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COLD ROLLING LUBRICATION

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This invention is concerned with the cold rolling of ferrous and non-ferrous metals.

In the cold rolling of metal (this operation most commonly being applied to steel, aluminium, copper and brass), metal stock in the form of sheet or strip is passed between pairs of metal work rolls to which pressure is applied to reduce the thickness of the metal to a desired value. The work rolls are commonly supported by back-up rolls of greater diameter in order to resist distortion of the work rolls by bending. In such metal rolling operations, it is necessary to apply a lubricant at the interface between the rolls and the metal. This lubricant serves to maintain a suitable coefficient of friction between the metal stock and the work rolls in order to ensure, in turn, the desired rate of deformation of the metal and to prevent the transfer of metal to the rolls themselves by frictional pick up with consequent damage to the surface of the metal being rolled. Lubrication is also necessary in the arc of contact between the work rolls and the back-up rolls. The lubricant also serves as a coolant to dissipate the heat produced by deformation of the metal stock and to control thermal distortion of the rolls and thus ensuring a satisfactory surface finish and flatness for the rolled metal.

The rolling lubricants customarily used in metal rolling operations are oil-in-water emulsions of varying degrees of stability and crude dispersions of oil in water maintained by mechanical agitation and these lubricants are subject to a number of disadvantages. During operation the lubricant is continuously circulated from a conveniently located reservoir to sprays or nozzles from which it is sprayed into the roll gaps and, in some cases, also on to the rolls and the lubricant then drains from the mill stands and is returned to the reservoir. The lubricant returning back into the reservoir carries with it metal detritus and scale formed or removed from the rolled material during rolling and it is difficult to remove this suspended material from the lubricant owing to the inherent difficulty of effectively filtering an emulsion or crude dispersion, which difficulty is enhanced by the fact that partial separation of the oil and water phases usually takes place during the actual rolling operations and in the reservoir. Due to such phase separation, the lubricating properties of the lubricant are deleteriously affected and skimming of the liquid in the reservoir to remove the separated oil phase is required.

It has hitherto been thought desirable that separation of the oil and water phases of such emulsions or crude dispersions should take place at the metal-roll interface in order that the optimum lubricating properties of the lubricant should be attained and various attempts have been made to overcome the problems posed by the persistence of such phase separation in the reservoir to which the lubricant is returned. Thus it has been proposed to use a lubricant composition which forms a stable emulsion only at a temperature below that attained at the metal-roll interface (which is the maximum temperature encountered during circulation of the lubricant) and it has been proposed to use a lubricant composition which forms a stable aqueous solution only at a temperature below that attained at the metal-roll interface. These proposals necessitate careful control of the temperature of the lubricant during the operation of the mill in order to ensure that the lubricant has cooled in the reservoir to a temperature at which the stable emulsion or solu-

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tion is reformed before it is returned to the mill via the sprays.

We have now found that the existence of separated oil and water phases at the roll-metal interface is not necessary in order to obtain good lubrication in the cold rolling of metals and we have developed a temperature stable, dilute aqueous solution of certain organic compounds which is an excellent metal rolling lubricant and from which none of the constituents separate at any temperature encountered in the circulation of the lubricant during cold rolling operations.

In accordance with the present invention, therefore, we provide a method of cold rolling metals, in which the roll-metal interface is lubricated with a circulating lubricating composition which is a dilute aqueous solution of a blend of (a) from 40 to 95% by weight of a salt formed between at least one amine which is non-volatile at ambient temperatures and a synthetic or naturally occurring fatty acid containing at least 12 carbon atoms, a fatty acid distillation residue or a synthetic polymerised fatty acid, (b) 0.1 to 20% by weight of a polyoxyalkylene oxide condensate of a fatty acid or rosin acid, a sorbitan ester of a fatty acid containing at least 12 carbon atoms, a fatty acid distillation residue or a synthetic polymerised fatty acid, or a polyoxyalkylene condensate of such a sorbitan ester, (c) 5 to 50% by weight of a synthetic fatty acid alkyl ester, the fatty acid containing at least 12 carbon atoms and the alkyl group containing up to 4 carbon atoms, and (d) 0 to 50% by weight of a water-soluble bactericide.

In contrast to the oil-in-water emulsions or crude dispersions which are currently used as mill lubricants, the foregoing aqueous compositions are solutions which are stable against any separation of one or more constituents thereof at all temperatures from slightly above the freezing point of the solution to the boiling point thereof. The solutions are, therefore, stable against separation of any constituent thereof, other than water by evaporation, under all the temperature conditions that are present in a cold rolling operation. The optimum temperature for any particular rolling operation can, therefore, be selected with no limitation being imposed by the mill lubricant employed.

Since the solutions remain stable, they can be filtered using filtering means capable of separating the finest suspended particles and can be centrifuged using the highest speeds in order to remove suspended metal and scale particles (arising from the rolling operation) therefrom without significant loss of the active ingredients from the solution. Suspended droplets of any extraneous oil, arising from leakage of mechanical or "hydraulic" systems, which may be present in the solution, are also removed by such filtration or centrifugation.

While the stability of the aqueous solution lubricants against separation of the constituents at elevated temperatures is their principal advantage, they also possess the further advantage that they give an excellent balance of lubricating and cooling properties for a wide range of reductions. In the cold rolling of steel, it is necessary to use a lubricant having high lubricity when carrying out a heavy reduction, that is a reduction in excess of 60%, for example in the production of thin sheet gauges (plate having a thickness of less than 0.024 inch) and to use a lubricant having a low lubricity when carrying out a light reduction, that is a reduction of less than 60%, for example in the production of thick sheet gauges (plate having a thickness greater than 0.024 inch).

The problems of changing from one lubricant to another on the rolling mill when the type of product rolled is being changed, are considerable. The aqueous solution lubricants used according to the present invention, however, give excellent results with a wide range of reductions

and can be used without any variation in their composition for the production of sheet steel products ranging in thickness from tinplate gauge (typically 0.008 inch), through the light and medium sheet gauges (typically less than 0.024 inch and greater than 0.024 inch respectively) up to the heavy sheet gauges (typically up to 0.075 inch).

A further advantage of the aqueous solution lubricants is that the traces thereof which are left on the material after the cold rolling operation are completely volatilised during annealing or other heat treatment carried out after cold rolling so that products with exceptionally clean surfaces are obtained.

Pickled hot band steel intended for subsequent cold rolling using such an aqueous solution lubricant is preferably coated at the finishing end of the pickle line with a similar solution which is dried on the steel surface by means of the drying equipment normally provided on such lines. The pickled hot band steel is coiled for storage pending cold rolling and the dried film affords excellent protection against rusting and minimises the risk of internal scratching within the coil due to relative movement of contact surfaces whilst handling. The dried film of the lubricant also provides lubrication for the first rolling pass in the mill.

The aqueous solution lubricants can also be used as the mill lubricant in the cold rolling of hot band steel that has been coated with a conventional mineral and/or fatty oil composition as protective lubricant; this situation can arise, for example, where hot band material coated with a conventional composition comes from an outside source for subsequent cold rolling. The presence of such conventional mineral and/or fatty oil compositions on the material subjected to cold rolling normally has no deleterious effects on the aqueous solution lubricants provided that proper steps are taken to remove excess oil from the mill lubricant system, for example, by filtration, centrifuging or regular skimming.

The amine salt constituent of the lubricant composition used according to the invention preferably contains a small excess of amine, for example a 5% excess. Suitable amines include, for example, mono-, di- and tri-ethanolamine, mixed isopropanolamine and aminomethylpropanol; methylamine, ethylamine, diethylamine and morpholine are unsuitable since they are too volatile at ambient temperatures. The long chain fatty acid present in the amine salt may, for example, be oleic or stearic acid. Alternatively, the acid component of the amine salt can be a residue from the distillation of fatty acids, which residue may contain polymerised fatty acids, such as pitch acids, or can be such a polymerised fatty acid, particularly oleic acid dimer or trimer, alone. The amine salt can, of course, be formed from a mixture of such acid components.

The polyoxyalkylene oxide condensate constituent of the lubricant composition is preferably a polyoxyethylene oxide condensate and the condensate is preferably one derived from the condensation of from 4 to 44 moles of the alkylene oxide with one mole of fatty or rosin acid; such condensates will, in general, have a molecular weight in the range of from 400 to 600. Examples of suitable condensates are those obtained by the condensation of 8 moles of ethylene oxide with 1 mole of crude tall oil fatty acids; of 9 moles of ethylene oxide with 1 mole of stearic acid; and of 22 moles of ethylene oxide with 1 mole of oleic acid. The polyoxyalkylene oxide condensate used should not be one that has a negative solubility coefficient in water. Instead of a polyoxyalkylene oxide condensate of a fatty or rosin acid, a sorbitan ester or polyoxyalkylene sorbitan ester, such as sorbitan monooleate or polyoxyethylene (20 moles) sorbitan monopalmitate can, as indicated above, be used.

As indicated above, the synthetic fatty acid alkyl ester employed is one derived from a fatty acid containing at least 12 carbon atoms and the alkyl group of which contains up to 4 carbon atoms. These fatty acid alkyl esters are completely peptised in the micellar structure of the

amine salt so that even though some of the alkyl esters have only limited solubility in water on their own, when present in the lubricant compositions they are effectively solubilised. These synthetic fatty acid alkyl esters act as anti-foaming agents. It is preferred to use fatty acid butyl esters, particularly butyl stearate.

Where the lubricant composition contains a water-soluble bactericide, the latter should be a compound which does not deleteriously affect the water-solubility of the other constituents of the composition. Suitable water-soluble bactericides are, for example, ortho-phenyl-phenol, amyl cresol, catechol, and 2-hydroxymethyl-2-nitro-propanediol, of which the first is preferred.

In order that the invention may be more fully understood, the following examples, in which the proportions are by volume, are given by way of illustration only.

EXAMPLE 1

A mixture of the following composition was formed by blending the components at 140° F.:

	Percent
Triethanolamine	25
Oleic acid	45
Ethylene oxide/crude tall oil condensate (8:1 molar)	7.5
Butyl stearate	22.5

A 2% solution of this blend in water was used as the mill lubricant on a Schloemann mill rolling mirror finish steel strip. The strip was rolled at 1500 feet/minute to obtain an overall reduction of 90% in three passes.

The same operation was also carried out using a conventional 5% oil-in-water emulsion lubricant.

The overall reduction of 90% was obtained with lower loads and the final product also had a better surface finish when the aqueous solution lubricant was used than when the emulsion lubricant was used.

When using the 2% solution lubricant, the lubricant circulation system remained cleaner and lasted six times longer than the emulsion lubricant before it had to be discarded. There was no separation of any constituent of the lubricant solution at any point in the circulation of the solution from the reservoir to the mill stand and from the latter back to the reservoir.

EXAMPLE 2

A mixture of the following composition was formed by blending the components at 140° F.:

	Percent
Triethanolamine	25
Oleic acid	22.5
Pitch acids	22.5
Sorbitan mono-oleate	7.5
Butyl stearate	22.5

A 2% aqueous solution of this blend was used as the mill lubricant on a wide 4-stand tandem mill rolling mild steel strip. With this lubricant, overall reductions of up to 84% were obtained at high speed with lower mill loads and with the production of a cleaner product than with a conventional crude oil-in-water dispersion lubricant that had previously been used on the same mill in rolling the same product. The mill and rolls remained significantly cleaner than had formerly been the case.

Gauges ranging from 0.010 to 0.060 inch were satisfactorily rolled using the same 2% aqueous solution, that is without any alteration in the lubricant composition.

The used 2% solution was allowed to remain static for several weeks and when again brought into service, there were no indications of the unpleasant odours normally associated with bacterial contamination and development. The cleanliness of the rolled material was found to be exceptionally good upon final inspection.

EXAMPLE 3

A mixture of the following composition was formed by blending the components at 140° F.:

98% of the blend of Example 2
2% of ortho-phenyl-phenol.

A 2% aqueous solution of this composition was found to be an excellent cold rolling lubricant. The bactericide, ortho-phenyl-phenol, has been found to afford protection against bacterial growth during the prolonged life possible with the lubricant composition described.

I claim:

1. In a method of cold rolling metals, in which the roll-metal interface is lubricated with a circulating lubricating composition, the improvement comprising using as said circulating lubricating composition a dilute aqueous solution of a blend of

(a) from 40 to 95% by weight of a salt formed between

(i) at least one amine which is non-volatile at ambient temperatures and

(ii) an acid selected from the group consisting of fatty acids containing at least 12 carbon atoms, fatty acid distillation residues, and synthetic polymerised fatty acids;

(b) 0.1 to 20% by weight of a surfactant selected from the group consisting of

(i) polyoxyalkylene oxide condensates of an acid selected from the group consisting of fatty acids and rosin acids,

(ii) sorbitan esters of an acid selected from the group consisting of fatty acids containing at least 12 carbon atoms, fatty acid distillation residues, and synthetic polymerised fatty acids, and

(iii) polyoxyalkylene condensates of said sorbitan esters (ii);

(c) 5 to 50% by weight of a synthetic fatty acid alkyl ester, the fatty acid containing at least 12 carbon atoms and the alkyl group containing up to 4 carbon atoms; and

(d) 0 to 5% by weight of a water-soluble bactericide; none of the constituents of the blend being emulsified in said solution and none of them separating from the solution at any of the temperatures encountered in the cold rolling and in the circulation of the solution during the cold rolling.

2. A method according to claim 1, in which said aqueous solution contains 0.5 to 10% by weight of said blend.

3. A method according to claim 1, in which said aqueous solution contains 1 to 4% by weight of said blend.

4. A method according to claim 1, in which said polyoxyalkylene oxide condensate (b)(i) is derived from the condensation of from 4 to 44 moles of the alkylene oxide with 1 mole of said acid.

5. A method according to claim 1, in which said polyoxyalkylene oxide condensate (b)(i) is derived from the condensation of 8 moles of ethylene oxide with 1 mole of crude tall oil fatty acids.

6. A method according to claim 1, in which said polyoxyalkylene oxide condensate (b)(i) is derived from the condensation of 9 moles of ethylene oxide with 1 mole of stearic acid.

7. A method according to claim 1, in which said polyoxyalkylene oxide condensate (b)(i) is derived from the condensation of 22 moles of ethylene oxide with 1 mole of oleic acid.

8. A method according to claim 1, in which said bactericide (d) is ortho-phenyl-phenol.

9. A method according to claim 1, in which said amine salt (a) contains a small excess of amine.

10. A method according to claim 9, in which the amine from which said salt is derived is selected from the group consisting of mono-, di- and triethanolamine.

11. A method according to claim 9, in which the acid component from which salt is derived is selected

from the group consisting of oleic acid, stearic acid, pitch acids, a synthetic fatty acid dimer and a synthetic fatty acid trimer.

12. A method according to claim 1, in which said sorbitan ester (b)(ii) is sorbitan mono-oleate.

13. A method according to claim 1, in which said polyoxyalkylene sorbitan ester (b)(iii) is polyoxyethylene-glycol sorbitan monopalmitate.

14. A method according to claim 1, in which the metal that is rolled is pickled hot band steel and in which a dilute aqueous solution as specified in claim 1 is applied to the pickled hot band steel and then dried to leave a film of said blend on the steel, prior to effecting cold rolling.

15. In a method of cold rolling steel, in which the roll-metal interface is lubricated with a circulating lubricating composition, the improvement comprising using as said circulating lubricating composition a dilute aqueous solution of a blend of

(i) about 70% by volume of the salt formed between triethanolamine and oleic acid;

(ii) about 7.5% by volume of an 8:1 molar condensate of ethylene oxide and crude tall oil fatty acids, and

(iii) about 22.5% by volume of butyl stearate; none of the constituents of the blend being emulsified in said solution and none of them separating from the solution at any of the temperatures encountered in the cold rolling and in the circulation of the solution during the cold rolling.

16. A method according to claim 15, in which said aqueous solution contains from 1 to 4% by volume of said blend.

17. In a method of cold rolling steel wherein the roll-metal interface is lubricated with a circulating lubricating composition, the improvement comprising using as said circulating lubricating composition a dilute aqueous solution of a blend of

(i) about 70% by volume of the salt formed between triethanolamine and a mixture of equal parts of oleic acid and pitch acids,

(ii) about 7.5% by volume of sorbitan mono-oleate; and

(iii) about 22.5% by volume of butyl stearate; none of the constituents of the blend being emulsified in said solution and none of them separating from the solution at any of the temperatures encountered in the cold rolling and in the circulation of the solution during the cold rolling.

18. A method according to claim 17, wherein said blend additionally contains 2% by volume of the total blend of ortho-phenyl-phenol.

19. A method according to claim 17, wherein said aqueous solution contains from 1 to 4% by volume of said blend.

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