PERMANENT MOLD FOR USE IN THE MANUFACTURE OF PIPE AND METHOD OF PRODUCING SUCH MOLD

Harold E. Willingham, Sky Drive, Anniston, Ala., 36201


7 Claims. (Cl. 204—37)

ABSTRACT OF THE DISCLOSURE

A method of producing a permanent mold including sand blasting a hollow body, inserting an anode within the same, immersing the mold body and anode in an electrolytic bath, causing current to flow from the body to the anode and then reversing the current to cause the current to flow from the anode to the body by electrically depositing material from the electrolytic bath onto the body.

This is a continuation-in-part application of co-pending application Ser. No. 453,218, now abandoned.

This invention relates to the manufacture of tubular bodies by the successive casting of the same in a permanent mold and utilizing centrifugal force, as opposed to the manufacture of cast tubular bodies in temporary molds of sand or the like and which consequently is a much more laborious, time-consuming and more expensive process.

The invention relates particularly to an improved permanent mold of a type that is particularly adapted for use in the centrifugal casting of soil, water, and other pipe, and to the method of producing such mold for the manufacture of such pipe rapidly, efficiently and economically.

The casting of pipe of iron or other metal in permanent molds is an art widely known and understood and its practice in industry is increasing. Prior to the advent of the permanent type mold for the centrifugal casting of iron pipe, which came into existence about twenty years ago, it was customary in foundries to use molding sand for both the inside and outside configuration of pipe cast in stationary or static molds, and over the years machinery had been developed to make both the molds and the cores for containing the molten metal easier to fabricate. Later came the advent of repeated production of pipe in the same mold utilizing centrifugal force, such molds, involving the use of basic foundation metals, being referred to in the industry as "permanent" molds.

In this process the molten metal is discharged into the interior of a generally cylindrical permanent mold having a roughened mold cavity and by rotation of such mold the introduced metal is caused to spread over the interior of the mold cavity with the thickness of the coating thus produced dependent upon the amount of molten metal introduced. Thus the exterior of the pipe produced is determined by the internal size of the mold, and the internal diameter and thickness of the pipe wall determined by the amount of metal introduced.

The permanent mold reduced the necessity for using sand within the cavity and eliminated the sand core. In the manufacture of cast iron soil and water pipe, a convenient size of the pipe mold is, for example, ten feet in length with a heavy wall thickness between two and three inches and with an inside diameter of a size to form the outside diameter of the pipe being manufactured. The more common ranges of inside of the mold diameter, in the example being considered, is from 2½ up to 12 inches and although there are many other sizes these are the most frequently used sizes. When desired, in order to provide a bellmouth at one end of the pipe of a size to receive the opposite end of an adjacent pipe, a plug or partial core of appropriate size and shape is cast in the end of the rotatable mold and fastened in a fixed relation thereto so that as the molten metal is introduced into the mold cavity it will flow along the cavity into the area between the mold and the plug and provide the configuration of the bellmouth on one end.

While the molds heretofore in use have been generally designated as permanent molds, they have been subject to certain inherent weaknesses and undesirable characteristics which interfere with and impose undesirable limitations on the manufacture of pipe including accretion of metal and removal of the casting from the mold, as well as the development of heat lines and cracks, flaking and dislocation of portions of the inner wall of the permanent mold as well as the erosive or wearing away of the basic metal of the permanent mold. This results in the frequent need for disassembly of the casting machine for repair of the permanent molds and even frequent discard of the same after it becomes no longer economically feasible to continue their use. In the manufacture of cast iron pipe and other tubular bodies involving the use of permanent molds, the action of the molten metal at approximately 2700° F. against a permanent mold having a temperature of approximately 400° to 600° F., produces a thermal shock or series of cycles of repeated chilling and heating of the permanent mold resulting in the defects and weaknesses above-mentioned.

One of the defects which was very noticeable and troublesome was the gradual removal, dislocation or wash-out of a depression in the mold cavity in the area where the white hot metal came into contact with the mold wall. When this wash-out or depression became sufficiently large and deep molten metal was introduced into the mold cavity to cast a pipe, a convex projection or protruding bulge in the pipe was formed within the depression. After cooling and contracting, the protruding bulge still exceeded the slight taper or draft angle of the mold cavity and made it difficult and sometimes impossible for the pipe to be shaped and mounted at one end of the mold cavity. It was then necessary to scrap the mold or to enlarge the bore or mold cavity to a size to cast a larger diameter pipe, whichever was most practical.

Also, when the molten metal was introduced into the mold, it caused localized expansion and contraction of the interior of the mold which resulted in the development of longitudinal cracks in the inner surface thereof. These cracks weakened the inner surface and subsequent expansion and contraction caused the internal stresses of the mold to lengthen and deepen the weakened...
area until the crack was large enough for the molten metal to flow into the same and form a flashing on the molten metal being introduced thereinto, provide an insulation for the cylindrical body from the heat of the molten metal, and disperse or prevent the formation of relatively long or deep cracks thereby facilitating the release and removal of cast pipes from the mold.

Other objects and advantages of the invention will be apparent from the following description taken in conjunction with the accompanying drawing in which:

FIG. 1 is a perspective view illustrating one application of the mold in use;

FIG. 2, an enlarged section of the mold on the line

FIG. 3, a sectional view of the mold illustrating the cleaning step;

FIG. 4, a view similar to FIG. 3 illustrating the electroplating step;

FIG. 5, an enlarged fragmentary section through the surface of the mold cavity illustrating a partial build-up of plating material during the electroplating step;

FIG. 6, a view similar to FIG. 3 illustrating the finned surface configuration of the mold cavity at the completion of the electroplating step and;

FIG. 7, a sectional view of the plated mold illustrating the heat treating step to relieve internal stresses.

With continued reference to the drawing, a permanent type centrifugal mold indicated generally at 10 includes a hollow generally cylindrical body 11 having an inner bore or mold cavity on which a plating of chromium or other hard material 12 is caused to adhere and be integrally bonded in a manner to produce a diverse irregular mosaic nodular surface 13. The mold body 11 may be in the form of a tube of any desired length with the wall of the tube being relatively heavy as, for example, between two and three inches in thickness and with the inner bore or mold cavity being of a size complementary to the outside diameter of the pipe to be manufactured. The wall thickness of the pipe to be manufactured is determined by the quantity of molten metal introduced into the mold cavity at the time the cast is made.

The mold body 11 may be new and unused or may be a used mold which has been in service in the casting of pipe or other tubular bodies. In a new mold, after the mold body is cast or otherwise formed with a slight taper or draft angle extending the full length of the mold cavity, all interior surface irregularities or projections are removed in any desired manner, as by machining with a boring bar or using an abrasive boring head or the like. When a used mold is to be plated, such mold is repaired by filling any cavities, depressions or cracks in any known manner, as by welding or the like, after which a boring bar or head is utilized to remove any surface irregularities.

The mold 10 is adapted to be rotated in any well known manner during the preparation and plating of the same, as well as during the casting of a pipe or other generally cylindrical object 14. As illustrated, in order to rotate the mold the body 11 is supported by a plurality of spaced rollers 15 carried by support members 16. Certain of the rollers 15 may be freely rotatable while one or more of such rollers may be mounted on a shaft 17 having a pulley or sprocket 18 thereon which is driven by a belt or chain 19 from a second pulley or sprocket 20 mounted on a gear reduction 21 which in turn is driven by a motor 22. When the motor is operated at least one of the rollers 15 will be driven to cause rotation of the body 11. Preferably either the gear reduction or the motors 22 or both are variable in a conventional manner (not shown) so that the body 11 may be rotated at any desired rate of speed.
If desired, the sprocket 20 may be driven by a direct current motor which can rotate such sprocket at any desired number of revolutions per minute.

In the instance of the invention the conventional permanent type centrifugal mold body 11, which may be provided with an enlargement or bellmouth 23 at one end, is mounted on the rollers 15 and slowly rotated. As illustrated in FIG. 3, a tube 25 having an offset nozzle 26 is introduced into one end of the mold cavity of the body 11 and a grit of sand, aluminum oxide, or other abrasive material 27 is forced through the tube 25 and the nozzle 26 under pressure and discharged against the inner surface of the foundation metal of the mold cavity to roughen the same and remove any foreign particles. The size of the grit or abrasive material, as well as the pressure, is predetermined and variable in accordance with the diameter of the pipe being molded.

For example, in the manufacture of 3 inch I.D. pipe it is desirable to have a surface roughness of 80 to 100 on the RMS (root mean square) scale, and this is accomplished by providing an 80 mesh grit and blasting such grit against the surface of the mold cavity at a pressure of approximately 80 p.s.i. For a 4 inch I.D. pipe a finish of approximately 100 to 125 on the RMS scale is desirable and this can be obtained by using an 80 mesh grit under a pressure of 150 p.s.i. The range of 8 to 10 inches I.D. are to be processed, a finish in the range of 200 to 250 on the RMS scale is desirable, and this can be obtained by using 16 mesh stellite shot. When the stellite or other metallic shot is used, it has a tendency to leave a deposit of slivers within the depressions formed in the mold cavity and it may be desirable to lightly sand-blast the mold cavity after the shot has been used to remove any excess slivers and to otherwise clean the surface depressions. The roughness of the mold cavity is important since the nodular surface 13 of the plating 12 is directly related to such roughness. The nodular surface must be sufficiently rough to pick up molten metal during the cast and simultaneously must be smooth enough to permit contraction of the metal to pull away from such surface when the metal cools.

Instead of grit or other abrasive material being forced through the pipe 25 and nozzle 26, the cavity of a relatively large mold body may be cleaned and roughened by an abrasive wheel or disk, by a rapidly rotating abrasive belt, by a rough machining or boring process, or by rapidly rotating any cleaning method which will obtain a roughness in the range of 200 to 250 on the RMS scale is acceptable since normally a light sand-blasting of the cavity will follow to clean the surface depressions and remove any slivers or other deposits.

After the abrasive blasting or cleaning step the nozzle 16 is inserted substantially entirely through the mold cavity and is slowly withdrawn at a constant rate, while the body rotates until the nozzle is entirely withdrawn from the cavity. Thereafter the nozzle is inserted in the opposite end of the cavity and the step is repeated. The abrasive blasting step thoroughly cleans the surface of the mold cavity and conditions the same for the reception of the plating material. After the abrasive blasting step has been completed, any excess grit is removed from the cavity in any desired manner, as by a vacuum, the introduction of a solvent, or in any other well known manner. It is noted that in certain cases, particularly with larger mold cavities, the mold body may be fixed and the nozzle 26 or other cleaning and roughening member may be rotated while traversing the length of the mold cavity.

In the event the body 11 has been exposed to the atmosphere for a considerable period of time, a coating of rust may have formed on the inner and outer walls of the mold. This coating may be removed in any well known manner, as by the process known as pickling in an acid bath prior to the sand-blasting of the mold cavity.

After the mold cavity has been thoroughly cleaned, an anode 30 (FIG. 4) is placed concentrically within the mold cavity of the body 11 to extend throughout its entire length and in close proximity thereto. Thereafter the body 11 and the anode 30 are placed within a tank 31 and immersed in an electrolytic bath 32 having chromic acid therein. The anode 30 and the body 11 are electrically connected to a generator 33 which preferably is of the reversible type or is provided with some means for reversing the normal flow of electrical energy through the anode 30 and the body 11. As soon as the anode and the body have been immersed and connections to the generator have been established, the generator is energized to cause current to flow in a direction reverse from its normal flow or from the body 11 to the anode 30 for a period of approximately 50 seconds. During this operation the body 11 functions as an anode and the anode 30 functions as a cathode to remove any residual oxides from the body and to form a light etch thereon and thereby make the body more receptive to the chromic plating. It is noted that a current of 2 amperes per square inch of surface area of the mold cavity has been found satisfactory. Also, care should be taken not to reverse the current for too long a period of time or a carbon deposit is likely to form on the surface of the mold cavity, and such carbon deposit would be detrimental in the adhesion of the plating material.

After the current has been reversed for approximately 50 seconds the generator is energized in a normal direction so that the anode becomes the anode and the body 11 becomes the cathode, under which conditions an electric current passes from the anode 30 to the mold body 11 which causes chromium particles suspended in the electrolytic bath to be electrically deposited on, and integrally bonded to, the surface of the mold cavity. Thereafter the plating process continues until a desired thickness of material has been deposited on the body 11. As a general rule, the transfer of material from the electrolytic bath to the cathode will take place at the rate of .001 inch per hour. It has been found that although thicknesses of from .001 inch to .005 inch are satisfactory, a working range of from .006 inch to .015 inch is preferable for economic reasons. Normally during an electroplating process, the anode will slowly disintegrate due to the combination of the passage of the electric current, the action of the acid in the electrolytic bath, and the attack of oxygen which gravitates to the anode during the process. The anode usually is made of lead since the lead particles which become detached from the anode will not contaminate the electrolyte. However, due to the length of the mold cavity, a lead anode would sag so that it would not be concentric for its full length and would result in uneven plating. Accordingly, the anode is constructed of a relatively hard electro-conductive material such as steel. Any steel particles which become detached will remain in suspension within the electrolyte.

Under microscopic examination, it has been found that chromium particles from the chromic acid of the electrolyte will build up at a faster rate on the nodular hills or projections disposed closer to the anode than in the valleys or depressions as illustrated in FIG. 5. This phenomenon causes the inner surface of the mold to be built up of a series of knobs or nodes which continue to grow and spread laterally until they join together in the valleys (FIG. 6) to form a diverse, irregular, most often nodular, highly reflective surface having a very low coefficient of friction. During the transfer of the plating material, hydrogen gas will gravitate to the cathode and oxygen gas will gravitate to the anode. Some of the hydrogen gas bubbles will become entrapped in the chromic plating and must be removed in a manner which will be described next. After the desired thickness of plating has been formed on the mold body, such body is removed from the tank 31 and rinsed.

The hydrogen bubbles entrapped within the plating are highly explosive when subjected to high heat which would
cause fractures or fissures in the plating when molten metal is introduced into the mold for the formation of pipe. In order to relieve the hydrogen bubbles, the mold body which has been plated is heat treated by slowly heating the same until the chromium plating reaches a temperature of at least 350° F. After reaching the desired temperature, such temperature is maintained for approximately one hour per thousandth inch of plating thickness, which causes the hydrogen bubbles to dissipate thereby relieving any stress within the plating 12. The mold body may be heated in any desired manner, as by mounting the body on the rollers 15 and slowly rotating the same while a relatively long pipe 35 (FIG. 7) having a gas burner 36 is introduced into the mold cavity and moved back and forth along the axis of the mold cavity. If desired the mold body may be heat treated to relieve stress in any other manner, as by placing the mold body in an oven and raising the temperature to the desired heat after which the temperature is maintained for the required time. The oven may be disposed in either a horizontal or vertical position.

Thereafter the mold can be placed in service for the centrifugal molding of pipe. Before molten metal is introduced into the mold cavity, a plug 37 is fitted into the bellmouth and secured to the end of the mold body 11 in any manner. The plug 37 is concentrically spaced from the mold cavity and defines the inner configuration of the bellmouth which receives the small end of the next pipe. If desired, a slurry of diatomaceous earth can be introduced into the pipe to act as a release agent and assist in the withdrawal of the molded pipe from the mold body. Also the diatomaceous earth will function as an insulator to control the chill of the pipe being cast since the heat of the molten metal coming into contact with a relatively cool mold cavity may cause the metal of the pipe to become brittle due to the rapid cooling thereof. This is particularly true of pipe which will be used in the formation of soil or sewage lines and therefore is not annealed. When a pipe is to be used as a pressure pipe, such as in the construction of a water line or gas line, such pipe will be annealed immediately after being formed and therefore the diatomaceous earth may be omitted and the molten metal poured directly onto the chromium plating within the mold cavity. Due to the hardness of the plating, as well as the highly reflective surface thereof, a substantial portion of the heat of the molten metal will be lost and will not pass to the metal of the mold body 11. Also the nodular construction of the surface of the plating will cause a substantial increase in the total surface area of the mold cavity and will spread the heat over a greater area and substantially prevent the formation of cracks or other fissures in the mold cavity. Due to the nodular and irregular surface configuration of the chromium plating, any cracks which tend to form will generally follow the valleys and will be dissipated before they reach harmful proportion.

When the molten metal is introduced into the mold cavity the valley or depression of the metal surface will receive the molten metal and carry the same upwardly in an orbital path when the mold body is rotated at a relatively high speed. The molten metal, which normally is approximately 2700° F. and while hot, will be distributed jointly by centrifugal force and the carrying capacity of the matte plating over the surface of the mold cavity and at a substantially uniform predetermined thickness in accordance with the amount of molten metal introduced into the cavity. As soon as the molten metal is discharged into the mold cavity, it begins to cool and solidify. Rotation of the mold body continues until the entire mass of metal has solidified and the color of the metal has changed to a dull red, after which the mold is halted and the pipe removed. The cooling and solidifying of the molten metal causes a slight contraction of the metal of the pipe which permits the pipe to be withdrawn axially of the mold. Since the metal of small pipes will contract a lesser amount than the metal of larger pipes, it is necessary that the nodular surface of the plating on the mold cavity be smaller than the nodular surface of larger molds so that the metal of the pipe will contract sufficiently to be withdrawn. It is noted that during the withdrawal of the pipe from the mold cavity minute particles of the chromium plating may erode away from the surface of the mold cavity and cling to the pipe thereby eventually removing the plating.

When the plating has been substantially reduced the mold can be taken out of service after which the plating can be stripped from the mold cavity and a new plating can be applied thereto in the manner above described.

It will be obvious to one skilled in the art that various changes may be made in the invention without departing from the spirit and scope thereof and therefore the invention is not limited by that which is illustrated in the drawing and described in the specification, but only as indicated in the accompanying claims.

What is claimed is:

1. The method of producing a permanent type centrifugal mold for use in the centrifugal casting of tubular metallic bodies comprising the steps of providing a permanent type centrifugal mold body having an inner surface defining an inner portion of said mold cavity, said mold cavity concentrically within said mold cavity, providing an electrical generator means electrically connected to said mold body and said anode, immersing said mold body and said anode in an electrolytic bath, providing a reverse mechanism for reversing the flow of electrical energy from said generator, energizing said generator to cause current to flow from said mold body to said anode, operating said reversing mechanism to cause current to flow from said anode to said mold body to electrically deposit material from said electrolytic bath onto the surface of said mold cavity, electroplating said mold cavity within a range of .006 inch to .015 inch and providing a diverse, irregular, mosaic, nodular surface having a very low coefficient of friction, and heat treating said electroplated material on said mold cavity to relieve stress, whereby said electroplated surface will reduce friction and will reduce and disperse cracks caused by internal stress when molten metal is introduced into said mold cavity.

2. The method of claim 1 including the additional step of applying a cleaning agent to said mold cavity after the cleaning step.

3. The method of claim 1 in which the heat treating step includes heating said electroplated material to an elevated temperature of substantially 350° F.

4. The method of claim 1 including the additional step of providing relative rotation between said mold body and said anode.

5. The method of producing a permanent type centrifugal mold for use in the centrifugal casting of tubular bodies comprising the steps of providing a permanent type centrifugal mold body having an inner bore defining a mold cavity, subjecting the entire surface of said mold cavity to an abrasive material to clean such surface and to provide a predetermined roughness, providing an anode having an external configuration substantially complementary to the surface of said mold cavity, mounting said anode concentrically within said mold cavity and in spaced relation thereto, connecting said anode and said mold body to a source of electrical energy, immersing said mold body and said anode in an electrolytic bath, causing an electric current to flow from said mold body to said anode for a short period of time, thereafter causing an electric current to flow from said anode to said mold body for an extended period of time to electrically deposit
material from said electrolytic bath onto the surface of said mold cavity to provide a diverse irregular mosaic nodular surface having a very low coefficient of friction within said mold cavity.

6. The method of claim 5 including the additional step of heat treating said electroplated material on said mold cavity to relieve stress.

7. The method of claim 6 including the additional step of rotating said mold body during said cleaning and heat treating steps.