern or matrix in the mold during the alloying process. In order to perform this successfully, and in order that the master pattern or matrix may be readily separated from the mold when they are removed from the furnace, it is necessary to form the master pattern or matrix of a material which will not unite with the material in the mold, or, at least, to cover the surface of the master pattern or matrix with a film structure of a substance which will prevent the union of the matrix and the mold. Where these conditions are to be met, we find that a master pattern made from steel containing silicon and chromium gives very good results. In practice we have used a steel containing 4% to 5% of silicon, 8% to 9% of chromium, with 0.40% to 0.50% carbon.

With a master pattern or matrix, formed of this material, the procedure is substantially the same as above described except, that the master pattern is not removed from the mold until after the copper has been alloyed with the steel. It is well known that chromium and copper are natural repellants, and we also find that during the alloying of the copper and steel in the reducing atmosphere, there is formed upon the surface of the master pattern or matrix a film of silicide which effectually prevents the brazing of the pattern and mold together. This protecting film may obviously be formed upon a master pattern containing silicon by subjecting it to heat treatment as above described, and either before it is placed in the receptacle with the divided steel or simultaneously with the alloying process.

Where the finest character of product is unnecessary, we find that the percentage of copper may be reduced to as low as 20% of the steel, and that an alloy comprising steel and copper in that ratio is susceptible to hardening treatment by heating and quenching.

While we have described our invention in detail for the purpose of clearness it is to be understood that the words which we have used are words of description and not of limitation and that changes within the purview of the appended claims may be made without departing from the true spirit of our invention in its broadest scope.

What we claim is—

1. The process of forming a mold or the like which comprises impressing the pattern into a mass of metal particles of sufficient fineness to be relatively arranged by the details of the pattern, and thereafter cementing the particles together with an alloy structure by another metal.

2. The process of forming a mold or the like which comprises impressing the pattern into a mass of metal particles of sufficient fineness to be relatively arranged by the details of the pattern, and thereafter introducing a filling metal into the voids of said mass to permanently preserve the arrangement of the particles.

3. The process of forming a mold or the like susceptible to hardening by heat treatment which comprises impressing the pattern into a mass of particles of sufficient fineness to be relatively arranged by the details of the pattern and of a metal adapted to be hardened by heat treatment, and thereafter introducing a filling metal into the voids of said mass to permanently preserve the arrangement of the particles.

4. The process of forming a mold or the like susceptible to hardening by heat treatment which comprises impressing the pattern into a mass of divided iron having a carbon content adapting it to be hardened by heat treatment and comprising particles of sufficient fineness to be relatively arranged by the details of the pattern, and thereafter combining the iron with copper in a reducing atmosphere at a temperature below the melting point of the iron to permanently preserve the arrangement.

5. The process of forming a mold or the like susceptible to hardening by heat treatment which comprises compressing separate particles of iron having a carbon content adapting it to be hardened by heat treatment into a coherent mass bearing an impress of the desired pattern, and thereafter subjecting the mass to heat treatment in contact with copper in an atmosphere of hydrogen.

6. The process of forming a mold or the like susceptible to hardening by heat treatment which comprises forming a pattern of steel containing silicon and chromium, compressing particles of iron, having a carbon content adapting it to be hardened by heat treatment, into a coherent mass carrying the pattern and impress thereof, and thereafter subjecting the whole to heat treatment in contact with molten copper in the presence of hydrogen.

7. The process of forming a pattern of the character described which comprises constructing the pattern of a composition containing iron and silicon and thereafter subjecting it to heat treatment in the presence of hydrogen to form a film of silicide on the surface thereof.

8. The process of forming a pattern of

the character described which comprises constructing the pattern of a composition containing iron, silicon and chromium and thereafter heat treating in the presence of hydrogen to form a film of silicide on the surface thereof.

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