A vibration-preventive centrifugal casting apparatus. The apparatus includes a mold shell adapted to be rotated for centrifugal casting and a cylindrical liner of a novel construction which is fitted into the mold shell. The liner is designed so that its outer surface will be spaced a minute distance from the inner wall of the mold shell when fitted therein. The outer surface of the liner has an uneven configuration which will provide discontinuous contact with the inner wall of the mold shell when the liner is thermally expanded. The discontinuous contact serves to retard the transmission of heat from the liner to the shell by conduction.

2 Claims, 3 Drawing Figures
VIBRATION-PREVENTIVE CENTRIFUGAL CASTING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to an improved vibration-preventive centrifugal casting machine.

2. Description of the Prior Art

The typical construction of a conventional centrifugal casting machine used for casting a roll consists essentially of a metallic mold shell formed with a pair of annular rings running around the outer periphery of the mold shell, the rings being positioned at the opposite ends of the mold shell and integral therewith; and two pairs of rollers, each pair of which is designed to carry or support one of the aforementioned rings thereon, the rollers being mounted on drive shafts which in turn are journaled in roller bearings of a conventional type.

It is customary that the mold shell of the machine is rotated at a very high R.P.M. with a melt being introduced into the cavity of the shell to produce a cast metal roll. However, such machines commonly have vibration problems which cause defective castings.

The factors responsible for such vibrations involve many complicated considerations, however, they may generally be classified into two categories, i.e., (a) mechanical unbalance or non-integrity in construction and (b) distortion in various parts of the machine due to heat transmitted from the melt being cast therein.

Most of the prior art attempts to overcome the vibrational problem were directed to the factors of category (a). Such attempted solutions were directed to, for example, unstable machine foundations, unbalanced mold shells, defective parallelism of two roller drive shafts or possible deflection of roller drive shafts during rotation, dimensional variation in the diameters of the two annular rings on the mold shell and in the diameters of the four rollers which carry the annular rings thereon, wear of the annular rings and rollers, resonance in the casting machine, etc.

The above-outlined prior attempted solutions were directed to relatively simple mechanical problems; nevertheless, they have met only partial success. The frequent repair of the machine rollers, such as by grinding to accurate dimensions, is still required. Furthermore, many of those prior attempts were indirect measures such as providing rubber layers on the rollers to absorb the vibration. The use of such a rubber layer incurs further problems arising from the high R.P.M. of the mold shell which is essential to this type of casting and from the heat and friction. Such rubber-layered rollers have failed to provide long periods of service.

SUMMARY OF THE INVENTION

Briefly stated, the subject invention involves two means for the reduction of vibration in a centrifugal casting apparatus. The first is a metallic liner which is adapted to be fitted in a mold shell, designed so as to be normally spaced a minute distance from the inner wall of the mold shell, the liner having an outer peripheral surface facing the inner wall of the mold shell and, when expanded, having discontinuous contact therewith. The liner is designed to retard heat transmission from the melt being cast to the outer mold shell and in turn to the annular rings thereon and eventually to the rollers supporting those rings. It has been discovered that the abrupt expansion of the shell rings and supporting rollers due to the heat being thus transmitted is the cause most contributing to vibration, because the rings, when expanded, deform due to temperature variations. The second means is a system wherein lubricating oil is circulated through circuits which incorporate lubricant temperature adjusting means, e.g., a heat exchanger, and an oil flow regulator which respond to changes in bearing temperature.

The novel metallic liner has an outer cylindrical surface that is corrugated or knurled or provided with another uneven configuration. Accordingly, discontinuous contact between the outer peripheral surface of the metallic liner and the inner surface of the mold shell results when the former is thermally expanded due to the heat transmitted from the melt. As can readily be appreciated by those skilled in the art, this provision will prevent or retard abrupt temperature changes in the shell, in the annular rings on the shell, and therefore in the rollers in contact therewith.

Some heat from the melt is transmitted from rollers through the shafts to the bearings. Additional heat is transferred to the bearings by radiation from the surface of the mold shell. The temperature of the bearings determines the bearing clearance so that even a slight temperature rise will necessarily affect the bearing clearance. Additional heat is generated within the bearings by friction with the bearings when rotated at a high R.P.M. The lubrication system is designed to remove heat from the bearings to maintain the bearings at a relatively low temperature.

Accordingly, it is an object of the present invention to minimize the vibration in a centrifugal casting apparatus caused by heat developed distortions in the annular rings and roller shaft bearings.

More specifically, it is an object of the invention to solve the vibration problem by eliminating or retarding abrupt temperature changes in various components of the casting machine.

It is another object of the present invention to provide a metallic liner of a novel construction to this end.

It is still a further object of the invention to maintain proper bearing clearance by controlling the bearing temperature by means of controlling the temperature and flow rate of the lubricant being fed to bearings.

Additional objects, features, and advantages of the present invention will become apparent to those skilled in the art from the following detailed description and the attached drawings, which illustrate the preferred embodiments of this invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic view of the outline of the centrifugal casting machine of the present invention, showing an oil circulating system.

FIG. 2 is a cross-sectional view of the mold shell or mold body of the centrifugal casting machine of the present invention.

FIG. 3 is an enlarged fragmentary cross-sectional view, taken along line 14—14 of FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, a centrifugal casting apparatus is shown as including a shell or mold body 1 of cast steel. Running around the outer peripheral surface of
the mold shell 1 are a pair of annular rings 2 integral therewith and located at the opposite ends of the shell 1. The rings 2 of rotatable mold shell 1 are each supported on two pairs of rollers 3 which are mounted on two shafts 7. The shafts 7 are journaled in bearings 6, i.e., four pairs of bearings. The lubricant circulates through a system which includes a pump 5, a reservoir 4, a flow rate regulator 8 and a heat exchanger 9 adapted to control the temperature of the oil being circulated.

Turning now to FIG. 2, there is shown a cross-sectional view of the mold shell 1 and the supporting roller assembly. The cavity of the shell 1 is divided into three sections cylindrical in shape, i.e., two identical recessed sections located at opposite sides and having the same diameter 12 and a middle section having a smaller diameter than that of the former. Shown at 13 is a metallic liner of a cylindrical shape which is fitted in the mold shell 1 but spaced a minute distance from the inner wall of the shell 1. The liner 13 is formed with a flange portion 19 at one end thereof, which flange is designed to abut the shoulder of the middle section of the shell. A bolt or pin 10 is provided to secure the flange 19 to the side of the shoulder of the middle section of the shell. The bolt 10 will be subjected to a shear stress when the liner 13 is expanded by heat from the melt when introduced therein; therefore, the bolt 10 should have a loose fit in the flange 19, with a predetermined clearance between the bolt and the hole through which the bolt extends. Alternatively, to allow for thermal expansion of the liner, any conventional fastening provision may be adopted, and thus the bolt may be attached in a direction radial to the inner wall of the shell.

Fitted in the recessed sections at opposite ends of the shell are sand molds 11 which provide roll holders for the cast roll. One sand mold 11 is positioned adjacent to the outer side of the flange 19 at one end of the liner 13, while the other sand mold abuts the other end of the metallic liner 13. This metallic liner 13 may be replaced with an identical liner or with a liner having a different wall thickness but the same outer diameter. Thus, a roll body of a different diameter may be produced merely by replacing liner 13 with one of the appropriate wall thickness. The thickness of the liner 13 is preferably within the range of 20 to 300 mm because of considerations with regard to strength and thermal characteristics. This feature represents a great savings over old systems that require another separate costly mold shell for casting a roll having a different diameter.

The metallic liner 13 has an outer peripheral surface 15 (FIG. 3) which is in the form of corrugations in cross-section. The apexes of the corrugations are designed to be spaced a minute distance from the inner wall of the shell 1, but will be in contact therewith when the melt is introduced in the cavity causing the metallic liner to expand. Located under the mold shell 1 are two pairs of rollers 3, one roller of each pair being mounted on one of two shafts 7 and designed to carry the annular rings 2 thereon. The shafts 7 are journaled in bearings 6 designed to receive the weight of the mold shell assembly and suited for rotation at a high R.P.M. It should be recognized that, because of the high R.P.M. and the heavy weight of the mold shell, the rollers are subjected to severe loading or service which problem is made more severe when heat is transmitted through the intermediate members from the melt. These forces could cause the rollers to become deformed or to suffer other mechanical failure which would, in turn, produce detrimental vibration or an interruption of the casting operation with the result that the cast roll would be defective.

In operation, when the melt is introduced into the cavity of the mold shell 1 through the cylindrical sand mold 11 with the shell being rotated for centrifugal casting, then the metallic liner is heated by the melt to a high temperature and thus expands. When the metallic liner 13 is so heated, the apexes of the corrugations on the outer peripheral surface 15 of the liner 13 come into contact with the inner wall of the mold shell. As has been described earlier, the corrugations on the outer surface 15 of the metallic liner 13 may be of any form provided there is a discontinuous contact between the inner wall of the shell and the outer peripheral surface 15 of the liner 13. This discontinuous contact will prevent or retard the abrupt heat transmission from the melt to the wall of the mold shell 1. On the other hand, that consideration need not necessarily be given to the sand mold 11, because of the porosity and the greater wall thickness thereof. The design of the liner 13 regards the transmission of heat which might otherwise cause an abrupt expansion of the rings which tends to be an unbalanced expansion of the rings that causes vibration. The design of the present invention, therefore, aids in reducing the vibration of the rotating mold shell.

The bearings are provided with a forced oil circulating means or pump 5, while the housings of the bearings are equipped with thermostats (not shown) for measurement of the temperature of the oil, the thermostats being designed to actuate a heat exchanger 9 and oil flow rate regulator 8.

Tests reveal that the temperature ranges measured for the circumferential temperature variations at the ring surfaces are reduced by the design of the present invention from 35°C to 5°C in a given time lapse after casting. Such test results are evidence of the efficacy of the present invention in the prevention or retardation of abrupt thermal influences by use of the novel metallic liner. The present invention allows use of the centrifugal casting apparatus in continuous casting cycles.

As is apparent from the foregoing, the provisions of the present invention minimize or retard abrupt heat transmission from the melt when introduced into the mold shell to the rings and to the rollers, thus precluding an uneven temperature rise in such parts and resulting in uniform but minimized expansion. Thus, such provisions prevent to a great degree the vibration encountered in conventional casting machines, thus improving the efficiency of the casting operation and the quality of the roll cast. The heat-transmission-retarding or preventive means further permits the casting of metals or alloys having higher melting points than those cases hitherto, thus widening the range of metals and alloys which can be handled by centrifugal casting apparatus. Also, the metallic liner may be replaced with a metallic liner having a different inner diameter but the same outer diameter, thus allowing the production of a roll having a different outer diameter without requiring another mold shell which shells are very costly.
Data obtained from actual use in production shows that the percentage of defective rolls produced is reduced to below 2 percent as compared with over 10 percent for conventional centrifugal casting apparatus.

The invention may be embodied in other specific forms without departing from its spirit or essential characteristics. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the claims rather than by the foregoing description, and all changes which come within the meaning and range of the equivalents of the claims are therefore intended to be embraced therein.

I claim:

1. A vibrationless centrifugal casting apparatus comprising:
   a mold shell adapted to be rotated for centrifugal casting said shell having a raised central section at its inner surface forming shoulders on the inner surface at each end of said central section;
   a cylindrical metallic liner fitted in said mold shell, said liner having an outer surface spaced a minimum distance from the inner wall of said mold shell when fitted therein and said outer surface having an uneven configuration which will provide discontinuous contact with the inner wall of said mold shell when said liner is thermally expanded, said liner having a flange portion at one end thereof and said flange being secured to one shoulder of the central section of said mold shell; and a pair of sand molds mounted within said mold shell and abutting each end of said liner.

2. The apparatus of claim 1 wherein said flange is secured to said one shoulder by means of at least one bolt, said bolt extending through a hole provided in said flange, said hole having a diameter sufficiently large to provide spacing between the outer periphery of said bolt and the circumferential wall of said hole, whereby said bolt will not undergo shear stress created, when said liner is thermally expanded and said bolt being protected from the direct contact with the melt by means of the sand mold.