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3,833,502  
**METHOD FOR IMPROVING THE ADHERENCE  
OF METALWORKING COOLANTS TO METAL  
SURFACES**

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**ABSTRACT OF THE DISCLOSURE**

Water-based, metalworking coolants may be made to  
adhere to metal surfaces by incorporating with such cool-  
ants small amounts of water-soluble polymers.

**INTRODUCTION**

In the metalworking industry it is now a common  
practice to use a variety of metalworking coolants. These  
coolants function in two manners, namely to dissipate  
heat from the work surface and the tool, and to lubricate  
the interface between the work surface and the tool,  
thereby extending tool life and improving the general  
characteristics of the finished workpiece. Metalworking  
coolants are used in a variety of metalworking and fin-  
ishing operations which are normally performed on such  
typical machines as lathes, drill presses, automatic chuck-  
ers, milling machines, screw machines, grinders, saws,  
lapping machines and the like.

In the past 20 years, great progress has been made in  
the development of improved metalworking coolants  
which are most frequently applied as water-based fluids.

Modern metalworking coolants may be generically cat-  
egorized as follows:

1. Synthetic Coolants—i.e., those that are water-solu-  
ble. These products are supplied in a concentrated form  
and are diluted with water when used in a machine tool.

2. Semi-Synthetic Coolants—i.e., those which contain  
less than 50% oil in the concentrated form. This type  
usually has a high emulsifier content resulting in small  
or average oil droplet diameter, which, in turn, frequen-  
tly results in clear product. These products are also sup-  
plied in a concentrated form to be diluted with water for  
machine operation.

3. Soluble Oil or Coolant—this type of product is sup-  
plied as an oil with emulsifiers added. It is designed to  
be diluted with water when used in a machine tool. It  
forms a milky emulsion.

In addition to the above type coolants, there is a  
fourth type which is a straight oil type metalworking cool-  
ant or fluid, the use of which is not covered by the teach-  
ings of this invention. As can be seen from the above de-  
scriptions, all of the above metalworking coolants are di-  
luted with water just prior to their use. Some of the in-  
gredients are soluble in water whereas others of the in-  
gredients are capable of being emulsified with water to  
form an oil-in-water emulsion which is then applied to  
the workpiece-tool interface.

The application of these metalworking coolants is ac-  
complished by taking a hose-like nozzle and applying a  
stream of the coolant directly to the area between the  
tool and the workpiece. As the metalworking coolant con-  
tacts the work surface or the tool, one of which is usually

moving in a rotational manner, the metalworking cool-  
ant tends to be thrown from the rotational workpiece  
or the tool which is being rotated due to the action  
of centrifugal force. This results in metalworking cool-  
ants being removed from the workpiece or tool in the  
form of fine droplets. Also, the metalworking coolant is  
frequently dissipated from the area to which it is applied  
due to the splash which occurs on the fluid contacting  
the surfaces to which it is applied. Due to the phenome-  
non of loss of metalworking fluid due to centrifugal force  
and splashes loss, substantial quantities of the fluid are  
lost into the atmosphere rather than being utilized in  
cooling and lubricating the tool and workpiece. In cer-  
tain limited applications these fluids are applied in the  
form of fine mists which tend to dissipate into the atmos-  
phere much of the fluid before it contacts the tool or  
workpiece.

If it were possible to treat metalworking fluids of the  
type described with a chemical composition which would  
allow the fluid upon contact with either the workpiece  
and/or the tool to be more firmly adhered thereto by the  
diminution of the splash and centrifugal force effects,  
less fluid would be needed in metalworking operations  
of the type described. Such an additive should not only  
improve the losses occasioned by splashing and centrif-  
ugal force but it should not adversely affect the cooling  
and lubricity factors of the metalworking fluid plus it  
should not affect their compatibility with water. If such  
an additive were available, an improvement in the art of  
metalworking would be afforded.

**THE INVENTION**

In accordance with the invention it has been found that  
the capability of water dispersible metalworking coolants  
to adhere more tenaciously to metal surfaces to which  
they are applied may be afforded by adding to the aque-  
ous phase of such coolants prior to their being applied to  
such metal surfaces at least five parts per million of a  
water-soluble polymer preferably the water-soluble poly-  
mer is formed by the polymerization of at least one mono-  
olefinic compound through an aliphatic unsaturated group,  
said polymer having a molecular weight of at least  
100,000.

**THE WATER-SOLUBLE POLYMERS**

As mentioned above, the polymers of the invention  
should have a molecular weight in excess of 100,000.  
Greatly preferred polymeric additives have a molecular  
weight of at least 300,000. In many instances the molecu-  
lar weight of the polymer additives ranges as high as  
1–10 million or more.

The preferred polymeric structures are derived by the  
polymerization of at least one mono-olefinic compound  
through an aliphatic unsaturated group to yield a water-  
dispersible synthetic polymer having a structure substan-  
tially free of cross-linkage. The polymer is therefore  
available for solubilization or sufficient dispersion in the  
particular metalworking fluid to be treated. Treating  
agents found to be especially effective for the purpose  
of the invention are water-dispersible synthetic polymers  
having a linear hydrocarbon structure and containing in  
a side chain, a hydrophilic group from the class consisting  
of carboxylic acid, carboxylic acid anhydride, carboxylic  
acid amide, hydroxy, pyridine, pyrrolidone, hydroxy alkyl  
ether, alkoxy, carboxylic acid salt groups, and mixtures of  
said groups.

Broadly speaking, the polymer treating agents which are effective fall into three classes; namely (1) those consisting of polymeric organic substances which in an aqueous medium will form organic anions having a substantial number of negative electrical charges distributed at a plurality of positions on the polymer; (2) those consisting of polymeric organic substances which in an aqueous medium will form organic cations having a substantial number of positive charges distributed at a plurality of positions on the polymer; and (3) those consisting of polymeric organic substances which in an aqueous medium will not form ions but nevertheless contain a sufficient number of hydrophilic groups to be water-dispersible. The first class of materials is referred to herein as anionic organic polymers, the second class is referred to herein as cationic organic polymers, and the third class is referred to herein as non-ionic organic polymers. The first two classes can also be referred to as polyelectrolytes.

The term "polyelectrolyte" is intended to cover synthetic organic polymers which in an aqueous medium will form organic ions having a substantial number of electrical charges distributed at a plurality of positions.

The synthetic organic polymers containing only carboxylic acid, carboxylic acid anhydride, and carboxylic acid salt groups in a side chain are anionic. The synthetic organic polymers containing only pyridine or other similar nitrogen-containing nuclei are cationic. The synthetic organic polymers containing only a carboxylic acid amide, pyrrolidone, a hydroxy, a hydroxy alkyl ether and/or an alkoxy group in a side chain are non-ionic. The invention contemplates the employment of polymers which contain anionic, cationic and/or non-ionic groups. It also contemplates the employment of mixtures of anionic, cationic and/or non-ionic water-dispersible synthetic organic polymers.

The following synthetic organic polymers illustrate the types of polymers which have been found to be effective for the practice of the invention:

TABLE I

Number	Name
1	Polyacrylate Sodium Salt.
2	Polymethacrylic Acid Sodium Salt.
3	Maleic Anhydride-Vinyl Acetate Copolymer.
4	Polyvinyl Methyl Ethermaleic Anhydride.
5	Methacrylic Acid-Acrylamide Copolymer.
6	Polyacrylic Acid.
7	Isopropenyl Acetate-Maleic Anhydride Sodium Salt Copolymer.
8	Itaconic Acid-Vinyl Acetate Copolymer.
9	Polyvinyl Pyridine-Hydrochloride.
10	$\alpha$ -Methyl Styrene-Maleic Anhydride Sodium Salt Copolymer.
11	Polyvinyl Pyrrolidone.
12	Styrene-Maleic Anhydride Sodium Salt Copolymer.
13	Polyvinyl Alcohol.
14	Polyvinyl Methyl Ether.
15	MethylmethacrylicMaleic Anhydride Sodium Salt Copolymer.
16	Acrylic Acid-Styrene Copolymer.

Any of the polyelectrolytes disclosed in U.S. Pat. No. 2,625,529 can be employed for the purpose of the invention. When the copolymers are identified in terms of their monomeric constituents, it should be understood that the names applied to these copolymers refer to the molecular structure and are not limited to the polymers prepared by the copolymerization of specific monomers. In many

cases, the identical copolymers can be prepared from other monomers and converted by subsequent chemical reaction to the desired copolymer.

Where the copolymer is derived from a polycarboxylic acid derivative and at least one other monomer copolymerizable therewith, the polycarboxylic acid derivative may be maleic anhydride, maleic acid, fumaric acid, itaconic acid, aconitic acid, citraconic acid, the amides of these acids, the alkali metal (e.g. sodium, potassium and lithium), the alkaline earth metal (e.g. magnesium, calcium, barium and strontium), and ammonium salts of these acids, the partial alkyl esters (e.g. methyl, ethyl, propyl, butyl, mono esters), the salts of said partial alkyl esters, and the substituted amides of these polycarboxylic acids. Where the hydrophilic maleic acid derivatives are used as one of the starting components to form the copolymer, the hydrophobic comonomers may be, for example, styrene, alphas-methylstyrene, vinyl toluene, chlorostyrene, vinyl acetate, vinyl chloride, vinyl formate, vinyl alkyl ethers, alkyl acrylates, alkyl methacrylates, ethylene, propylene, and/or isobutylene.

The foregoing synthetic copolymers are preferably obtained by reacting equimolar proportions of a polycarboxylic acid derivative and at least one other monomer. However, certain of the hydrophilic derivatives of unsaturated polycarboxylic acids can be polymerized in less than equimolar proportions with some of the less hydrophobic comonomers, for example, vinyl formate and vinyl acetate.

In addition to homopolymers and copolymers of any of the just mentioned monomers, combinations thereof or others, terpolymeric substances may likewise be usually employed in reducing mist of sprayed herbicidal liquid concentrates. A greatly preferred group includes polymerized acrylamide as one of the components of either a copolymer or terpolymer. Usually the copolymer or terpolymer contains acrylamide as a major ingredient. Greatly preferred polymers include acrylamide-acrylic acid copolymers, and acrylamide-maleic acid-methacrylic terpolymers.

In addition to the above described results with cationic and anionic organic materials, highly desirable results have been obtained when high molecular weight ethylene oxide polymers are used. These polymers have a viscosity in centipoises at 25° C., of from 500 to 30,000 when made up in one-half to five percent aqueous solutions. For best results, such polymers should have molecular weights in excess of one million. The lower molecular weight materials have molecular weights starting at about 200,000. These polymers are prepared by heating appropriate quantities of ethylene oxide with initiating molecules such as ethanol, ethylene glycol and the like in a sealed tube for six hours or more in the presence of a catalyst. Suitable catalysts include alkaline earth metal carbonates such as strontium or calcium carbonate. While ethylene oxide condensate polymers are the most preferred materials, other non-ionic, polypolar polymers are not precluded from use in the invention. The expression "polypolar polymers" refers to polymers having a plurality of non-ionized groups whereby said polymers are rendered hydrophilic. Such compounds for use with this invention desirably include polyacrylamide, poly-substituted acrylamides, polyvinyl alcohols, polyvinyl pyrrolidones and polyvinyl oxazolidones, as mentioned above.

Organic polymeric coagulants of vegetable and cellulosic origin may also be used in the newly invented process covered in this application. These include water-soluble or dispersible starches, starch derivatives, dextrans, phosphorylated starches, Gum Ghatti, Jaguar, Locust Bean Gum, carboxy methyl cellulose, and other well-known high-molecular weight water-soluble vegetable gums and their derivatives.

Most of the polymers described above are in the form of solids which must be placed into the aqueous phase of

the metalworking fluid prior to their being applied to either a workpiece and/or the tool. Frequently in the case of high molecular weight polymers such as sodium polyacrylate this requires extremely long agitation periods to completely dissolve the polymer. This means that certain work schedules must be adjusted to allow for the time required to dissolve the polymer into the aqueous phase of the metalworking coolants.

To allow more flexibility in preparation time for the addition of the polymers into the metalworking coolants, it has been found by us that a convenient method for rapidly dissolving these polymers is described in U.S. 3,624,019 the disclosure of which is incorporated herein by reference. In essence the teachings of the above patent indicate that if the water-soluble polymers of the type described above are first prepared in the form of a water-in-oil emulsion they may be rapidly dissolved in water by inverting these emulsions.

#### THE WATER-IN-OIL EMULSIONS

The water-in-oil emulsions described above may be prepared by any number of known techniques. The oils used in preparing these emulsions may be selected from a large group of organic liquids which include liquid hydrocarbons and substituted liquid hydrocarbons.

A preferred group of organic liquids are the hydrocarbon liquids which include both aromatic and aliphatic compounds. Thus, such organic hydrocarbon liquids as benzene, xylene, toluene, mineral oils, kerosenes, naphthas and, in certain instances, petrolatums may be used. A particularly useful oil from the standpoint of its physical and chemical properties is the branch-chain isoparaffinic solvent sold by Humble Oil & Refining Company under the trade name Isopar M. Typical specifications of this narrow-cut isoparaffinic solvent are set forth below in table II:

TABLE II

Specification properties	Minimum	Maximum	Test method
Gravity, API at 60/60° F.....	48.0	51.0	ASTM D 287.
Color, Saybolt.....	30		ASTM D 156.
Aniline point, ° F.....	185		ASTM D 611.
Sulfur, p.p.m.....		10	ASTM D 1266.1
Distillation, ° F.....			ASTM D 86.
IBP.....	400	410	
Dry point.....		495	
Flash point, ° F. (Pensky-Martens closed cup).....	160		ASTM D 93.

<sup>1</sup> Nephelometric mod.

The amount of oil used in relation to the water to prepare the emulsion may be varied over wide ranges. As a general rule, the amount of oil-to-water may vary between 5:1-1:10 with preferable emulsions being prepared in the ratio of 1:2 to 1:10. These ratios are illustrative of emulsions that can be prepared, although it should be understood that the invention is not limited thereby.

The emulsions may be prepared by any number of techniques. For example, the emulsions may be prepared by using high-speed agitation or ultrasonic techniques. In most instances, however, it is desirable that the emulsion be a stable emulsion and to achieve the end it is often necessary to employ an oil-soluble emulsifying agent. The amount of emulsifying agent to provide an emulsion will have to be determined by routine experimentation. As a general rule it may be said that the amount of oil-soluble emulsifier may range from 0.1 to 30 percent by weight based on the weight of the oil. To produce stable emulsions the amount of emulsifier will normally be within the range of 12-20 percent by weight of the oil.

Rather than provide a listing of suitable emulsifiers, we prefer to generally recommend as being satisfactory the so-called low HLB materials which are well documented in the literature and are summarized in the Atlas HLB Surfactant Selector. Although these emulsifiers are

useful in producing good water-in-oil emulsions, other surfactants may be used as long as they are capable of producing these emulsions. For instance, we have found that certain high HLB surfactants are capable of producing stable water-in-oil emulsions. A typical low HLB emulsifier is sorbitan monooleate.

#### DISPERSING THE POLYMERS INTO THE WATER-IN-OIL EMULSIONS

In accordance with the first step or procedure, the water-soluble vinyl addition polymers or the gums are dispersed into the water-in-oil emulsion. The polymers as produced by most manufacturing processes are in the form of powders or lumplike agglomerates of varying particle size. It is desirable that the particles, before being placed into the emulsion, be comminuted by grinding, abrading or the like so that their average particle size is less than 5 millimeters and preferably is within the range of 1-5 microns. After the powders have been comminuted, they may be dispersed into the water-in-oil emulsion by means of agitation provided by such devices as stirrers, shakers and the like. To be commercially practical, the amount of polymer in the emulsion should be at least 2 percent by weight. It is contemplated using emulsions containing between 5-75 percent by weight with preferred emulsions having a polymer concentration within the range of 10-45 percent by weight. In some cases the starting emulsions are converted to suspensions due to the nature and the amount of the polymer present therein.

From a commercial standpoint it is beneficial that the polymer emulsions thus described be stable, yet at the same time contain relatively large amounts of polymers. One method of insuring that the polymers do not precipitate when dispersed in the emulsion is that the particle size of the polymer be as small as possible. Thus polymers dispersed in the emulsifiers are quite stable when the particle size is within the range of 5 millimicrons up to about 5 microns. To produce particle sizes within these limitations, spray dryers with appropriate size nozzles may be used. It also is possible to prepare the polymer-containing emulsion of the water-soluble vinyl addition polymers directly from the vinyl monomers from which these polymers are synthesized. Such polymer-containing emulsion may be synthesized by using the water-in-oil emulsion polymerization technique set forth in U.S. Pat. No. 3,284,393. The teachings of this patent comprise forming a water-in-oil emulsion of water-soluble ethylenic unsaturated monomers. The emulsion is formed by utilizing a water-in-oil emulsifying agent. To this monomer is added a free radical-type polymerization catalyst and then heat is applied under free radical-forming conditions to form water-soluble polymer latices. The polymeric latices produced by this patent are relatively unstable and frequently must be treated with additional emulsifiers to render the products stable.

#### INVERTING THE EMULSION

When the polymer-containing emulsions of the type described are inverted in the presence of water, the polymer rapidly goes into solution. The polymer-containing emulsions release the polymer in the water in a very short period of time when compared to the amount of time required to dissolve a solid form of the polymer.

The polymer-containing emulsions may be inverted by any number of means. The most convenient means resides in the use of a surfactant added to either the polymer-containing emulsion or to the water into which it is to be dissolved. The placement of a surfactant into the water causes the emulsion to rapidly invert and release the polymer in the form of an aqueous solution. When this technique is used to invert the polymer-containing emulsion the amount of surfactant present in the water may vary over a range of 0.01 to 50 percent based on polymer. Good inversion often occurs within the range of 1.0-10 percent based on polymer.

The preferred surfactants are hydrophylic and are further characterized as being water-soluble. Any hydrophilic-type surfactant such as ethoxylated nonyl phenols, ethoxylated nonyl phenol formaldehyde resin, dioctyl esters of sodium sulfonsuccinate, and octyl phenol polyethoxy ethanol can be used.

Other surfactants that may be employed include the soaps such as sodium and potassium myristate, laurate, palmitate, oleate, stearate, resinates, and hydroabietate, the alkali metal alkyl or alkylene sulfates, such as sodium lauryl sulfate, potassium stearyl sulfate, the alkali metal alkyl or alkylene sulfonates, and sodium cetyl sulfonate, sulfonated mineral oil, as well as the ammonium salts thereof; and salts of higher means like lauryl amine hydrochloride, and stearyl amine hydrobromide.

Any anionic, cationic, or nonionic compounds can be used as the surfactant. Examples of suitable surfactants are alkali metal, ammonium and amine soaps; the fatty acid part of such soaps contains preferably at least 16 carbon atoms because soaps based on lauric and myristic acids have a greater tendency to develop abundant foam.

Other examples of suitable anionic surfactants are alkali metal salts of alkyl-aryl sulfonic acids, sodium dialkyl sulfosuccinate, sulfated or sulfonated oils, e.g., sulfated castor oil; sulfonated tallow, and alkali salts of short chain petroleum sulfonic acids.

Examples of suitable cationic surfactants are salts of long-chain primary, secondary, or tertiary amines, such as oleylamine acetate, cetylamine acetate, di-dodecylamine lactate, the acetate of aminoethyl-aminoethyl stearamide, dilauroyl triethylene tetramine diacetate, 1-aminoethyl-2-heptadecenyl imidazoline acetate; and quaternary salts, such as cetylpyridinium bromide, hexadecyl ethyl morpholinium chloride, and diethyl di-dodecyl ammonium chloride.

Examples of suitable nonionic surfactants are condensation products of higher fatty alcohols with ethylene oxide, such as the reaction product of oleyl alcohol with 10 ethylene oxide units; condensation products of alkylphenols and ethylene oxide, such as the reaction products of isoctylphenol with 12 ethylene oxide units; condensation products of higher fatty acid amides with five, or more, ethylene oxide units; polyethylene glycol esters of long-chain fatty acids, such as tetraethylene glycol monopalmitate, hexaethyleneglycol monolaurate, nonaethylene-glycol monostearate, nonaethyleneglycol dioleate, tridecaethyleneglycol monoarachidate, tricoethyleneglycol monobenhenate, tricoethyleneglycol dibehenate, polyhydric alcohol partial higher fatty acids esters such as sorbitan tristearate, ethylene oxide condensation products of polyhydric alcohol partial higher fatty esters, and their inner anhydrides (mannitolanhydride, called Mannitan, and sorbitol-anhydride, called Sorbitan), such as glycerol monopalmitate reacted with 10 molecules of ethylene oxide, pentaerythritolmonooleate reacted with 12 molecules of ethylene oxide, sorbitan monostearate reacted with 10 to 15 molecules of ethylene oxide; long-chain polyglycols in which one hydroxyl group is esterified with a higher fatty acid and the other hydroxyl group is esterified with a low molecular alcohol, such as methoxypolyethylene glycol 550 monostearate (550 meaning the average molecular weight of the polyglycol ether). A combination of two or more of these surfactants may be used, e.g. a cationic may be blended with a nonionic or an anionic with a nonionic.

Following is a list of suitable surfactants that could be used in the practice of this invention. Any water-soluble surfactant could be used, but naturally some are more efficient than others. Useful surfactants include but are not limited to: polyoxyethylene alkyl phenol, polyoxyethylene (10 mole) cetyl ether, polyoxyethylene alkyl-aryl ether, polyoxyethylene monolaurate, polyoxyethylene vegetable

oil, polyoxyethylene sorbitan monolaurate, polyoxyethylene esters or mixed fatty and resin acids, polyoxyethylene sorbitol lanolin derivative, polyoxyethylene (12 mole) tridecylether, polyoxyethylene sorbitan esters of mixed fatty and resin acids, polyoxyethylene sorbitan monostearate, polyoxyethylene sorbitan monooleate, polyoxyethylene monostearate, polyoxyethylene (20 mole) stearyl ether, polyoxyethylene (20 mole) oleyl ether, polyoxyethylene (15 mole) tridecyl ether, polyoxyethylene fatty alcohol, polyoxyethylene alkyl amine, polyoxyethylene glycol monopalmitate, polyoxyethylene sorbitan monopalmitate, polyoxyethylene (20 mole) cetyl ether, polyoxyethylene oxypropylene stearate, polyoxyethylene lauryl ether, polyoxyethylene lanolin derivative, sodium oleate, quaternary ammonium derivative, potassium oleate, N-cetyl N-ethyl morpholinium ethosulfate, and pure sodium lauryl sulfate.

In addition to using the water-soluble surfactants described above, other surfactants may be used such as silicones, clays and the like which are included as surfactants since, in certain instances, they tend to invert the emulsion even though they are not water-soluble.

In other specific cases the surfactant may be directly added to the polymer-containing emulsion; thereby rendering it self-inverting upon contact with water. These products, while capable of being used in certain systems, must be carefully formulated since the surfactants may tend to interact with the emulsifier or the emulsion and destroy it prior to its being used.

Other techniques for inverting the emulsions include the use of agitation, high voltage electrical fields, heat and pH shift, as well as the placement into the water, into which the polymer-containing emulsion is to be dissolved, certain electrolytes. For any particular polymer-containing emulsion a suitable method for its inversion may be readily determined by routine experimentation.

#### ADDITION OF THE POLYMERS INTO THE METALWORKING COOLANT

It is evident that all of the above polymers are water-soluble. They are most conveniently added to the aqueous phase of the metalworking coolants by first incorporating the polymers into the water into which the metalworking lubricant is to be dissolved or emulsified to produce either an aqueous concentrate or to produce a level of coolant concentration suitable for application in metalworking operations of the type described. In certain instances the water-soluble polymers or the water-in-oil emulsion form of the water-soluble polymers may be directly incorporated with the metalworking coolants which are normally provided as concentrates. In many instances, however, they are not compatible therewith and therefore, the prior dilution of the water-soluble polymers into the water which is used to prepare the finished metalworking coolants provides a preferred mode of practicing the invention.

The amount of polymer needed to effectively improve the adhesive or cohesive characteristics of the metalworking fluids onto the workpiece or tool may vary from as little as 5 parts per million up to as much as 500-1,000 parts per million. In the case of extremely high molecular weight polymers, care must be taken so that the viscosity of the metalworking coolant does not increase to such a point that it becomes difficult to work with and apply.

Depending upon the nature of the polymer, its molecular configuration, molecular weight, etc., use dosages may be varied over a considerable range. It is preferred that the viscosity of the metalworking coolant not be increased more than 20 centipoises after addition of polymer. The dosages of polymer can be therefore adjusted within these limits. Excessive dosages of high molecular weight polymer have the tendency in most instances to increase the viscosity beyond the above stated range, and should be avoided.

TYPICAL METALWORKING COOLANTS

A. Synthetic Coolants.—A typical synthetic coolant would have the following formula:

THEORETICAL SYNTHETIC FORMULA

	Percent
Water .....	20-95
Sulfurized and/or Chlorinated Material (animal or vegetable only no petroleum!)	0-25
Emulsifier system:	
Amine .....	0-25
Fatty Acid .....	0-25
Non ionics .....	0-25
Sulfonates (not of petroleum base) .....	0-10
Rosin Soaps .....	0-10
Sulfates of Fatty Acids .....	0-10
Alkali Soaps .....	0-10
Coupling Agents (glycols, esters, ethers, etc. as hexylene glycol, butyl carbotal, etc.)	0-2
Anti foam agents .....	0-3
Chelating agents .....	0-2
Rancidity Control Agents .....	0-1
Odor Masks .....	0-1
Dyes .....	0-5
Metal Deactivators .....	0-10
Corrosion Protectors .....	0-10

Coolants of this type as supplied by the manufacturer are in a concentrated form and are diluted with water at dilution factors ranging between 5-1 and 100-1 depending upon its ingredients, the nature of the particular metalworking operation and the like. A typical dilution would be one part of the above typical formula to forty parts of water.

B. Soluble Oils.—A typical soluble oil used in metalworking industries would have the following formula:

THEORETICAL SOLUBLE OILS

	Percent
Sulfur containing base (vegetable, animal or petroleum base) .....	0-25
Chlorine containing base (vegetable, animal or petroleum base) .....	0-25
Emulsifiers:	
Will make anionic emulsifiers:	
Amine .....	0-25
Fatty Acid .....	0-25
Nonionic emulsifier .....	0-10
Sulphonates (anionic emulsifier) .....	0-10
Rosin Soaps (emulsifier) .....	0-10
Sulfated Fatty Oils (emulsifier) .....	0-10
Alkali Soaps (emulsifier) .....	0-10
Coupling Agents .....	0-5
Rancidity Control Agents (Dowicides, etc.) .....	0-1
Anti Foam Agents .....	0-1
Chelating Agents (for hard water areas) .....	0-1
Solvent Oil (Kerosene, mineral seal oil, paraffins, naphthenic, etc.) .....	10-95
Odor Masks .....	0-1
Dyes .....	0-1
Metal Deactivators (prevent stain or attack on copper, brass etc.) .....	0-5
Corrosion Inhibitors .....	0-2

The above formula as in the case of the synthetic coolant would be diluted with about 40 parts of water to produce a coolant that would be used in many metalworking type operations.

In formulas of the type described in A and B above, they would be prepared by adding them to water into which had previously been dissolved or dispersed the polymers of the invention. To illustrate the typical commercial metalworking formulas that have been evaluated and

found to be successful using the teachings of the invention, Formulas C and D are presented below:

FORMULA C

	Percent
5 Water .....	76.50
Polymer Emulsion* .....	0.60
Triethanolamine .....	12.80
Dodecyl Amine (Rx 10 Moles, etc. amine polyglycol) .....	1.00
10 Sodium Nitrate .....	2.40
Chlorinated phenols .....	0.30
Calcocid Blue Dye .....	0.005

FORMULA D

	Percent
15 Paraffin Oil .....	76.47
Petroleum Sulphonate .....	6.60
Potassium salt of processed rosins and tall oils .....	12.10
Potassium Hydroxide .....	0.45
20 Phenol .....	0.25
85% Phosphoric Acid .....	0.19
Diethylene Glycol .....	1.15
Oleic Acid .....	1.19
Chlorinated phenols .....	1.00
25 Silicone oil antifoam .....	0.60

\*30% sodium polyacrylate in a water-in-oil emulsion which contains a nonionic dispersant for purposes of inverting the emulsion.

EVALUATION OF THE INVENTION

To evaluate the invention the following test setup was used:

Example 1

Into a commercial lathe was chucked a three-inch diameter steel bar which was one foot long. The lathe was equipped with a supply hose for directing coolant onto the workpiece and the lathe cutting tool. The speed of the workpiece was set at 900 r.p.m. and the cutting tool set at a rake angle of 30° with the feed rate being relatively moderate. A coolant corresponding to Formula C without the water-soluble polymer present was diluted with forty parts of water. This formula was flooded onto the workpiece and tool during the cutting operation which lasted three minutes. A strobe light was set up and adjusted to allow visual observation of the droplet and splash patterns generated by the application of the coolant. It was observed that a substantial amount of liquid droplets were ejected from the rotating workpiece into the atmosphere. A substantial amount of splashes could be observed at points contiguous to the area upon which the fluid was directed. Using the same setup, Formula C was applied at the same dilution e.g. forty parts of water to one part of the formula and again visual observations were made using the strobe light. Splashing and coolant dissipation was reduced about 80 percent.

Example 2

Using the same test method as described in Example 1, Formula D was tested both with and without the same water-soluble polymer present at 15 p.p.m. in the aqueous phase. Once again splashes and ejection of droplets into the air was reduced about 75 percent due to the presence of the polymer.

In both the above tests no difference was observed in the degree of cutting efficiency or in the degree of cooling provided by the metalworking coolant formulas.

Having thus described our invention it is claimed as follows:

1. A method for improving the capability of water dispersible metalworking coolants to adhere to metal surfaces to which they are applied which comprises the steps of adding to the aqueous phase of said coolants prior to their being applied to a metal surface at least 5 p.p.m. of a readily inverted water-in-oil emulsion of a

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water-soluble polymer having a molecular weight of at least 200,000, and then applying said metalworking coolants to a metal surface.

2. The method of Claim 1 where the water-soluble polymer is a sodium polyacrylate.

3. The method of Claim 1 where the sodium polyacrylate is added to the aqueous phase of said metalworking coolant in the form of a water-in-oil emulsion which is then inverted.

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H. M. S. SNEED, Primary Examiner

U.S. Cl. X.R.

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UNITED STATES PATENT OFFICE  
CERTIFICATE OF CORRECTION

Patent No. 3,833,502 Dated September 3, 1974

Inventor(s) EDWARD F. LEARY and HOBART M. KRILLIC

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 33, delete "of sprayed herbicidal liquid concentrates."

Column 7, line 19, after "suitable" add --anionic--.

Signed and sealed this 11th day of March 1975.

(SEAL)  
Attest:

RUTH C. MASON  
Attesting Officer

C. MARSHALL DANN  
Commissioner of Patents  
and Trademarks