A water-cooled furnace roll has a hollow rotating arbor, having cooling fluid passages formed therein, wherein the arbor is formed from a heat resistant centrifugally cast alloy, and a plurality of annular tires spaced along said arbor and secured to the arbor, wherein the spaces between the tires is adapted to receive refractory material to insulate the arbor.
1. Field of the Invention

The present invention relates to a water cooled roll for transporting work pieces in heated environments, more particularly, the present invention relates to a water-cooled roll with a heat resistant arbor design for a roller hearth furnace.

2. Background Information

A variety of water-cooled roll designs have been proposed. Samples of earlier water-cooled roll designs are found in U.S. Pat. Nos. 2,085,575; 2,045,773; and 3,860,387. U.S. Pat. Nos. 5,379,829; 5,082,047; and 4,991,276 all disclose a water-cooled roll design with a "flexible" arbor or shaft intended to bend and guide the work piece. The tires are provided with extensions from one side thereof for attachment to the arbor. The tires are also provided with reduced section areas and openings to reduce heat flow from the working support surface of the tire to the arbor. These features combine to form a tire with a complex shape which is not easy to manufacture or assemble in the roll. Further, the bendable shaft construction is not a simple construction, or really a practical solution in a hearth furnace environment.

U.S. Pat. Nos. 5,421,724, 5,370,530, and 5,362,230 disclose roll designs for roller hearth furnaces. A rotary mounted main roll body may be provided with a plurality of spaced tires for contacting and transporting a charge carried by the roll. An internal coolant circulation system is provided within the main roll body. Insulation may be provided around the main roll body.

U.S. Pat. No. 6,638,472 discloses a furnace roll for transporting of a continuously cast stock of a continuously casting plant through a temperature equalizing and heating furnace which includes a rotating arbor supported outside of the furnace and having cooling medium channels provided in its interior, a plurality of tires supported on the arbor and forming a transporting plane for the transported stock, at least one clamping ring provided between a tire and the arbor and formed of metal or alloy having a maximum possible thermal conductivity and susceptible to both cold and hot deformation, and at least one steel sleeve provided sidewise of the clamping ring.

U.S. Pat. No. 6,432,030 discloses a water-cooled roll that includes a hollow rotating arbor with a system for supplying cooling water to the interior of the arbor. Annular tires are spaced along the arbor, each tire including a plurality of recesses spaced along an inner periphery of the tire on opposite sides of the tire. Locking bars are attached to the arbor, each locking bar extending into one recess of one tire. Each tire includes at least two locking bars extending into recesses thereof for rotationally and axially positioning the tire on the arbor. The '030 patent design addresses a number of issues with the prior art designs however it is not designed to accommodate certain system failures that have been known to happen. The other described prior art designs also do not adequately account for similar system failures such as when the surrounding refractory fails or if the water supply to the water cooled roll is interrupted. These system failures are not a problem with the roll design itself, but can still result in an unsuitable warping of the arbor from the heat. A warped arbor requires the entire roll to be replaced. In the prior art designs, when the water cooled rolls having tires and insulation between the tires are operating properly, the arbor or shaft is the coolest part of the roll next to the water supply pipe. The arbor is adjacent to cooling fluid flow, the arbor is insulated from the working environment by insulation between the tires and by the tires themselves, and the tires are formed with minimal arbor contact area to decrease thermal transfer thereto.

There remains a need to improve water cooled roll designs including the associated systems such as the coolant supply.

SUMMARY OF THE INVENTION

It is noted that, as used in this specification and the appended claims, the singular forms "a," "an," and "the" include plural referents unless expressly and unequivocally limited to one referent.

For the purposes of this specification, unless otherwise indicated, all numbers expressing invention parameters used in the specification and claims are to be understood as being modified in all instances by the term "about." Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained by the present invention. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of the number of reported significant digits and by applying ordinary rounding techniques.

All numerical ranges herein include all numerical values and ranges of all numerical values within the recited numerical ranges. Notwithstanding that the numerical ranges and parameters set forth the broad scope of the invention are approximations, the numerical values set forth in the specific examples are reported as precisely as possible. Any numerical value, however, inherently contain certain errors necessarily resulting from the standard deviation found in their respective testing measurements.

The various embodiments and examples of the present invention as presented herein are understood to be illustrative of the present invention and no restrictive thereof and are non-limiting with respect to the scope of the invention.

It is an object of the present invention to improve water cooled roll designs to accommodate system failures such as deterioration of removal of a portion of the refractory insulation or an interruption of the cooling fluid. According to one non-limiting embodiment of the present
invention, the invention provides a water-cooled furnace roll comprising a hollow rotating arbor, having cooling fluid passages formed therein, wherein the arbor is formed from a heat resistant centrifugally cast alloy, and a plurality of annular tires spaced along said arbor and secured to the arbor, wherein the spaces between the tires is adapted to receive refractory material to insulate the arbor.

[0015] These and other advantages of the present invention will be clarified in the description of the preferred embodiments taken together with the attached figures.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] FIG. 1 is a side view, partially in section, of a water-cooled roll according to the present invention;

[0017] FIG. 2 is a side view of a water supply pipe for the water-cooled roll of FIG. 1;

[0018] FIG. 3 is a side view of the water-cooled roll shown in FIG. 1 illustrating the positioning of the water supply pipe within the arbor of the water-cooled roll of FIG. 1;

[0019] FIG. 4 is a section view of the water-cooled roll shown in FIG. 1 taken along line IV-IV illustrating a tire arrangement and tire connection for the water-cooled roll of FIG. 1; and

[0020] FIG. 5 is a section view of the tire arrangement shown in FIG. 4 taken along line V-V illustrating the tire arrangement and tire connection for the water-cooled roll of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

[0021] FIGS. 1 and 3 illustrate a water-cooled roll 10 according to the present invention. The water-cooled roll 10 generally includes a hollow rotating arbor or shaft 12 with a system for supplying cooling water to the interior of the arbor 12, and a plurality of annular tires 14 spaced along the arbor 12. Within the meaning of the present application, the term “water-cooled” is not intended to be limited to water since any cooling fluid may be utilized, as desired. The term refers to a hollow rotating arbor or shaft 12 as well as an internal circulatory passages for cooling material, which is typically water. Consequently, these types of internally cooled rolls are generally called “water-cooled” rolls.

[0022] The arbor 12 is sized to minimize the deflection of the roll 10 under loading by the workpiece. Of course, it is understood that all rolls will deflect, to some extent, under loading, however, the arbor 12 is sized to provide a relatively stiff structure. For example, the outer diameter of the arbor 12 at the position of the tires 14 is about 6" with an inner diameter of about 3". The outer diameter of the left hand side of the arbor 12 is reduced for positioning of the arbor 12 within a bearing assembly (not shown).

[0023] The tires 14 are generally set a fixed distance apart from each other, for example, 10"-12" from centerline to centerline. The tires 14 are generally not positioned symmetrically about the center point of the arbor 12. The center point of the arbor 12 is the centerline of the furnace in which the roll 10 is to operate. This asymmetrical positioning of the tires 14 about the center point allows for staggered positioning of the tires 14 on adjacent rolls 10 in a furnace to help prevent marks on the work pieces. An adjacent roll 10 will have the tires 14 positioned about the center point of the arbor 12 in a mirror image of that shown in FIGS. 1 and 3. These two asymmetric roll designs can be references as right hand and left hand rolls 10, allowing for such right hand and left hand rolls to be alternated throughout the furnace to achieve the desired tire staggering.

[0024] The system for supplying cooling fluid to the interior of the arbor 12 is conventional. The central core of the supply system is shown in FIG. 2 and is essentially a water supply pipe 16 which is positioned within the arbor 12 and spaced from the inner walls thereof by a plurality of spacers 18 on an outer periphery of the pipe 16 to create an annular space between the pipe 16 and the arbor 12. The pipe 16 is not shown in FIG. 1. This configuration allows the cooling water, or other fluid, to flow down the interior of the pipe 16 to slots 28, through the slots 28 and back down the length of the pipe 16 and arbor 12 in the annular space formed there between. Other circulation passage forming cores can be used, but pipe 16 is believed to be efficient and cost effective. The roll 10 may be installed, rotated, and supplied with cooling fluid in a conventional fashion.

[0025] The details of the construction of the tires 14 and the attachment of the tires 14 to the arbor 12 are best illustrated in FIGS. 4-5. Each tire 14 is formed as an annular body having an outer work contacting surface and an inner bore sized to receive the arbor 12 therein. A plurality of recesses 36 are adjacent the inner bore on opposite sides of the annular body. The annular body is tapered from the work contacting surface to the recesses 36, as shown in FIG. 5. Four recesses 36 are positioned on each side of the annular body. Recesses 36 on one side of the annular body are offset from the recesses 36 on the other side of the annular body by about 45 degrees. Other specific numbers of recesses 36 and spacing there between are also possible. Each recess 36 has a pair of generally planar abutment walls on opposed sides of the recess 36 and a substantially planar back wall. The side abutment walls are attached by a curved upper wall. The upper wall is curved to reduce stresses in the annular body. The recesses 36 provide for positioning or attachment of the tire 14 to the arbor 12. Additionally, the recesses 36 serve to reduce the effective width of the annular body to reduce the heat transferred to the arbor 12 from the work contacting surface. A plurality of locking bars 44 are attached to the arbor 12 by welding, as shown by weld rods 46. The arbor 12 is omitted from FIG. 5 for clarity. Each locking bar 44 extends into one recess 36 of one tire 14, abutting against one abutment wall and the back wall 40 for positioning or attachment of the tire 14 on the arbor 12. In general, each recess 36 will have a locking bar 44 extending therein. At a minimum, each tire 14 includes at least two locking bars 44 extending into recesses 36 thereof for rotationally and axially positioning the tire 14 on the arbor 12. Additionally, it will be apparent that, at a minimum, some locking bars 44 will have to be positioned on opposite sides of the tire 14 and against opposed respective abutment walls 38. Many alternative arrangements are possible within the present invention.

[0026] The roll 10 will have refractory material 50 positioned between the tires 14 to provide further insulation between the work surface or work environment of the tires 14 and the arbor 12. The refractory material can be attached to the roll 10. Alternative refractory designs have been
proposed where the protective refractory is stationary surrounding the roll, and this configuration could also be used, if desired, for the roll 10.

[0027] As noted above, the roll 10 will generally be installed in a roller hearth furnace, or other heated environment with a series of other rolls 10, wherein adjacent rolls 10 have offset tires 14. The most significant features of the roll 10 are in the design of the arbor 12. The general construction of the roll 10 is as described in U.S. Pat. No. 6,432,030 which is incorporated herein by reference in its entirety.

[0028] Existing water cooled roll designs having tires and refractory insulation between the arbor and the working environment. This insulation from outside and the internal cooling from inside have been provided such that the arbor itself can be made from conventional, non-heat resistant composition. The design criteria for the arbor in the prior art was mainly for strength considerations alone. The present invention intends to address situations where the refractory is damaged or the cooling water supply is interrupted. Specifically the arbor 12 of the present invention is formed from a heat resistant centrifugally cast high performance alloy.

[0029] The American Society of Testing Materials (ASTM) is an international voluntary standards organization that develops and produces technical standards for materials, products, systems and services. ASTM A297 standard covers iron-chromium and iron-chromium-nickel alloy castings for heat-resistant service. ASTM A608 standard covers iron-chromium-nickel, high-alloy tubes made by the centrifugal casting process intended for use under pressure at high temperatures. Super alloy, or high-performance alloy, is an alloy with superior mechanical strength, good surface stability, corrosion resistance, and the ability to withstand high temperatures without oxidizing or losing mechanical properties. Typical applications are in the aerospace industry, e.g. for turbine blades for jet engines. Super alloys are typically based on nickel, cobalt or iron. Many other elements, both common and exotic, can be present, such as chromium, molybdenum, tungsten, aluminium, zirconium, niobium, rhenium, carbon and silicon.

[0030] In the present invention the arbor 12 is formed from a heat resistant centrifugally cast high performance alloy under the ASTM A297 and ASTM A608 standard. Specifically, grades Hf, HH, HK, HT, HN, HU and HX are preferred, with grades HH, HK and HIF being more preferred and Hf being the most preferred. These grades allow for both the structural aspects of the arbor 12 to be easily achieved and the intended heat resistance to be present in the resulting arbor 12.

[0031] A centrifugally cast arbor 12 from grade Hf alloy material will allow for the roll 10 to operate for a given time (e.g. a shift or a day) without detrimental effects even if the refractory 50 is removed in a portion of the roll 10 and/or the cooling fluid supply is interrupted to the interior of the arbor 12. This construction allows the minor problem to be addressed, e.g. the coolant supply reconnected, the piece of refractory replaced, without replacing the entire roll 12.

[0032] Other groupings or classifications of acceptable heat resistant high performance alloys that are particularly well suited for use in forming the centrifugally cast arbor 12 of the present invention are known. The heat resistant alloy forming the centrifugally cast arbor 12 may be as currently sold under the MO RE® mark by Duraloy Technologies, Inc, particularly the alloy sold under the MO RE 1 mark, which are referred to collectively in this application as the MO RE® alloys, or particularly as the MO RE 1 alloy.

[0033] Further, U.S. Pat. No. 4,077,801 to Heyer et al. discloses heat resistant casting compositions that may be used for the arbor 12, and this patent is incorporated herein by reference. The alloys disclosed and claimed in U.S. Pat. No. 4,077,801 to Heyer et al. is referenced in this application as the Heyer '801 alloys.

[0034] U.S. Pat. No. 2,540,107 to English et al. discloses high temperature alloys that may be used for the arbor 12, and this patent is incorporated herein by reference. The alloys disclosed and claimed in U.S. Pat. No. 2,540,107 to English et al. is referenced in this application as the English '107 alloys.

[0035] U.S. Pat. No. 3,127,265 to Avery discloses high temperature alloys that may be used for the arbor 12, and this patent is incorporated herein by reference. The alloys disclosed and claimed in U.S. Pat. No. 3,127,265 to Avery is referenced in this application as the Avery '265 alloys.

[0036] U.S. Pat. No. 3,260,594 to Ornitz et al. discloses high temperature alloys that may be used for the arbor 12, and this patent is incorporated herein by reference. The alloys disclosed and claimed in U.S. Pat. No. 3,260,594 to Ornitz et al. is referenced in this application as the Ornitz '594 alloys.

[0037] U.S. Pat. No. 3,403,998 to Ornitz et al. discloses high temperature alloys that may be used for the arbor 12, and this patent is incorporated herein by reference. The alloys disclosed and claimed in U.S. Pat. No. 3,403,998 to Ornitz et al. is referenced in this application as the Ornitz '998 alloys.

[0038] As discussed above, in the present invention the arbor 12 is formed from a heat resistant centrifugally cast high performance alloy such as under the ASTM A297 and ASTM A608 standard, particularly grades HH, HK, HT, HN, HU and HX; or a high temperature resistant MO RE® alloy; or a Heyer '801 alloy; or an English '107 alloy; or an Avery '265 alloy; or an Ornitz '594 alloy; or an Ornitz '998 alloy. These particular examples are not intended to limit the present invention, but merely identify particulars that are available for forming the present invention. The present invention will allow for the roll 10 to operate for a given time (e.g. a shift or a day) without detrimental effects in unintended manner of operation, such as if the refractory 50 is removed in a portion of the roll 10 and/or the cooling fluid supply is interrupted to the interior of the arbor 12. This construction allows the minor problem to be addressed, e.g. the coolant supply reconnected, the piece of refractory replaced, without replacing the entire roll 12.

[0039] Whereas particular embodiments of this invention have been described above for purposes of illustration, it will be evident to those skilled in the art that numerous variations of the details of the present invention may be made without departing from the invention as defined in the appended claims. The present invention is not intended to be restricted to the particular embodiments disclosed but defined by the appending claims and equivalents thereto.
What is claimed is:

1. A water-cooled furnace roll comprising:
   a hollow rotating arbor, having cooling fluid passages formed therein, wherein the arbor is formed from a heat resistant centrifugally cast alloy; and
   a plurality of annular tires spaced along said arbor and secured to the arbor, wherein the spaces between the tires is adapted to receive refractory material to insulate the arbor.

2. The roll of claim 1 wherein each annular tire has an outer work contacting surface and an inner bore sized to receive the arbor, and a plurality of recesses adjacent said inner bore on opposite sides of the tire, wherein each recess is adapted to receive a locking member therein for securing the tire to the arbor.

3. The roll of claim 2 wherein each tire recess has a pair of planar abutment walls adapted to abut against the locking member and a back wall extending between the abutment walls, each said abutment wall extending in a radial direction and extending parallel to a longitudinal axis of the tire and to a longitudinal axis of the work transporting roll.

4. The roll of claim 1 further including refractory material connected to the arbor between the tires.

5. The roll of claim 1 wherein each said tire is tapered inwardly from an outermost work contacting surface toward the arbor.

6. The roll of claim 1 wherein the arbor is formed from a heat resistant centrifugally cast high performance alloy under the ASTM A297 and ASTM A608 standard.

7. The roll of claim 1 wherein the arbor is formed from one of grades HH, HK and HF alloy material.

8. The roll of claim 1 wherein the arbor is formed from HF grade alloy material.

9. The roll of claim 1 wherein the arbor is formed from at least one of a Heyer '801 alloy, an English '107 alloy, an Avery '265 alloy, an Ornitz '594 alloy, and an Ornitz '998 alloy.

10. An arbor for a water cooled roll of a roller hearth furnace, the arbor configured to have a plurality of spaced tires with refractory insulation there between, and including internal passages for cooling fluid, the improvement comprising wherein the arbor is formed from a heat resistant centrifugally cast alloy.

11. The arbor of claim 10 wherein the arbor is formed from a heat resistant centrifugally cast high performance alloy under the ASTM A297 and ASTM A608 standard.

12. The arbor of claim 10 wherein the arbor is formed from one of grades HH, HK and HF alloy material.

13. The arbor of claim 10 wherein the arbor is formed from HF grade alloy material.

14. The roll of claim 1 wherein the arbor is formed from at least one of a Heyer '801 alloy, an English '107 alloy, an Avery '265 alloy, an Ornitz '594 alloy, and an Ornitz '998 alloy.

15. A water-cooled roll for transporting material through a furnace, the roll comprising:
   a hollow rotating arbor, wherein the arbor is formed from a heat resistant centrifugally cast alloy;
   a water supply pipe positioned within said arbor spaced from the inner walls thereof by a plurality of spacers on an outer periphery of said pipe to create an annular space there between;
   a plurality of annular tires spaced along said arbor, each said tire including an annular body having an outer work contacting surface and an inner bore sized to receive said arbor therein; and
   a plurality of locking bars attached to said arbor, each said locking bar extending into one said recess of one said tire.

16. The roll of claim 15 wherein the arbor is formed from a heat resistant centrifugally cast high performance alloy under the ASTM A297 and ASTM A608 standard.

17. The roll of claim 15 wherein the arbor is formed from one of grades HH, HK and HF alloy material.

18. The roll of claim 15 wherein the arbor is formed from HF grade alloy material.

19. The roll of claim 15 wherein the arbor is formed from at least one of a Heyer '801 alloy, an English '107 alloy, an Avery '265 alloy, an Ornitz '594 alloy, and an Ornitz '998 alloy.

20. The roll of claim 1 wherein the arbor is formed from a MO RE 1 alloy.

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