METHOD OF MANUFACTURING HOLLOW PISTON CORES
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This invention relates to the manufacture of pistons and in particular to a method of forming a unitary shell type sand core for use in the casting of aluminum pistons.

It is conventional in the automotive industry to cast aluminum pistons using permanent metal molds and cores. The outside contour of a piston is formed by means of an iron or steel mold against which the aluminum is cast and the interior surfaces of the pistons are formed by the surfaces of a five-piece steel core. This method of casting aluminum pistons is satisfactory. However, it requires the use of relatively complicated equipment to remove the five-piece cores from the cast piston.

The recently developed techniques in foundry practice employ thin-walled dispensible molds and cores composed of sand and a plastic binder. These procedures are frequently referred to as shell molding processes and are particularly suited for the production of precision castings of a wide variety of metals.

Essentially the shell molding process consists of using a thermosetting plastic or resin as a binder for sand grains to form thin-walled structures for use as molds and cores. The molding material which is generally a dry mixture of a major proportion of silica sand and a minor proportion of a thermosetting binder, is used in powder form. Phenolic-formaldehyde and melamine-formaldehyde resins are typical examples of suitable thermosetting binders which may be used. The sand employed is preferably free of metal oxides, clay, moisture and organic matter.

These sand resin or cores are prepared by allowing the dry mixture of the sand and the resin powder to come in contact with a hot metal mold for a short period of time. A layer of the mix adheres to the metal surface due to the heating of the resin which entraps the sand with which it is intimately mixed, thereby accurately producing the pattern or mold detail. Metal patterns must be employed because they are necessarily subjected to elevated temperatures. Pattern temperatures in the range of between 250° to 350° F. are typical but higher temperatures up to 800° F. may be advantageously employed under particular conditions. The pattern temperature and the length of time the molding material is allowed to remain in contact with the hot metal surfaces determines the resulting thickness of the shell mold or core. Mold buildup time may range from a few seconds to approximately one minute for various applications.

After this short time interval, the excess dry sand and resin are removed, and the closely adhering sand and resin layer is preferably cured by heating it to a temperature within the broad range of about 300° to 1300° F. for a period of time ranging from a few seconds to about five minutes, while in contact with the molding surface. This baking operation results in the conversion of the resinous material to a hard insoluble binder which securely binds the sand grains together. After the removal of the pattern and mold or core from the curing oven, the mold or core is stripped from the pattern. The formed molds or cores are in effect shells which have sufficient strength and rigidity to make them suitable for casting operations.

A principal object of this invention is to provide an inexpensive process for rapidly and conveniently forming hollow sand-resin cores for high production use in the casting of aluminum pistons and the like. A further object of the invention is to provide a core forming process which will produce accurate shell type cores for use in casting aluminum pistons wherein the formed thin-walled cores possess good dimensional stability, satisfactory gas permeability, smooth surfaces and adequate strength.

In general, these and other objects are carried out by providing a core box having a cavity of dimensions and configuration substantially identical to the inner contour and dimensions of the piston to be subsequently formed. The cavity is also provided with a configuration for defining a pair of spaced core halves which is provided with vents leading from outside the core box to the core print defining portions of the cavity. The cavity is further provided with an opening leading from outside the core box to the base of the cavity or to the base of the core to be subsequently formed therein. The cavity surfaces of the core box are maintained at a suitable temperature in the range of from 250° to 800° F. Thereafter a shell molding sand-binder mixture is blown into the cavity through the opening. The sand-binder mixture is permitted to remain in contact with the heated core box surfaces for a time sufficient to form a partially cured self-sustaining shell core having a predetermined thickness thereabout. The remaining uncured sand-binder mixture is then blown out of the cavity by applying air pressure thereto through the core print vents. The core box is then subjected to heating in a broad range of about between 300° to 1300° F. for a predetermined time to complete the cure of the partially cured shell.

Other objects and advantages of this invention will be more fully apparent from the following description of the process embodying the present invention, reference being made to the accompanying drawings in which:

FIGURE 1 is a vertical sectional view of a metal core box associated with a sand magazine of a sand blowing apparatus, suitable for making a shell type sand-resin core for use in molding aluminum pistons.

FIGURE 2 is the apparatus shown in FIGURE 1 in the process of being rotated 180°.

FIGURE 3 is a view of the core box shown in FIGURE 1 rotated 180°, wherein the sand magazine of the sand blowing apparatus has been replaced by a sand receiving receptacle.

FIGURE 4 is a cross sectional view taken along line 4—4 of FIGURE 3.

Referring more particularly to the drawings which show a core forming apparatus suitable for practicing the process of the present invention, reference is made to FIGURE 4 which includes a core box having two mating halves 10 and 12, pivotally mounted for rotational movement by ball and socket connections 14 and 16 associated with a frame means (not shown).

The core box includes a cavity 18 having a configuration and dimension substantially identical to the inner contour and dimensions of the piston to be subsequently formed. The cavity includes oppositely disposed annular portions 20 and 22 which together with vent plugs 24 and 26 respectively inserted in openings 25 and 27 respectively of the core box define a core print configuration extending from the wrist pin opening portions of the piston core to be formed in accordance with the present invention. The vent plugs 24 and 26 may be of any suitable material such as porous metal or of any suitable form well known in the art. FIGURE 4 shows the core box in a position such that the cavity defines the contour of a piston core in a vertical position and has an opening 28 at the base thereof.

The process of the present invention will now be described in sequential steps. FIGURE 1 shows one of the core box halves 10 in an inverted position. It is to be understood, of course, that in the practice of the process both halves of the core box are used, only the one half
The sand/magazine 30 is first filled with a suitable shell molding sand-binder mixture which may suitably consist of about 95% silica sand such as Clayton sand and 5% of a potentially thermosetting resin such as the novolak form of a phenol-formaldehyde resin together with a curing agent such as hexamethylene tetramine and a small amount of ferrous metal. The sand-binder mixture 30 is clamped over the opening 28 of the core box and is maintained thereon for rotational movement therewith. It is to be understood that the present invention does not reside in the use of any particular sand-binder mixture per se and any suitable shell molding sand-binder mixture well known in the art may be used. Preferably the sand and resin are thoroughly mixed in a manner such that potential thermosetting resin binder coats each sand particle.

The core box which is provided with means for heating the cavity surfaces thereof, preferably in the form of electric strip resistant heaters (not shown) embedded in the walls thereof, is heated to a temperature ranging between 250° and 800° F. depending on the type of sand-binder mixture used and the thickness of the core walls desired. In the specific example described herein, a core cavity surface temperature of about 450° F. has been found to produce satisfactory results.

After the magazine 30 has been molded with the sand-binder mix and clamped to the core box as is shown in FIGURE 1, air is applied to the column of the sand-binder mix in the sand magazine 30 at a pressure preferably in the order of 15-20 pounds per sq. inch with the result that the dry sand-binder mixture is blown into the core box cavity 18 through the opening 28. In accordance with the embodiment of the invention shown in the drawing, the core box and sand magazine are rotated as shown in FIGURE 2 about the axis defined by the ball joint connections 14 and 16 through an angle of at least 180° whereby the sand-binder mix is deposited evenly over the cavity surfaces. During the course of the movement of the core box through 180°, the core box cavity is substantially filled with the sand-resin mix. The sand-binder mixture begins to cure as soon as it strikes the cavity surfaces due to the heat imparted to it from the heated cavity surfaces. The sand-resin mix is permitted to cure for a predetermined time sufficient to partially cure the binder adjacent the core box surfaces to form a relatively thin shell core 31 as indicated by broken lines in FIGURE 3 of a predetermined thickness adjacent the core box cavity. The thickness of the shell core may be controlled by a variation of the curing time and the specific binder used. In the specific example described herein, a curing time of from 5 to 8 seconds has been found to produce satisfactory results.

While the aforementioned curing operation takes place, the sand magazine 30 is removed and a suitable receptacle 32 as shown in FIGURE 3 is clamped to the base of the core box 10 over the opening 28 thereof. As soon as the sand-resin mix within the core box cavity has been permitted to cure to the above described predetermined degree, air under pressure is applied to the vents 24 and 26 by means of air nozzles 34 and 36 whereby air under pressure is admitted to the core box cavity 18 to blow or flush out the remaining uncured sand-binder mixture with the result that only a shell core of a predetermined wall thickness remains in the core box. The remaining uncured sand-binder mix is flushed out of the core box cavity, the core box cavity surfaces are subjected to further heating in the order of 300° to 1300° F. for a period of time ranging from a few seconds to 5 minutes, whereby the partially cured shell core is thoroughly cured. Thereafter the core box halves are opened and the shell core is removed therefrom. In the manufacture of aluminum pistons utilizing the shell cores described above, ferrous metal parts, as for example steel struts, may be pasted to the core surfaces which in the subsequent casting operations will become a structural member of the aluminum piston and actuate to compensate for the difference in expansion of the aluminum piston and the ferrous metal cylinder. In the manufacture of aluminum pistons the hollow shell core having the steel strut or the like pasted thereto, is placed on a base ring for location between the halves of suitable ferrous metal molds. The molds are closed about the hollow core and preferably vacuum is applied to the opening 28 at the base of the core. The aluminum is poured into the mold and around the shell core. The vacuum applied to the base of the core has the effect of ejecting the gases formed by the hot aluminum and permits improved fluidity of the aluminum at lower pouring temperatures. This is an important advantage since the lower the pouring temperature of the aluminum, the denser and more metallurgically sound the piston casting will be.

The present invention has the advantage of eliminating the complicating casting equipment including the multi-piece metal cores of the prior art and the apparatus necessary to withdraw the complicated multi-piece cores from the cast piston. Moreover since the hollow permeable core enables gases to be withdrawn during the casting operations, the density of the cast piston is of the same density as the core box casting, and there is no “flash” or “heating” required on the aluminum surface. While the present invention has been described by means of a certain example, it is to be understood that the scope of the invention is not to be limited thereby except as limited by the appended claims.

We claim:

1. A process for forming a one-piece hollow core for use in casting a piston, said process comprising the steps of heating the cavity defining surfaces of a core box having internal dimensions substantially identical to the inner dimensions of said piston and including portions corresponding to the wrist pin openings of the piston and having a configuration for the formation of oppositely spaced core prints extending outwardly from said portions and having an opening at the base thereof; blowing a sand-resin mixture into said heated surfaces through said opening; retaining said mixture on said surfaces for a time sufficient to cause the binder to melt, partially cure and form with the sand a self-sustaining shell of predetermined thickness on said surfaces; blowing out the remaining uncured sand-resin mixture from said cavity through said opening by forcing air under pressure through the wall of said core print; subjecting said cavity surfaces to completely cure said partially cured shell; and stripping the shell from the core box.

2. A process for forming a unitary hollow core for use in casting a piston, said process comprising the steps of heating the cavity defining surfaces of a core box having internal dimensions substantially identical to the inner dimensions of the piston and including portions corresponding to the wrist pin openings of the piston and having a configuration for the formation of oppositely spaced core prints extending outwardly from said portions and having an opening at the base thereof; blowing a sand-resin mixture into said heated surfaces through said opening by means of a pressurized magazine containing the sand-resin mixture; retaining said mixture on said surfaces for a time sufficient to cause the binder to melt, partially cure and form with the sand a self-sustaining shell of predetermined thickness on said surfaces; blowing out the remaining uncured sand-resin mixture from said cavity into an exhaust manifold through said opening by forcing air under pressure through the walls of said core prints into said cavity; then subjecting said cavity defining surfaces to heat at an elevated temperature to completely cure said partially cured shell and stripping the core from the core box.

3. A process for forming a one-piece hollow core having an opening on only one side thereof, said process...
comprising the steps of heating the cavity defining surfaces of a core box having internal dimensions identical to the outer surface dimensions of the core to be formed and having a blow opening at the base thereof and a vent opening closed by a gas permeable plug at the surface of said cavity; blowing a sand-resin mixture onto said heated surfaces through said blow opening; retaining said mixture on said surfaces for a time sufficient to cause the binder to melt, partially cure and form with the sand a self-sustaining shell of predetermined thickness on said surfaces; blowing out the remaining uncured sand-resin mix from said cavity by forcing air under pressure through said plug and the adjacent wall of said shell; subjecting said cavity defining surfaces to heat at an elevated temperature to completely cure said partially cured shell, and stripping the shell from the core box.

4. A process for forming a one-piece hollow core for use in casting a piston, said process comprising the steps of heating the cavity defining surfaces of a core box having internal dimensions substantially identical to the inner dimensions of said piston and having an opening at the base thereof and a vent opening closed by a gas permeable plug at the surface of said cavity; blowing a sand-resin mixture onto said heated surfaces through said opening; retaining said mixture on said surfaces for a time sufficient to cause the binder to melt, partially cure and form with the sand a self-sustaining shell of predetermined thickness on said surfaces; blowing out the remaining uncured sand-resin mix from said cavity by forcing air under pressure through said vent plug and the adjacent wall of said shell; subjecting said cavity defining surfaces to heat at an elevated temperature to completely cure said partially cured shell; and stripping the shell from the core box.

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