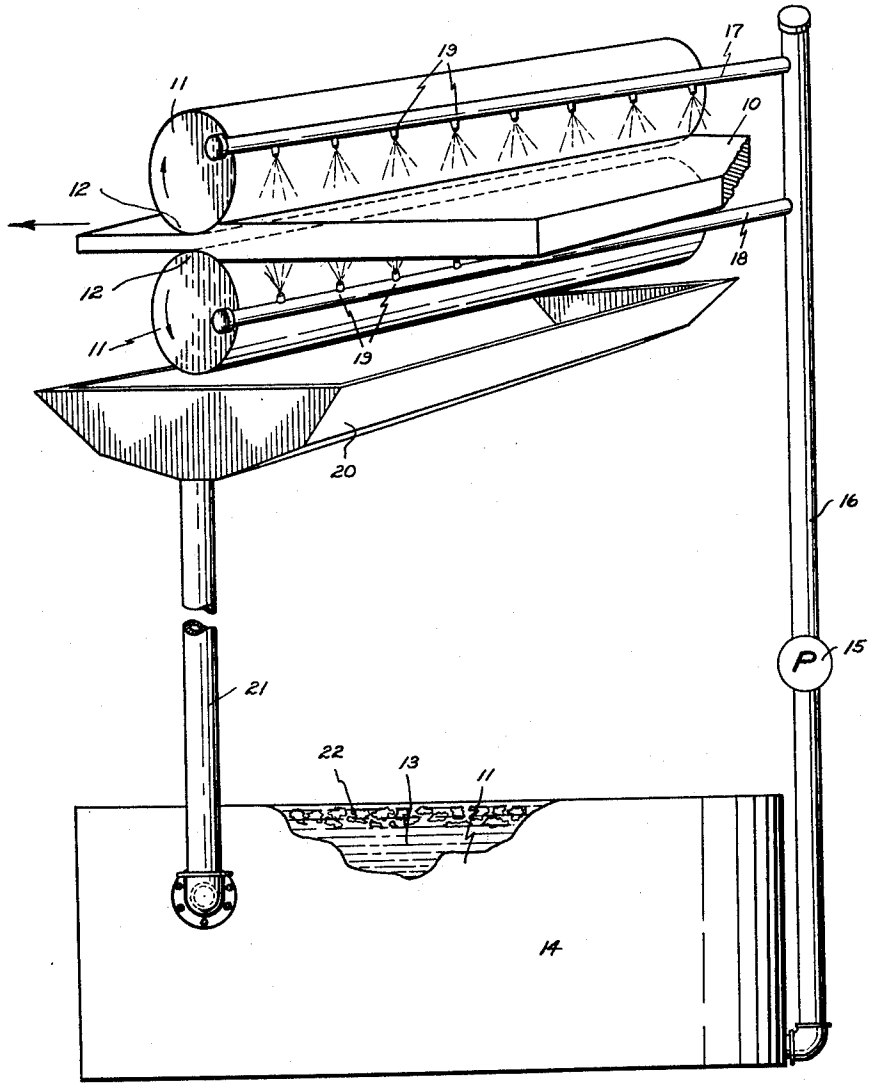
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METHODS FOR COLD METAL REDUCTION

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METHODS FOR COLD METAL REDUCTION

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This invention has to do with improvements in processes for cold metal reduction, applicable generally to the dimensional reduction of ferrous and non-ferrous metals by drawing, extrusion or rolling operations. One field of major importance being the reduction of metals to sheet form, the invention will be described with particular reference to this typical adaptation, and to the use of the conventional pressure rolls which receive between them and effect thickness reduction of the work metal.

The general operation employed is to pass the work metal between hard surface metal rolls which engage the work at extremely high unit area pressure while simultaneously rotating as the work metal is progressively reduced and advanced. The complete reduction of the work metal to a sheet stock of desired thinness may necessitate passage of the sheet in successive degrees of reduction, through successive reducing rolls. The pressure conditions existing at the roll-work interfaces necessitate constant circulation against the roll and work surfaces of a liquid which must serve the dual functions of a coolant to remove the frictionally generated heat, and a surface coating intended to prevent such seizure of the work by the rolls as would interfere with smooth and uniform reduction of the metal. Reducing progression of the work metal between the rolls occurs as a result of rotation of the rolls in a work advancing direction and ordinarily at a rate greater than the speed of travel of the work itself, so that slippage exists at the interface. Due to the cold working thus given the metal, it frequently becomes necessary, depending upon its intended use and quality, subsequently to anneal the metal by heat treatment.

The present invention is concerned primarily with the composition of the coolant liquid and with the maintenance at the roll-work interface of a barrier film that will permit the metal-reducing cooperation between the work and rolls to greater advantage and at higher operating efficiencies than have been obtainable by any prior practices within our knowledge. The invention is further directed toward improving the entire metal reducing operation with respect also to the ease of avoiding contamination of the liquid coolant, as well as the surfaces of the reduced metal.

Heretofore the tendency has been to regard the requirement for maintenance of the metal reducing conditions at the interfaces, as one of cooling and also of lubrication in the sense that lubrication and the characteristics of lubricating oils ordinarily are construed. Accordingly, the prevailing practice has been to disperse in the coolant water, as by emulsification therewith, water insoluble oils, particularly vegetable oils such as palm oil, with the object of using the water as a carrier to deposit droplets of the insoluble oil on the work and roll surfaces, so that the oil would tend to film and lubricate the surfaces at the pressure-applying interfaces. Being water insoluble, the oil tends to deposit as a relatively thick film having the characteristics of a lubricant coating in the usual sense.

While extensively used, such oils and emulsions have presented serious difficulties and limitations in a number of respects. Despite their lubrication tendencies, these oils do not prevent at times rather excessive binding or "chattering" of the rolls and resultant irregularities of the reduced metal dimensions, the likely cause being the inability of the lubricant to form and maintain a continuous film at the interface, or to withstand the extreme pressures there existing. Also such oils are particularly objectionable because of their tendency to accumulate mineral oils and greases collecting in the coolant from the rolling mill equipment and with which the coolant may become contaminated by reason of the inseparable adherence or solubilizing of the vegetable and mineral oil particles. The main difficulty created by such contamination is deposition of the oil particles on the reduced metal surfaces, and the tendency of the oil so deposited to discolor and otherwise adversely affect the surface condition of the metal upon its becoming annealed.

Also, we may mention the requirement imposed by some additive oils for having to heat the coolant mixture in order to suspend or emulsify the oil particles with the water.

The invention is distinguished from the usual practices outlined in the foregoing in a number of respects, among which is its departure from the conventional theories and practices of lubrication at the work and reducing roll interfaces. In accordance with the invention, we provide for the maintenance at the interface of what we prefer to regard as a barrier film, characterized by its great strength and resistance to the metal reducing pressures apart from the usual quantity and concentration concepts of a lubricant oil or grease film and characterized further and distinctly in comparison with conventional practices in that the film has single phase composition resulting from complete dissolution in the coolant water of a sulphated fatty material of the class later described. The invention presents the surprising discovery that dilute aqueous solutions of these sulphated water soluble fatty materials are capable of forming at the working interfaces, barrier films of such continuity and strength as to withstand the applied pressures, and having the capacity for assuring smoother cooperation between the rolls and work than has been possible of accomplishment by the conventional oils and lubricants. The result of thus smoothing and regularizing the action of the rolls against the work, is the accomplishment not only of greater dimensional uniformity (e.g. thickness) of the reduced metal, and elimination of the necessity for scraping the rejects, but also the ability to reduce the metal to smaller dimension or thickness than heretofore obtainable in practicably feasible or economical operation.

In addition to forming a better film condition at the working interface, the aqueous sulphate solutions contemplated by the invention have other distinct and important practical advantages. Being a true aqueous solution, the present coolant will not dissolve or tend to hold mineral oil or grease other than in a suspended condition permitting effective separation of the contaminants and their elimination from the surfaces of the reduced metal to be annealed or otherwise treated. Also, the fatty sulphonate compounds being soluble in the water at normal temperatures, no heating of the coolant liquid is required for effective entrainment of the filming agent.

One major object of the present invention is to employ as the aqueous coolant, a dilute water solution of a water soluble filming agent containing effective concentrations as filming materials, of soluble sulphated higher fatty alcohols. As used herein, including the claims, the term sulphated higher fatty alcohols shall be understood to mean the water soluble sulphate ester or esters of one

or a mixture of monohydric fatty alcohols, containing in the aliphatic chain between 12 to 20 carbon atoms, and of which the following are typical: cetyl, stearyl, palmoleyl, oleyl alcohols, and n-tetradecanol. In natural oils, these higher alcohols are understood to occur mainly as esters with fatty acids. For example, sperm oil is reported to be composed mainly of unsaturated higher fatty acids, possibly of the oleic series, esterified with the fatty alcohols, mainly oleyl and cetyl alcohols.

In commercial practice it has been found that these sulphated higher fatty alcohols are outstanding in imparting to the barrier film the required strength and other properties. The invention contemplates the presence in the sulphated solution or entire dissolved filming agent, of the sulphated fatty alcohols in varying concentrations so long as they are present in sufficient amounts to contribute and impart their properties substantially to the barrier film formation. Accordingly, the dissolved sulphonate may consist of the alcohol sulphate, except perhaps for small percentages of other soluble materials or sulphates. On the other hand, it is found that the favorable effectiveness of the sulphated alcohols is sufficiently great that the dissolved filming agent may contain, and for most purposes is preferred to contain substantial quantities of other sulphated or sulphonated (whichever term may be preferred) fatty materials. Thus the dissolved filming agent may comprise a mixture of sulphated fatty alcohols and sulphated fatty acids (including their glycerides), typically sulphated unsaturated fatty acids of the ethylenic (oleic) series and of which such mono-ethylenic acids within the C_{12} to C_{20} range as palmitoleic, oleic, godoleic, cetoleic and myristoleic acids and any glycerides thereof are typical. Generally it is contemplated that the sulphated fatty alcohol content of the sulphated soluble filming agent, or of a sulphated fatty alcohol-sulphated fatty acid mixture, shall be at least 25% by volume of the agent or mixture.

As to the total concentration of the dissolved filming agent in the water, the solution need only be dilute and within the range of about ½ to 10 parts by volume of the filming agent to the total solution volume, and ordinarily within the narrower and more economical range of from about ½ to 3 parts of the agent.

The invention lends itself to the use of sulphated natural oils containing the higher fatty alcohols andf their glycerides, and to oils containing other sulphatable fatty compounds or glycerides. Outstanding results have been obtained in the practice of the invention, using as the filming agent and within the concentration ranges indicated, the water soluble sulphates of sperm oil, and comprising mainly the sulphate esters and sulphates, respectively, of the higher fatty alcohols and fatty acids of the molecular size herein contemplated and which are present in sperm oil. It is to be understood that in the preparation of the sulphated filming agent, the sperm oil may be treated in accordance with any known procedure for production of the water soluble sulphate esters or their mixture with water soluble sulphated fatty acids present in the oil. The following may be cited as a typical procedure for sulphating a commercial sperm oil containing predominately, it is believed, the esters of higher fatty alcohols and fatty acids.

To 800 grams of bleached commercial sperm oil may be added from 15 to 25% by weight of concentrated (66 Bé.) sulphuric acid, slowly and with constant agitation during the mixing. The temperature of the mixture preferably is maintained substantially above atmospheric temperature and below 150° F., over a period of time that may range from 15 to 90 minutes. After this period the mixture is agitated with around 200 grams of water for about 10 minutes, the aqueous acid solution is allowed to settle and is drawn off from the bottom of the mixture. The sulphated residual material is washed with around 240 grams of an aqueous sulphate salt solution, for example a 22% solution of ammonium sulphate.

Other sulphates such as an alkali metal or aluminum sulphate may be used. The aqueous sulphate liquor is drawn off and this wash is repeated using a fresh ammonium sulphate solution. The sulphated fatty ester material then is finished preferably by treatment with a small amount of an appropriate base, e.g. alkali metal or ammonium hydroxide, the quantity of which may be variable. (For terminology purposes, ammonia is included in the alkali metal group.) Ordinarily it is preferred to finish the material by treatment with e.g. ammonium hydroxide solution sufficient to clarify and at least render it free of unneutralized sulfuric acid. The product thus made is a water soluble freely fluid material.

The method of application of the coolant and film-forming solution, and the separation therefrom of accumulated mineral oil impurities will be understood more fully from the following description of a typical adaptation of the invention as applied to the rolling and reduction of sheet metal stock. Throughout the description reference is had to the accompanying drawing illustrating diagrammatically the rolling and coolant circulation equipment.

The sheet metal stock **10** to be reduced is shown to be advanced between a pair of hard metal rolls **11** of the kind used in steel rolling mills and rotatably driven by suitable means (not shown) in the directions indicated so as to simultaneously rotate and advance the work metal **10**. With the peripheral speed of the rolls exceeding the linear advancing speed of the work metal **10**, slippage occurs between the roll and work metal surfaces at their interfaces **12**.

Heat frictionally generated at the interfaces is dissipated, and barrier films assuring smooth and regular reduction of the work metal are maintained at the interfaces, by continuous circulation of say a ½ to 3% water solution of the previously described completely water soluble sulphated filming agent against the work and roll surfaces in the vicinity of their interfaces. Typically the dilute aqueous coolant solution **13** is shown to be taken from tank **14** and discharged by pump **15** through line **16** into headers **17** and **18** respectively above and below the work metal **10** and in proximate relation to the rolls **11**. The solution is sprayed from the headers through nozzles **19** against the roll and work metal surfaces approaching the interfaces **12**, thus maintaining a constant flow of the coolant for heat removal, and assuring the presence at the interfaces of the barrier films. Flowing from the rolls and work metal, the solution enters an appropriate cooler **20** and drains back through line **21** into the tank **14**.

As previously indicated, the usual rolling mill equipment gives off mineral lubricating oil or grease which contaminates the aqueous coolant solution. By reason of the coolant itself being a complete solution of the fatty sulphonates, the insoluble mineral oil or grease accumulated by the liquid is present therein free from any association with the dissolved filming agent which could give rise to the condition heretofore recounted where an insoluble vegetable oil lubricant has adhered to prevent independent separation of the mineral oil contaminants. In the present system, the latter may readily be separated from the aqueous solution in any suitable manner, as by continuously or intermittently skimming off the mineral oil scum **22** collecting on the body of liquid in the tank **14**.

We claim:

1. The process of cold metal reduction that comprises, subjecting the work metal to reduction while moving relatively against a pressure-applying metal surface, and cooling the work metal and pressure-applying surface interface by continuously feeding thereto a dilute aqueous solution consisting essentially of less than 10% of a water soluble sulphated material of the group consisting of alkali metal salts of sulphated higher fatty

monohydric alcohols containing between 12 to 20 carbon atoms and sulphated higher unsaturated fatty acid esters of said higher fatty alcohols, thereby continuously coating the work at said interface with a barrier film formed by the dilute solution.

2. The process of cold metal reduction that comprises, subjecting the work metal to reduction while moving relatively against a pressure-applying metal surface, and cooling the work metal and pressure-applying surface interface by continuously feeding thereto a dilute aqueous solution containing under 10% of a water soluble sulphonated material of the group consisting of alkali metal salts of sulphated higher fatty monohydric alcohols containing between 12 to 20 carbon atoms and sulphated higher unsaturated fatty acid esters of said higher fatty alcohols under conditions whereby insoluble mineral oil is introduced into the solution, thereby continuously coating the work at said interface with a barrier film formed by the dilute solution, and separating the mineral oil from the sulphate solution.

3. The process of cold metal reduction that comprises, subjecting the work metal to reduction while moving relatively against a pressure-applying metal surface, and cooling the work metal and pressure-applying surface interface by continuously feeding thereto a dilute aqueous solution containing under 10% of alkali metal salts of sulphated sperm oil, thereby continuously coating the work at said interface with a barrier film formed by the dilute solution.

4. The process of cold metal reduction that comprises, subjecting the work metal to reduction while moving relatively against a pressure-applying metal surface, and cooling the work metal and pressure-applying surface interface by continuous feeding thereto a dilute solution in water of between ½ to 3% of a water soluble filming agent consisting essentially of alkali metal salts of sulfated sperm oil under conditions whereby insoluble mineral oil is introduced into the solution, thereby continuously coating the work at said interface with a barrier film formed by the dilute solution, and separating the mineral oil from the solution.

5. The process of cold metal reduction that comprises, subjecting the work metal to reduction while moving relatively against a pressure-applying metal surface, and cooling the work metal and pressure-applying surface interface by continuously feeding thereto a dilute aqueous solution consisting essentially of under 10% of a water soluble material resulting from the sulphation and substantial neutralization of a mixture of higher unsaturated fatty acids of the ethylenic series and containing between 12 to 20 carbon atoms, and a fatty material of the group consisting of higher fatty monohydric alcohols containing between 12 to 20 carbon atoms and higher unsaturated fatty acid esters of said higher fatty alcohols, thereby continuously coating the work at said interface with a barrier film formed by the dilute solution.

6. The process of cold metal reduction that comprises, subjecting the work metal to reduction while moving relatively against a pressure-applying metal surface, and cooling the work metal and pressure-applying surface interface by continuously feeding thereto a solution consisting essentially of water and under 10% of a dissolved filming agent composed of water soluble alkali metal salts of sulphated higher monohydric fatty alcohols containing 12 to 20 carbon atoms, thereby continuously coating the work at said interface with a barrier film formed by the dilute solution.

7. The process of cold metal reduction that comprises, subjecting the work metal to reduction while moving relatively against a pressure-applying metal surface, and cooling the work metal and pressure-applying surface interface by continuously feeding thereto a solution consisting essentially of water and under 10% of a dissolved filming agent composed of water soluble alkali metal salts of sulphated higher monohydric fatty alcohols containing between 12 to 20 carbon atoms under conditions whereby insoluble mineral oil is introduced into the solution, thereby continuously coating the work at said interface with a barrier film formed by the dilute solution, and separating the mineral oil from the solution.

8. The process of cold metal reduction that comprises, subjecting the work metal to reduction while moving relatively against a pressure-applying metal surface, and cooling the work metal and pressure-applying surface interface by continuously feeding thereto a solution consisting essentially of water and under 10% of a dissolved filming agent composed of alkali metal salts of sulphated unsaturated fatty acid esters of higher fatty alcohols containing between 12 to 20 carbon atoms, thereby continuously coating the work at said interface with a barrier film formed by the dilute solution.

9. The process of cold metal reduction that comprises, subjecting the work metal to reduction while moving relatively against a pressure-applying metal surface, and cooling the work metal and pressure-applying surface interface by continuously feeding thereto a solution consisting essentially of water and under 10% of a dissolved filming agent composed of alkali metal salts of sulphated higher unsaturated fatty acid esters of higher fatty alcohols containing between 12 to 20 carbon atoms under conditions whereby insoluble mineral oil is introduced into the solution, thereby continuously coating the work at said interface with a barrier film formed by the dilute solution, and separating the mineral oil from the solution.

10. The process as defined in claim 1, in which the work metal is steel and the pressure applying metal surface is that of one of metal rolls between which the steel is drawn.

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