

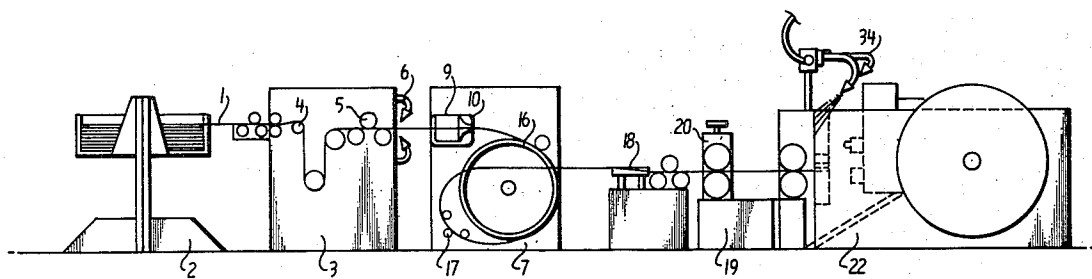
- [54] **METHOD OF LUBRICATING A WORK, ESPECIALLY A WIRE IN A WARM FORGING PROCESS**
- [75] Inventors: **Toshihiro Minami; Akito Shiina**, both of Kobe, Japan
- [73] Assignee: **Kobe Steel, Inc.**, Kobe, Japan
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- [52] **U.S. Cl.** **72/45**
[51] **Int. Cl.**..... **B21j 3/00**
[58] **Field of Search** 72/41, 42, 43, 44, 45, 72/200, 201, 202, 236
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Primary Examiner—Charles W. Lanham
Assistant Examiner—E. M. Combs
Attorney, Agent, or Firm—Oblon, Fisher, Spivak, McClelland & Maier

[57] **ABSTRACT**
A method of lubricating a workpiece, especially a wire of steel, titanium, or the like, in a warm forging process such as warm heading performed at a temperature between 450°–800°C, characterized by using an oily lubricant, such as oil, fat, mineral oil and polyethylene glycol mixed with about 5–20 times as much water and spraying the mixture of said lubricant and water by using airless spray at nozzle pressure from 50 to 150 kg/cm² into engaging surfaces of the workpiece and a tool, whereby due to a cooling effect by the water, the oily lubricant operates satisfactorily even at a high temperature range of 450°–800°C.

4 Claims, 9 Drawing Figures



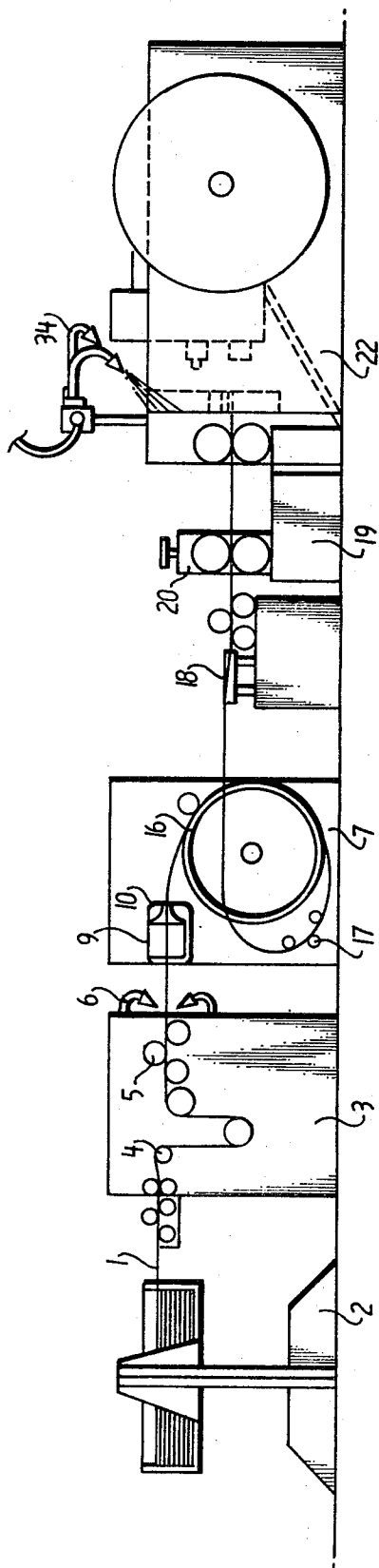


FIG. 1

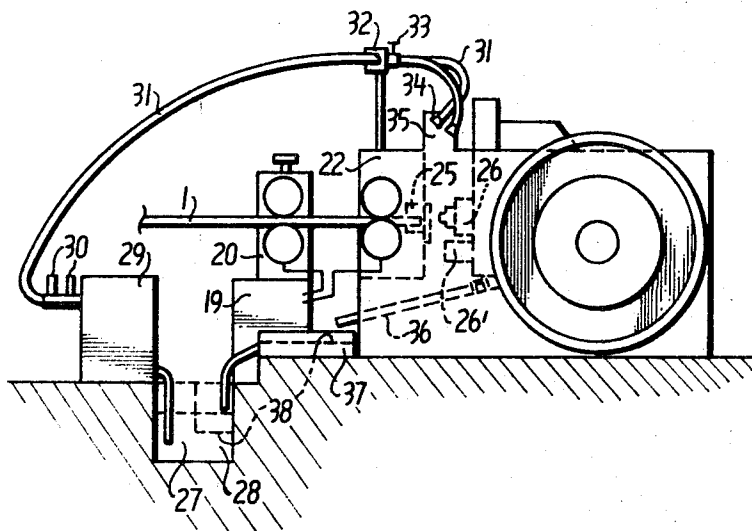


FIG. 2

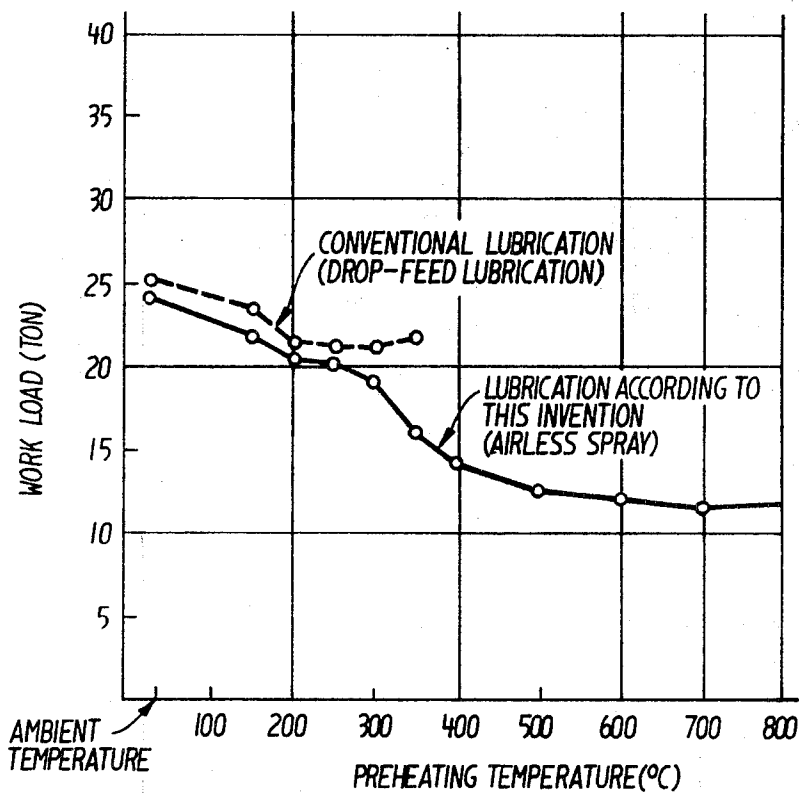


FIG. 4

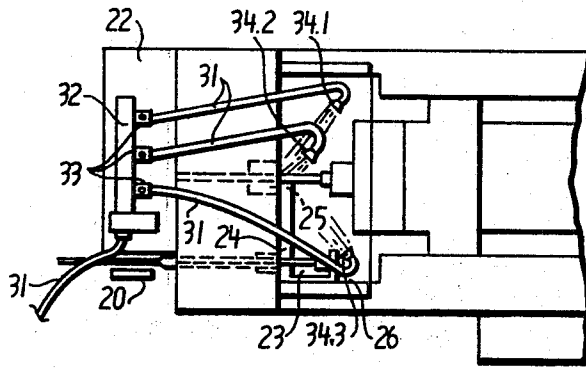


FIG. 3

FIG. 5

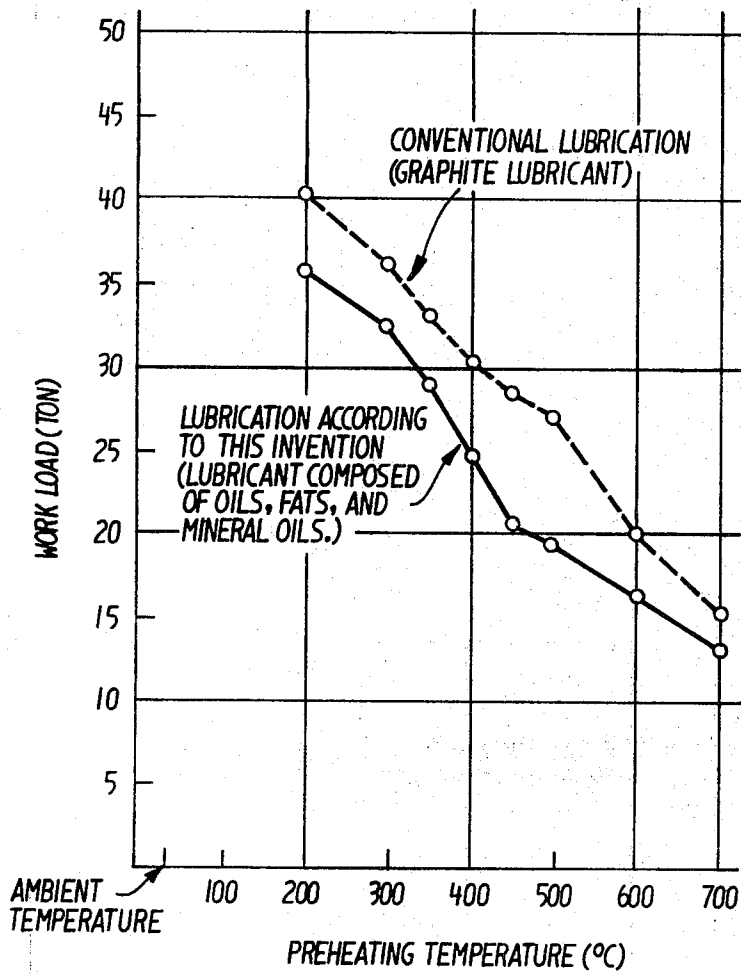


FIG. 6

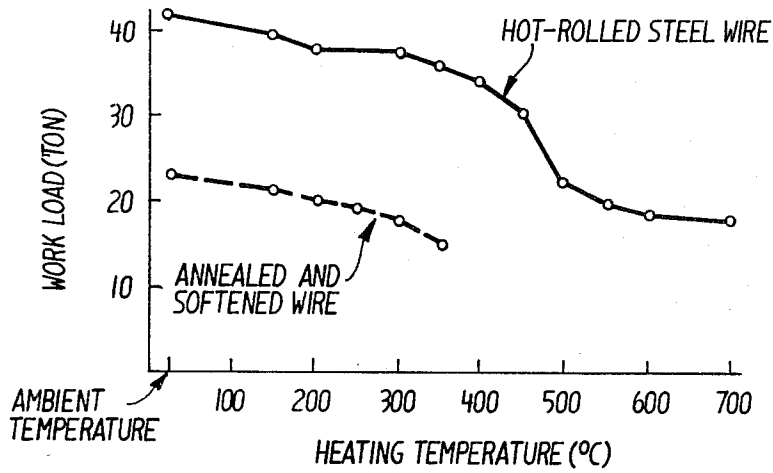
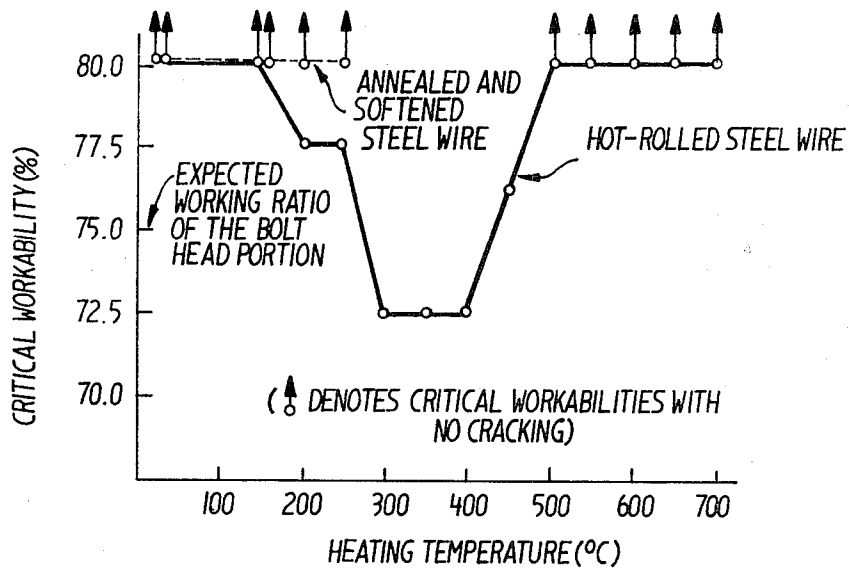


FIG. 7

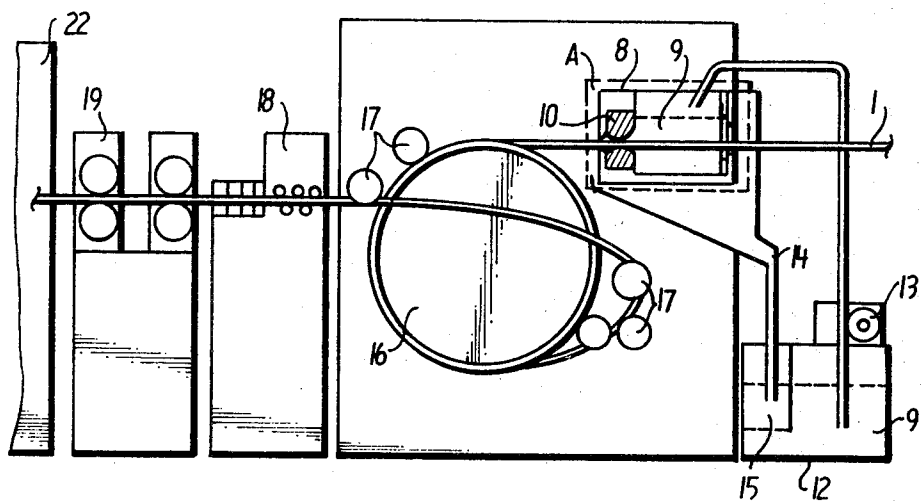


FIG. 8

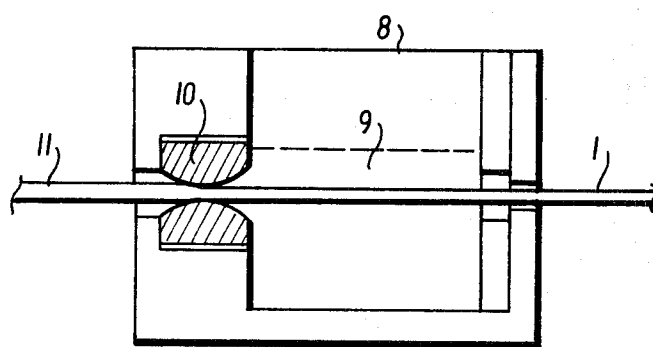


FIG. 9

METHOD OF LUBRICATING A WORK, ESPECIALLY A WIRE IN A WARM FORGING PROCESS

BACKGROUND OF THE INVENTION

1. Field of the Invention:

This invention relates generally to a method of lubricating a workpiece, and more particularly to a method of lubricating a wire of steel, titanium, or the like, in a warm forging process such as warm heading.

2. Description of the Prior Art:

In the art of continuous warm forging of a wire of steel, titanium, or the like, by heating the wire up to a temperature of 450° – 800°C by means of electric resistance heating or high frequency heating, there have been various problems arising regarding a proper lubricant as well as appropriate means of applying the same.

Conventionally, when a workpiece is heated to a temperature below 300°C, oily materials such as oils, fats or grease are conventionally used as a lubricant, such materials being easily removed from the work after the completion of the forging process. However, when a workpiece is heated beyond the abovementioned temperature, especially to a temperature above 450°C, the lubricating performance of the oily lubricant is almost lost, and therefore, in such cases graphite or molybdenum disulfide are used as a lubricant. In that case, the surface of the work results in being covered with a film of graphite or molybdenum disulfide, which can be very difficult to remove. In order to remove such a film or scale, it is required to use a very strong acid, whereby the surface of the work after the descaling becomes coarse and the dimensional precision of the work is degraded.

As for the method of applying a lubricant in a warm forging process, it is conventional to have drops of lubricant drip onto the work just prior to the warm forging thereof when the work is a relatively thin wire, but when the work is a wire of a relatively large diameter or a block, the lubricant is applied to the engaging surfaces of the work and associated tool by means of brushes. However, if the above-mentioned oily lubricant or other resinous lubricants are applied by the method of brushing, in a warm forging process performed at temperature higher than 400°C, there are encountered various operational difficulties, such for example as burning, smoking, generation of badly smelling gases, and the like.

SUMMARY OF THE INVENTION

Accordingly, one object of this invention is to provide a new and improved method of lubrication in a warm forging process performed at a temperature between 450° – 800°C which reduces or eliminates burning, smoking, and generation of gases.

A further object of this invention is to provide a new and improved method of lubrication in a warm forging process performed at a temperature between 450° – 800°C and to provide an improved method of lubrication whereby problems such as burning, smoking, generation of gases, and the like are avoided and the degreasing of the workpiece after the forging process can be readily accomplished, thus providing a good surface condition of the workpiece.

Briefly, in accordance with one embodiment of this invention, these and other objects are obtained by providing a method of lubricating a workpiece especially a wire in a warm forging process such as warm heading performed at a temperature of between 450° – 800°C, characterized by using an oily lubricant mixed with water and spraying the mixture of said lubricant and water onto engaging surfaces of the workpiece and an associated tool.

BRIEF DESCRIPTION OF THE DRAWING

A more complete appreciation of the invention and many of the attendant advantages thereof will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a schematic diagram showing an apparatus for embodying the method according to this invention;

FIG. 2 is an elevational view of the warm heading portion of the apparatus shown in FIG. 1 in larger scale;

FIG. 3 is a plan view of a portion of the warm heading portion shown in FIG. 2 in still larger scale;

FIGS. 4 and 5 are graphs showing examples of the relationship between heating temperature and working load of an annealed and softened steel wire with respect to warm forging under application of conventional lubrication and lubrication according to this invention;

FIG. 6 is a graph showing the relationship between heating temperature and working load of a hot-rolled steel wire and an annealed and softened steel wire, both being worked in a warm heading process under application of lubrication according to this invention;

FIG. 7 is a graph showing the relationship between heating temperature and workability with no cracking of a hot-rolled steel wire and an annealed and softened steel wire, both being worked in a warm heading process under application of lubrication according to this invention;

FIG. 8 is an elevation of a part of the apparatus shown in FIG. 1, especially a device adapted to treat the wire for the purpose of preventing spark generation; and

FIG. 9 is an enlarged view of part A of FIG. 8.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

In the following, this invention is described in more detail with reference to the accompanying drawing.

The oily lubricants to be used in the method of this invention are those which are normally used in a warm forging process performed at a temperature below 400°C and are to be construed herein as including oils, fats, mineral oils and water soluble resinous synthetic lubricants which may be used alone or in combination and should preferably form a content of more than 30 percent of the lubricating fluid. In addition to those principal components, the lubricating fluid may preferably be mixed with other proper materials for controlling the viscosity, suppressing rusting and so on. As the lubricants preferably used in the method of this invention, there are exemplarily given two compositions thereof as follows:

Lubricant principally composed of oils, fats and mineral oils

Sulfide of oils and fats	20%
Oils and fats	10%
Asphalt	8%
Anion activator	12%
Cation activator	5%
Anti-rusting agent	10%
Mineral oils	30%
Balance	5%

Lubricant principally composed of water soluble synthetic lubricants

Polyethylene glycol	70%
Phosphate	5%
Poly acrylic acid	5%
Kalium hydroxide	0.5%
Balance	19.5%

According to the method of this invention, the lubricants as exemplarily described above are mixed with or dissolved in water and are sprayed onto the engaging surfaces of a workpiece and associated tool in a warm forging process. It is preferable that the oily lubricants as described above are dissolved in water of 5 - 20 times amount to produce a lubricating fluid. If the ratio of the lubricant or the thickness of the lubricating fluid is too low, the lubricating performance of the lubricating fluid becomes unfavorably low. If the thickness is too high, the fluid becomes too viscous and is apt to cause a burning problem when sprayed onto the engaging surfaces of a workpiece and associated tool. Therefore, it is to be noted that the effect of water is very important in the method of this invention. In this case, the water operates not only as a fluidizing agent of the lubricant to have the lubricant uniformly applied on the engaging surfaces but also as a cooling medium to protect the lubricant from burning and sticking onto the hot engaging surfaces.

The manner of spraying the lubricating fluid is not particularly defined in the method of this invention, but in order to have the lubricant uniformly applied over the entire engaging surfaces of a workpiece and tool, in the form of mist, it is more favorable that the lubricating fluid be sprayed from a high pressure nozzle after having been compressed indirectly by compressed air in an airless pump than to be compressed together with high pressure compressed air. By the lubricating fluid being compressed in an airless pump, the fluid is kept free of bubbles and is applied uniformly onto the engaging surfaces of workpiece and tool. As for the spraying pressure in the high pressure nozzle, it is favorable that the pressure is in the range of 50 - 150 kg/cm², because if the pressure is below 50 kg/cm², the pressure is too low to have the lubricant sprayed in a good condition. If the pressure is higher than 150 kg/cm², the pressure is too high to have the sprayed mist of the lubricant well attached to the engaging surfaces of the workpiece and tool. However, the most favorable spraying pressure changes according to the viscosity of the lubricating fluid, the diameter of a wire to be worked, the distance between the high pressure nozzle and the wire and tool, as well as positional relations among them.

When a forging process is performed under application of the lubricant according to the method of this invention, since the lubricant is attached onto the engaging surfaces of a workpiece and tool in the form of a mist, the lubricant is uniformly applied and forms a fine film thereof over the engaging surfaces, whereby burning of the workpiece is prevented and the life of the tool is elongated by the cooling effect of the aqueous lubricating fluid.

Another important effect of this invention is that the working load is substantially lowered as compared with the conventional method of dripping lubricant in a warm forging process performed at relatively high temperature range, such as above 300°C, whereby the warm forging process is performed with extremely high efficiency.

A hot-rolled wire is generally inferior in workability and can not be worked well in a cold forging process or in a conventional warm forging process performed at a relatively low temperature due to the restriction imposed by the temperature limit of the conventional oily lubricants. This is because there has been a danger that cracks have been generated during the process of forging. Therefore, in conventional cold or warm forging, an annealed and softened wire has been used. However, if warm forging is performed at a temperature higher than 450°C by employing the lubricating method according to this invention, a hot-rolled wire can be worked at a working load equivalent to or lower than that in warm forging of an annealed and softened wire without encountering problems of cracking. Therefore, it is a great advantage of this invention that a cheap hot-rolled wire can be worked in a warm forging process without annealing and softening the wire. When a hot-rolled wire is directly worked, the scale formed on the surface of the wire is first removed by mechanical or chemical descaling means. It is more favorable to employ mechanical descaling means than to employ chemical descaling means to avoid problems caused by acid. The descaled hot-rolled wire is then heated and transferred to a warm forging process. When the wire is formed into bolts in a warm forging process, it is preferable that the wire experiences a slight expansion working. By applying the expansion working process to the wire, the surface of the wire is improved as to its affinity for a lubricant for protecting sparking (material principally composed of polyethylene glycol). Such lubricant has an effect of preventing the generation of sparks at the contacting portions of electrodes with the wire in electric resistance heating of the wire. Furthermore the dimension of the wire is more uniform prior to the warm forging thereof.

It is very important to prevent the generation of sparks during electric resistance heating when a wire of steel, titanium, or the like is continuously heated by such means for a warm forging process. If sparks are generated at the contacting portions of electrodes with the wire, the surface of the wire is often formed with scars in the form of pin holes. These scars deteriorate the surface condition of the products and often cause cracking during subsequent working processes. As a countermeasure, to prevent sparking, the wire is conventionally mechanically shaved of its surface portion or is coated with a film of material having a good electric conductivity prior to electric resistance heating. However, such countermeasures are difficult and complicated.

In this connection, it is proposed, according to an additional feature of this invention, to treat the wire prior to electric resistance heating by expansion under application of a lubricant principally composed of polyethylene glycol. By applying the lubricant, as described above, in the expansion process of the wire, the surface of the wire is uniformly coated with a film of the lubricant and the generation of sparks is effectively suppressed. It is preferable that the lubricant includes more than 50 percent polyethylene glycol, and in addition, the lubricant may include other organic and inorganic materials having effects of improving the expansion performance, suppressing corrosion or rusting and so on. Within such materials are phosphate, polyacrylic acid, kalium hydroxide, and the like.

In the following embodiments, the steel wire worked herein has a composition shown in the following Table 1 and has been formed into bolts of scale M10 by a warm heading process.

TABLE 1

Type of Steel	C	Si	Mn	P	S
AISI1027	0.27	0.27	1.51	0.010	0.017

Example 1 (annealed and softened steel wire)

A steel wire made of AISI1027 having the composition as shown in Table 1 was hot-rolled and thereafter annealed and softened. The wire, as a raw material, was formed into bolts of scale M10 by a warm heading process.

FIG. 1 shows schematically the apparatus for processing the wire. The annealed and softened steel wire 1 is placed in a coil stand 2 and is fed through a mechanical descaler 3 including bending rollers 4 and brush rollers 5 to descale the wire. The scale powders attached on the surface of the wire are blown off by air nozzles 6 provided at the exit of the mechanical descaler. This descaling process serves to elongate the life of an expanding die 10 of an expander 7. The wire descaled by the mechanical descaler is fed to the expander 7 and is led through a bath of spark preventing lubricant 9 and is shaved to a required dimension by means of the expanding die 10.

The expanded wire is wound about wind-up wheel 16 and is passed through a plurality of guide rollers 17 and thereafter is fed through a rectifier 18 to be rectified into a straight wire. The rectified straight steel wire is then fed into an electric resistance heating device 19. Since the surface of the wire fed into the electric resistance heating device is uniformly coated with a film of a resinous lubricant having a high electric conductance, formed in the preceding expansion process, spark generation at the contacting portions of the wire and electrodes 20 is avoided. The wire heated by electric resistance is fed into a warm heading device 22 to be processed in a manner of warm heading.

The warm heading device 32 is shown in more detail in FIGS. 2 and 3. The wire is heated at a portion laid between the two electrodes 20 of the electric resistance heating device 19 and is transferred by a pair of transfer rollers 21 to be fed into the warm heading device 22. The forward end of the wire is first abutted against a stopper 26 to define the end position of the wire and is cut to a piece of a predetermined length by a cutting die 24. The pieces of predetermined length are worked

in a manner of warm heading by a main die 25, first punch 26 and second punch 26'. During the warm heading process, the aforementioned lubricant is sprayed onto the engaging surfaces of the wire and the working tools in the form of an airless spray. The lubricant is pumped from a bath 27 contained in a lubricant vessel 28 by an airless pump 29 and after having been pressurized to a relatively high pressure is passed through filters 30 to remove impurities and is fed through a high pressure hose 31 to a manifold 32. In the shown embodiment, the lubricant is divided into three parts by the manifold 32 but when the heading device is of larger size, the manifold may have more branches. Each divided lubricant path is fed through a touch cock 33 and the pressure is controlled in a high nozzle 34.1, 34.2 or 34.3. Spraying pressure at the high pressure nozzles 34.1 - 34.3 is controlled in the range of 50 - 150 kg/cm² according to the material and dimension of the wire. The high pressure nozzle 34.1 serves mainly to cool and lubricate the main die and blow off impurities from the main die. The position or arrangement of the high pressure nozzle 34.1 is to be properly determined taking into consideration the spraying amount to be applied to the main die and the wire and the spraying pressure. As an example, the high pressure nozzle 34.1 may preferably be positioned about 300mm above the main die 25 with an inclining angle between 35° - 45°. In this case a relatively high spraying pressure of 100 kg/cm² is favorable. The high pressure nozzle 34.2 is not usually used but is adapted to replace the high pressure nozzle 34.1 or to supplement the high pressure nozzle 34.1 when lubricating performance is lowered. Therefore, even when the performance of the high pressure nozzle 34.1 is decreased or lost, the productivity of the heading device is always maintained at the full rate. The high pressure nozzle 34.3 serves to apply the lubricant to the cut surface of the material and to the engaging surfaces of the punches 26 and 26' so as to have the wire piece lubricated over all surfaces thereof as well as to remove impurities which attach to the surfaces of the cutting die 24 and the punches 26 and 26'. As a result of applying lubrication by means of the high pressure nozzle 34.3, the life of the cutting die and punches is elongated. In conventional lubrication by dripping lubricant on the surface of the wire the cut surface of the wire piece is not lubricated, whereby the lives of the punches are relatively short. To have maximum effect of the high pressure nozzle 34.3, it is preferable that the nozzle is positioned 300mm above the cutting die 24 at an inclined angle at between 34° - 45°. The spraying pressure should preferably be selected to be a relatively low value between 50 - 70 kg/cm². A safety cover 35 serves to fix the nozzles and to prevent blowing up of a mist of lubricant thereby to improve the effect of the lubricant. The workpieces thus processed in a warm heading under application of the lubricant according to the method of this invention fall onto a chute 36 and reach a lubricant recovery means 37 to be separated from the lubricant. Since the lubricant includes many impurities, it is filtrated by a filter 38 before it is returned to the bath 27.

By employing the apparatus shown in FIGS. 1 - 3, the steel wire AISI1027 (annealed and softened wire) was experimentally worked into bolts of scale M10 in a warm forging, the results of which are shown in FIGS. 4 and 5. FIG. 4 shows the relationship between the heating temperature and the working load for the cases

of warm forging performed under application of a lubricant composed of oils, fats and mineral oils according to the method of this invention employing an airless pump and spraying pressure of 100 kg/cm² in a first case and according to the conventional method of dripping the drops of lubricant in a second case. The working ratio at the bolt head portion was 75.0 percent. As is seen from FIG. 4, the working load at a heating temperature below 250°C is substantially the same in the cases according to this invention as well as according to the conventional method of dripping, but at a heating temperature above 300°C, the working load in the case according to this invention rapidly decreases allowing smooth warm forging. In the case of the conventional dripping method, the working load shows a tendency to increase due to burning and sticking of the lubricant. Thus, although it has been conventionally thought that the lubricant composed of oils, fats and mineral oils is employable as a lubricant only in a temperature range up to 300°C, such lubricants are satisfactorily used up to a temperature of 700°–800°C according to the method of this invention.

FIG. 5 shows the relationship between heating temperature and working load for the cases of warm forging of bolts of scale M10, wherein a first case the warm forging has been performed under application of a lubricant composed of oils, fats and mineral oils according to the method of this invention, said lubricant being sprayed at a spraying pressure of 100 kg/cm², while in a second case the warm forging has been performed under application of graphite lubricant according to the conventional dripping method. As is seen from FIG. 5, the working load in the case according to this invention is lower than that according to the conventional method by as much as 4–8 tons over the entire heating temperature region, showing that the lubrication according to the method of this invention is very superior. In addition, when the lubricant composed of oils, fats and mineral oils or the water soluble resinous lubricants are used according to the method of this invention, the lubricants are very easily removed by being pickled with weak acid with no difficulty in making the surface of the products coarse in contrast to the conventional high temperature warm heading performed under application of graphite or molybdenum disulfide.

EXAMPLE 2 (HOT-ROLLED STEEL WIRE)

The steel wire AISI1027 as shown in Table 1 was, during hot-rolling worked into bolts of scale M10 by a warm heading process employing the apparatus as shown in FIGS. 1–3. FIG. 6 shows the relationship between heating temperature and working load for two cases, one being the case of warm forging a hot-rolled steel wire under application of lubrication according to the method of this invention employing a lubricant composed of oils, fats and mineral oils and a spraying pressure of 100 kg/cm², the other being the case of warm forging and annealed and softened steel wire under application of lubrication according to the conventional dripping method employing the same lubricant. The working ratio at the bolt head portion was 75.0 percent. As is seen from FIG. 6, in warm forging at a heating temperature above 400°C, the hotrolled steel wire is worked with a working load which is equivalent to or lower than that of the annealed and softened steel wire worked under application of the conven-

tional lubricating method, showing that a smooth warm forging is performed according to the method of this invention.

FIG. 7 shows workabilities with no cracking in the two warm forging cases described with reference to FIG. 6. In warm forging according to the method of this invention, the workability in the heat range of 300°–400°C is lowered due to the blue heat brittleness of steel. Since in this region the workability is of the order of 72.5 percent which is lower than the expected working ratio (75 percent) of the bolt head portion, there is a danger that cracks will be generated at the bolt head portion. However, if the heating temperature reaches 450°C, the workability is rapidly recovered and at heating temperatures above 500°C, the workability with no cracking attains the value of 80 percent, and cracking is avoided in such a high temperature region.

EXAMPLE 3 (LUBRICANT FOR PREVENTING SPARKING)

An annealed and softened wire of steel AISI1027, as shown in Table 1, is first pickled and then treated with lime or is first pickled and then treated with bondelite (not shown) and is then fed to the die box 8. In the die box 8, the wire is coated with lubricant 9 and is passed through the expansion die 10 to be shaved to a desired dimension. The lubricant 9 is composed of 70 percent polyethylene glycol, 5 percent phosphate, 5 percent polyacrylic acid, 0.5 percent kalium hydroxide and the balance water. The surface of the wire expanded through the expansion die 10 is uniformly coated with a film 11 of lubricant having good electric conductivity. The lubricant is stored in a vessel 12 and is pumped by a circulating pump 13 to be fed into the die box 8, and is returned therefrom via a return pipe 14 to the vessel 12. In this case, since the lubricant returned from the die box 8 includes impurities, it is filtrated by a filter 15. The expanded wire is wound about the wind-up wheel 16, guided around a plurality of guide rollers 17 and the straightening device 18. The straight steel wire is then led through the electric resistance heating device 19. In the electric resistance heating process performed in device 19, generation of sparks at the electrodes 20 is perfectly avoided since the wire is coated with a film having good electric conductivity. The wire heated by electric resistance heating is fed to the heading device 22 for the required warm heading. The film of lubricant substantially composed of polyethylene glycol also has the effect of preventing rusting of the wire and of course can readily be removed from the surface of the products by washing with a proper degreasing agent of weak acid, for example, 10 percent aqueous solution of hydrochloric and/or nitric acid.

Obviously, numerous modifications and variations of the present invention are possible in light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described herein.

What is claimed as new and desired to be secured by Letters Patent of the United States is:

1. A method of lubricating a workpiece, such as a wire in a warm forging process at a temperature between 450°–800°C, comprising the steps of:

preparing a mixture of oily lubricant and water, wherein said oily lubricant is mixed with 5–20 times as much water; and

spraying said mixture onto an engaging surface of said workpiece, wherein said mixture is sprayed by being compressed by an airless pump at a spraying pressure within the range of 50–150 kg/cm².

2. A method according to claim 1, wherein said oily lubricant includes at least one selected from oils, fats, mineral oils and polyethylene glycol.

3. A method according to claim 1, wherein said wire

is coated with a lubricating film of polyethylene glycol in a heating up process for warm forging performed by electric resistance heating.

4. A method according to claim 3, wherein said lubricating film of polyethylene glycol is coated on said wire at the same time said wire is expanded through a die means.

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