

Description

METHOD AND APPARATUS FOR HEAT TREATING A BUSHING

5 Technical Field

This invention relates to heat treating and more particularly to a method and apparatus for simultaneously heat treating a bushing from the outer peripheral surface and inner circumferential surface.

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Background Art

Known track assemblies for endless track laying machines include a plurality of links with laterally overlapping ends joined by bushings, pins, oil seals that are interposed between the ends of the bushings and the links, and track shoes which are fixed with bolts and nuts on the links.

The main causes of damage to the bushings are wear and fatigue cracks. In an effort to increase bushing life, the outer peripheral surface and inner circumferential surfaces are hardened to resist wear. The outer peripheral surface of the bushing requires a high hardness and a hardened depth because it is the surface that engages the sprocket for driving the track. The center of the inner circumferential surface requires high fatigue resistance because of the stresses created by the load transfer path from the sprocket into the bushing. The end portions of the inner circumferential surface require high surface hardness because of high stress caused by contact between the bushing and the pin.

In order to meet such severe conditions, bushings for tracks are given various heat treatments.

An example of a method of heat treating a bushing is disclosed in U.S. Patent 5,032,192 issued

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5 July 6, 1991 to Tsuchiya et al. The above patent uses
a medium carbon steel for the bushing material. The
steps for the heat treating process is first comprised
of carburizing the bushing and then cooling to ambient
10 temperature. After which, the outer peripheral
surface of the bushing is induction-heated so that an
entire wall cross-section is heated to a quenching
temperature. The entire bushing is then cooled by a
quenching liquid so that the bushing is evenly
hardened. After hardening, the bushing is tempered.

15 Another example of a method of heat treating
a bushing is disclosed in U.S. Patent 5,049,207 issued
Sep. 17, 1991 to Sahara et al. This example also uses
a medium carbon steel for the bushing. In this
process, the bushing is first induction hardened from
20 the outer peripheral surface until the inner
circumferential surface reaches the austenitic
transformation temperature of 1540 degrees Fahrenheit.
Then, the bushing is cooled by quenching across the
entire thickness of the bushing. The bushing is then
25 tempered in a furnace between a specified temperature
range so as not to impair the effective hardness
acquired by the heat treating process. The last step
of this process is to induction temper the bushing
from the inner circumferential surface using the
30 conductive heat to temper the outer peripheral surface
at a temperature lower than that on the inner
circumferential surface.

The methods described above require multiple
heating steps, moving the bushing from one heating
35 apparatus to another, and a considerable consumption
of manufacturing time. The result being increased
labor and manufacturing cost, and a waste of energy
and resources.

5 The present invention is directed to
overcoming one or more of the problems as set forth
above.

Disclosure of the Invention

10 In one aspect of the invention, a method for
heat treating a bushing in generally a simultaneous
operation is provided. The method comprises
concentrically locating the bushing with respect to a
central axis. The bushing is then supported by the
15 ends and is rotated in a circumferential direction
about the central axis. One of the bushing and the
heating coils are moved relative to the other in an
axial direction. As the bushing is being rotated and
axially moved it is heated by induction on the outer
20 peripheral surface, the inner circumferential
surfaces, and the pair of ends. Finally the bushing
is cooled by quenching.

 In another aspect of the invention, an
apparatus is provided for heat treating a bushing.
25 The apparatus includes locating means mounted on a
machine frame for positioning the bushing with respect
to a central axis. A driver that supports one end of
the bushing is rotatably mounted on a first carriage.
The first carriage is attached to the machine frame.
30 A quill that supports the bushing from one end is
rotatably mounted on a tailstock. The tailstock is
reciprocally mounted on a plurality ways which are
attached to the machine frame. A first induction
coil that is used for heating the bushing on the inner
35 circumferential surface, is supported by the tailstock
in axial alignment with the bore of the quill. A
second induction coil that is used for heating the
bushing from the outer peripheral surface, is

5 supported by the tailstock and is axially aligned
around the outer diameter of the quill. An inner
cooling ring and an outer cooling ring are also
supported from the tailstock for quenching the bushing
after the induction heating takes place.

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Brief Description of the Drawings

FIG 1. is an axially sectioned view of a
bushing employing the present invention;

15 FIG 2. is an end view of a bushing employing
the present invention;

FIG 3. is a perspective view of the
apparatus employing the present invention for heat
treating the bushing;

20 FIG 4. is a side elevation view of the
apparatus employing the present invention for heat
treating the bushing;

FIG 5. is a side elevation view of the
apparatus employing the present invention for heat
treating the bushing;

25 FIG 6. is a front elevation view of the
apparatus employing the present invention for heat
treating the bushing; and

FIG 7. is a cut away view in section of the
serrated drive; and

30 FIG 8. is a cut away view in section of the
serrated quill.

Best Mode for Carrying Out the Invention

35 Referring to the FIGS. 1 and 2, a bushing
10 is illustrated, to which the method and apparatus
of the invention is applied. The bushing 10 is formed

5 of substantially a cylindrical configuration having an
outer stepped peripheral surface 12 extending
generally the full length of the bushing 10, a pair of
ends 14, a longitudinal bore 18 extending between the
pair of ends 14, and a central axis 19. The
10 longitudinal bore 18 has a pair of inner
circumferential surfaces 20 and a center portion 24
positioned intermediate the pair of inner
circumferential surfaces 20. A hardened layer 26
extends inwards approximately 2.0 to 10.0 mm thick
15 from the pair of inner circumferential surfaces 20,
the pair of ends 14, and the outer stepped peripheral
surface 12. A soft core 28 is positioned juxtaposed
to the center portion 24 and intermediate the hardened
layer 26.

20 The bushing has a length "L" extending
between the pair of ends 14 and an outer diameter "D".
The pair of inner circumferential surfaces 20 are
substantially the same length "H" with the remaining
center portion 28 having a length of "L'".

25 Preferably the bushing 10 is manufactured
from a cold rolled bar stock of medium carbon steel
alloy. The raw material is similar to the
specification S.A.E. 1040 or 1056 and has a chemical
composition shown in Table 1.

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TABLE 1

Chemical Composition of Material (wt%)				
C	Mn	P	S	Si
0.40-0.58	0.50-0.80	0.025 Max	0.025-0.050	0.15-0.35

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The bar stock is saw cut to length slightly longer
than the bushing length "L" and is machined to final
dimensions. After machining in a conventional manner
the bushing 10 is ready for the heat treating process.

5 In FIGS. 3, an apparatus 30 is shown for
heat treating the bushing 10. The apparatus 30
includes a machine frame 32 which may be mounted on a
suitable base or other support not shown. A means for
locating 34, the bushing 10, is connected in a
10 conventional manner to a first hydraulic cylinder 36
as best shown in FIG 4. In this application the means
for locating 34 is a solid locator 35, it should also
be recognized that other types of locators could be
used such as expandable collets, hydraulic arbors, and
15 the like. The first hydraulic cylinder 36 is mounted
to a bracket 37 attached to the machine frame 32.

A carriage 38 is attached to the machine
frame 32.

A driver 40 is rotatably mounted on the
20 carriage 38. The driver 40 is generally cylindrical
in shape and defines a bore 42 and an end 44. The
locator 34 is in axial alignment with and slidably
disposed within the bore 42 of the driver 40. The end
44 of the driver 40 has an intermittent surface 46 as
25 seen in FIG. 7. In this application, an intermittent
surface 46 such as a serrated surface 48 is provided
on the end 44 for supporting the bushing 10 from one
of the ends 14. The driver 40 is operatively
connected to a hydraulic motor 50.

30 A tailstock 52 is mounted on a plurality of
ways 54 which are secured to the machine frame 32. A
second hydraulic cylinder 56 is secured to the
tailstock 52 and to the carriage 38.

A quill 60 is rotatably mounted on the
35 tailstock 52. The quill 60 is generally cylindrical
in shape defining a longitudinal bore 62 and an end 64

5 as shown in FIG. 8. The end 64 of the quill 60 has an intermittent surface 66. In this application, an intermittent surface 66 such as a serrated surface 68 is provided on the end 64 for supporting the bushing 10 from one of the ends 14.

10 A first induction coil 70 is supported by a support plate 72 in axial alignment with the longitudinal bore 62 of the quill 60 and the longitudinal bore 18 of the bushing 10. The first induction coil 70 comprises a plurality of turns
15 formed to a predetermined diameter smaller than the longitudinal bore 18 of the bushing 10. The first induction coil 70 is connected to a high frequency power supply (not shown). Also supported by the support plate 72 and suspended through the center of
20 the first induction coil 70 is an inner cooling ring 76 which is also in axial alignment with the longitudinal bore 62 of the quill 60 and the longitudinal bore 18 of the bushing 10. The inner cooling ring 76 is in a preestablished location and spaced relationship to the first induction coil 90 and
25 has a coolant 78 therein. For example, in this application the inner cooling ring 76 axially extends about 25mm from the first induction coil 70, and approximately 100mm above one of the pair of ends 14
30 of the bushing 10, with the tailstock 52 in its initial position.

A second induction coil 80 is supported by the support plate 72 in axial alignment with the outer peripheral surface 12 of the bushing 10. The second
35 induction coil 80 comprises a plurality of turns formed to a predetermined diameter larger than the

5 outer peripheral surface 12 of the bushing 10 and the
quill 60. The second induction coil 80 is connected
to the high frequency power supply (not shown). Also
supported by the support plate 72 and suspended in a
preestablished location and spaced relationship to the
10 second induction coil 80 is an outer cooling ring 82
having a coolant 78 therein. For example, in this
application, the outer cooling ring 82 axially extends
about 25mm from the second induction coil 80 and
approximately 100mm above one of the pair of ends 14
15 of the bushing 10, with the tailstock 52 in its
initial position. In this position, each of the inner
cooling ring 76 and the outer cooling ring 82 are
axially aligned.

A third hydraulic cylinder 84 is mounted to
20 the tailstock 52 by a plurality of standoffs 86. The
third hydraulic cylinder 84 is connected to the
support plate 72 in a conventional manner.

Industrial Applicability

25 In operation the apparatus 30 would be set
in the factory on a machine base or table (not shown)
in a working relationship with any conventional
automation system(not shown) for introducing bushings
10 to a machine. To begin the operation, a bushing 10
30 is placed over the means for locating 34 in contacting
relationship to one of the pair of inner
circumferential surfaces 20 positioning the bushing 10
with respect to the central axis 19. The bushing 10
is supported at one of the pair of ends 14 coming in
35 contact with the intermittent surface 46 of the driver
40. The second hydraulic cylinder 56 is actuated in a

5 conventional manner moving the tailstock 52 axially
along the plurality of ways 54 causing the
intermittent surface 66 of the quill 60 to contact one
of the pair of ends 14 of the bushing 10 as best seen
in FIG. 5. After pressure is reached within the
10 second hydraulic cylinder 56, the bushing 10 is
supported at the pair of ends 14 between the driver 40
and the quill 60. The first hydraulic cylinder 36 is
then actuated retracting the means for locating 34
from the longitudinal bore 18 of the bushing 10. The
15 third hydraulic cylinder 84 is then actuated is
axially moving the inner and the outer cooling rings
76,82 and the first and the second induction coils
70,80 through the longitudinal bore 18 of the bushing
10. When the inner and the outer cooling rings 76,82
20 have moved through both of the pair of ends 14 and
extend beyond the bushing 10 about 25mm the third
hydraulic cylinder 84 is de-actuated stopping the
axial movement as seen in FIG. 6. The hydraulic motor
50 is then actuated rotating the driver 40, the
25 bushing 10, and the quill 60 in unison. The first
induction coil 70 and the second induction coil 80 are
then energized. After a short dwell the third
hydraulic cylinder 84 is again actuated moving the
inner and the outer cooling rings 76,82 and the first
30 and the second induction coils 70,80 axially upward.
At this point the coolant 78 is supplied to the inner
and the outer cooling rings 76,82. The coolant 78
employed can be one of water, soluble oil, and polymer
quenchants. The short dwell assures that the outer
35 peripheral surface 12, one of the pair of ends 14 and
the inner circumferential surface 20 reach the



5 austenitizing temperature of about 1540 degrees
Fahrenheit. The second induction coil 80 remains
energized during the entire axial travel. The first
induction coil 70 remains energized only during the
dimension "H" of the inner circumferential surface 20
10 has been reached. When the axial movement of the
inner and the outer cooling rings 76,82 and the first
and the second induction coils 70,80 causes the first
induction coil 70 to travel through the "L'" dimension
of the bushing 10, the first induction coil 70 is
15 again energized. The axial movement of the inner and
the outer cooling rings 76,82 and the first and the
second induction coils 70,80 continues until the inner
induction coil 70 moves through the remaining
dimension "H" of the After the quenching is completed
20 the third hydraulic cylinder 84 is retracted
completely. At this point the hydraulic motor is de-
actuated stopping the rotation of the driver 40, the
bushing 10, and the quill 60. The second hydraulic
cylinder 56 is then actuated moving the tailstock 52
25 and the quill 60 axially upwards along the plurality
of ways 54. The heat treated bushing 10 is removed
from the apparatus 30 by any conventional automation
system (not shown) completing the process. Thus,
providing a more efficient cost-effective method for
30 heat treating a bushing can be utilized.

Other aspects, objects and advantages of
this invention can be obtained from a study of the
drawings, the disclosure and the appended claims.





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Claims

1. An apparatus for heat treating a bushing, said apparatus comprising:

a machine frame;

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means for locating said bushing concentrically with respect to a central axis, said means for locating;

a carriage being attached to said machine frame;

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a driver having a generally cylindrical configuration and defining a bore, said bore radially supporting the bushing, said driver supporting one of the pair of ends, said driver being rotatably mounted to the carriage, and being rotatably and slidably disposed about said means for locating;

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a plurality of ways being mounted to said machine frame;

a tailstock being connected to said plurality of ways, said tailstock being movable along said plurality of ways;

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a quill having a generally cylindrical configuration and defining a bore, said bore radially supporting the bushing, said quill supporting one of the pair of ends, said quill being rotatably mounted to the tailstock;

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a first induction heating coil having a plurality of turns formed to a predetermined diameter smaller than the longitudinal bore of the bushing and being supported by the support plate;

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a second induction heating coil having a plurality of turns formed to a predetermined diameter larger than the outer peripheral surface of the bushing and being supported by the support plate;



5 an inner cooling ring being supported by the
support plate and suspended through the center of the
first induction coil in a preestablished location and
spaced relationship to the first induction coil; and
10 an outer cooling ring being supported by the
support plate and suspended in a preestablished
location and spaced relationship to the second
induction coil.

2. The apparatus as set forth in claim 1,
15 wherein said means for locating is a solid locator
that extends axially into the longitudinal bore of the
bushing a preestablished distance;

3. The apparatus as set forth in claim 1,
20 including a means for controlling the movement of the
tailstock along the plurality of ways, the movement of
the locator, the movement of the first and the second
induction coils and the rotation of the driver.

25 4. A method for the heat treatment of a
bushing comprising the steps of:
 positioning the bushing from one of the pair
of inner circumferential surfaces with respect to a
central axis;

30 supporting the bushing from the pair of
ends;

 rotating the bushing in the circumferential
direction with respect to the central axis of the
bushing;

35 moving one of said bushing and said first
and second heating coils relative to the other;

 induction-heating the bushing at the outer
peripheral surface the pair of ends and at the pair of



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inner circumferential surfaces in generally a simultaneous operation;

quenching the bushing thereafter.

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5. The method of claim 4, wherein the induction-heating step comprises heating the bushing to an austenizing temperature of about 1540 Degrees F.

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6. The method of claim 4, wherein the quenching step comprises quenching the outer peripheral surface, the pair of radial ends, and the pair of inner circumferential surfaces.

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7. The method of claim 6, wherein the quenching is performed by water.

8. The method of claim 4, wherein the steel used for the bushing includes a carbon content of 0.55-0.58% by weight.

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